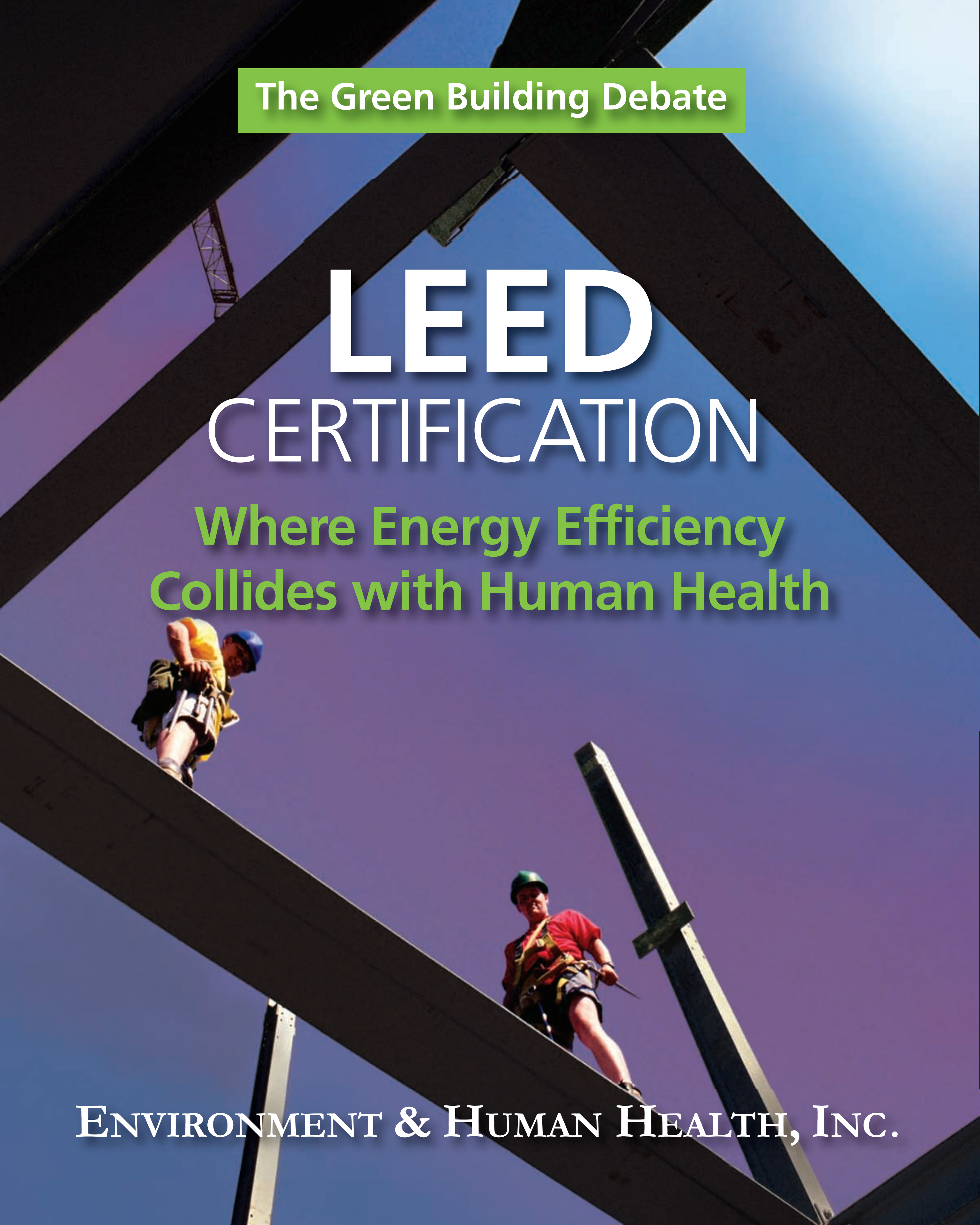

The Green Building Debate

LEED CERTIFICATION

Where Energy Efficiency Collides with Human Health

ENVIRONMENT & HUMAN HEALTH, INC.

THE GREEN BUILDING DEBATE

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Research and publication of this report was made possible by The Forrest & Frances Lattner Foundation, The Tortuga Foundation and The William C. Bullitt Foundation.

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Printed on recycled paper with soy-based inks

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I. Introduction

Problem Statement

The purpose of this report is to evaluate the LEED program's standards that many assume protect human health from environmental hazards within the built environment.

New federal, state and local laws tied to "Green Building Standards" are on the rise in the United States and throughout the world. As a growing number of governmental regulations are linked to green building standards, certification criteria that insufficiently account for threats to human health are becoming deeply embedded in U.S. law.

The U.S. Environmental Protection Agency (EPA) defines "green building" as "the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle, from site selection to design, construction, operation, maintenance, renovation and deconstruction."[1]

The green building movement is now thriving in many wealthier nations. The building industry began to establish voluntary programs and standards for energy-efficient development following the rapid surge in energy prices in 1974 after the Mideast oil embargo.

This research report presents a thorough evaluation of the Leadership in Energy and Environmental Design (LEED) program's consideration of human health within the built environment, as a basis for proposing changes that would more fully value human health.

Many building programs now exist to encourage energy efficiency and environmental responsibility. The most prominent and successful include the LEED program sponsored by the U.S. Green Building Council (USGBC), the United Kingdom's Building Research Establishment Environmental Assessment Method (BREEAM) program, Australia's

Green Star program, and the U.S. EPA's ENERGY STAR for Buildings program. All have similar objectives and employ similar criteria to evaluate building performance.

This report evaluates the LEED certification program for New Construction and Major Renovation. LEED has also developed other certification categories, including commercial interiors, core and shells, schools, homes and existing buildings. New rating systems will soon be available for "health care facilities, retail buildings and neighborhoods."

LEED for new construction evaluates projects, and assigns points or scores for categories such as energy efficiency, site renovation, innovative design, efficient waste management, use of recycled materials, access to public transit, and use of building materials deemed to be environmentally responsible.

Development projects voluntarily submit building details, and LEED staff award certificates according to accumulated points for "platinum," "gold," or "silver" performance. These designations are both symbolically important and economically valuable, as their award tends to increase property resale value. Governments at all levels have adopted new laws that reward LEED certification, including loan guarantees, lower-interest loans, mortgage interest rate reductions, income tax credits, property tax reductions and other public subsidies.

Green building programs also are attracting considerable investment by the building industry. The green building market is predicted to more than double from today's $36–49 billion to $96–140 billion by 2013.[2] Most corporations, government agencies, and academic institutions are now "greening" their real estate portfolios.[3]

The purpose of this report is to evaluate the LEED program's standards that many assume protect human health from environmental hazards within the built environment. The LEED scoring system is weighted heavily toward energy conservation and the use of new and renewable energy technologies.

This critique… is intended to sound the alarm about the health dangers of broad adoption of LEED standards by governments, corporations, and others unless the LEED award system is changed to require protection of human health from hazardous chemicals.

A building may receive "platinum," or the highest ranking in the LEED system, without any points being awarded in the category intended to protect human health.

The effect is to encourage tighter buildings, resulting in lower levels of exchange between indoor and outdoor air. Since indoor air is often more contaminated than outdoor air, the effect may intensify chemical exposures, increasing the likelihood of unintended health consequences.

Elements of the built environment that potentially affect human health include the location of buildings, waste management, building materials, infrastructure to deliver air and water, furnishings, and appliances that burn fuels indoors. All of these elements are considered in this assessment of the growing conflict between green building development standards and human health.

Much of this critique is devoted to the LEED program's failure to place enough emphasis on the indoor air in the built environment. Building materials are known to include many well-recognized toxic substances, including metals, adhesives, plastics, solvents, flame retardants, sealants and biocides.

The final building structure comprises thousands of these chemicals, and many materials "off-gas"—or become airborne—and are inhaled by occupants. Chemicals often employed include respiratory stressors, neurotoxins, carcinogens, reproductive hazards, hormone mimics and developmental toxins.

EPA now estimates that Americans spend, on average, 90 percent of their time indoors or within vehicles. The time within vehicles is approximately 5 percent. Time spent outdoors is declining, and this trend is associated with a growing sedentary lifestyle and the increasing use of electronic media. The effect is increased human exposure to indoor chemical mixtures that are not monitored or managed under LEED requirements.

The LEED program for "new construction and renovation" considers human health within its "indoor environmental quality" category, which is allotted 15 points out of a possible total point score of 110. Thus, human health concerns constitute only 13.6 percent of the total possible award.

Points may be awarded in other subcategories, including daylight and views, thermal comfort, lighting, air delivery monitoring, ventilation, chemical and pollutant source control, and material emissions.

Greater insulation, less ventilation, and a huge increase in new chemicals and products, within new buildings, collectively induce chemical exposures and threats to health never previously experienced in human history.

Chemical and pollutant source control and materials emissions are perhaps most relevant to human health among all the criteria considered, yet collectively account for a very small percentage of the total score awarded to a project. A building may receive "platinum," or the highest ranking in the LEED system, without any points being awarded in the category intended to protect human health (Appendix I).

During the last half-century, society's growing exposure to chemicals has been accompanied by an increase in the prevalence of many illnesses and conditions. These include respiratory diseases, childhood asthma, neurological impairments, declining sperm counts, fertility failure, increase in autoimmune disease and severe allergies, breast and prostate cancers, and developmental disorders among the young. Some of these problems have been caused or exacerbated by exposure to commercial chemicals and pollutants.[4] There is little doubt, for example, that tobacco, lead, mercury, radionuclides, solvents, vehicle exhaust, combustion by-products, dioxins, PCBs and many pesticides have caused extensive human illness.

The rise in childhood asthma, beginning in the early 1980s, has paralleled an increase in energy efficiency of buildings, and data suggest that increased chemical exposure in indoor environments may be the reason. Greater insulation, less ventilation, and a huge increase in new chemicals and products, within new buildings, collectively induce chemical exposures and potential health effects never previously experienced in human history.

LEED building certification standards that insufficiently account for threats to human health are being adopted or encouraged by many U.S. laws and regulations. A rapidly growing number of federal, state, and local laws and regulations are adopting LEED standards that affect building codes and zoning and subdivision regulations.

In Connecticut, for example, any new state building costing more than $5 million must achieve LEED certification. Many corporate, governmental and educational institutions are now required by law or policy to meet LEED standards for future development and renovations.

As the world wrestles with climate change, nations, corporations, and individuals are reconsidering how they produce and consume energy. Clearly, the building sector is a keystone to a sustainable energy future.

Within the United States, for example, more than 100 million buildings consume 76 percent of the nation's electricity and emit nearly half of the country's greenhouse gases. Energy consumption within buildings is predominantly used to heat and cool air, to provide light, to heat water, and to run electronic equipment.

The Green Building Council is an association of private executives from the fields of engineering, construction and architecture, and representatives of trade associations. Many of these individuals have little expertise in the hazards associated with chemicals used in the building industry, or the potential effects on human health from exposure to these compounds.

This critique is not meant to diminish the importance of the Green Building Council's efforts to encourage greater energy efficiency within the built environment. It is, however, intended to sound the alarm about the health dangers of broad adoption of LEED standards by governments, corporations and others, unless the LEED award system is changed to require protection of human health from hazardous chemicals.

The Green Building Council is an association of private executives from the fields of engineering, construction and architecture, and representatives of trade associations (Appendix II). Many of these individuals have little expertise in the chemicals used in the building industry, or the potential effects on human health from exposure to these compounds.

The Green Building Council does not disclose the points it awards following its evaluation of individual building components and performance. The Council also remains unaccountable to the public, and it is not subject to the Administrative Procedures Act or the Freedom of Information Act. Despite the freedom from oversight by either the Congress or state legislatures, LEED standards are being rapidly incorporated into diverse laws, regulations and policies at all levels of government.

II. LEED Program

The U.S. Green Building Council (USGBC) was formed in 1993 as a non-profit "green building" organization. By 1994, the organization had formed a committee composed of architects, real estate agents, a building owner, a lawyer, an environmentalist and industry representatives to develop a certification system for the sustainable building industry, otherwise known as LEED. In 1997, the U.S. Department of Energy agreed to fund Green Building Council's committee, which would launch a program (*LEED Version 1.0*) a year later. In the spring of 2009, *LEED Version 3.0* was released.[1]

LEED's purpose is to evaluate "environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a 'green building.'"[2] The program is intended to protect the environment, protect occupant health, promote financial return, provide a standard for the term "green," and promote an integrated design process.[3]

Energy and sustainable rating programs are developing rapidly and gaining wider adoption in places such as Great Britain, Europe, South Africa, Australia and New Zealand. The most recognized programs outside the United States include the U.K.'s BREEAM and Australia's Green Star.

BREEAM, funded mainly by the U.K. government, provides research and information to the building industry on environmental protection and sustainable development. It is the most widely used environmental rating scheme in the United Kingdom. While voluntary, it adopts the U.K. Building Regulation as a benchmark to rate the level of performance improvement. BREEAM was the inspiration for LEED, but lacks the strong commercial mindset, which the U.K. Green Building Council (UKGBC) is now trying to replicate.[4]

Despite the freedom from oversight by either Congress or state legislatures, LEED standards are being rapidly incorporated into diverse laws, regulations and policies at all levels of government.

Green Star is the most popular voluntary building environmental assessment program in Australia, and has been adopted in New Zealand and South Africa. Like LEED and BREEAM, it uses a credit rating system and has become a national guide to evaluate the environmental design and performance of buildings.[5]

Over the past decade, LEED has expanded rapidly. Rating systems are now available for commercial interiors, core and shells, schools, homes and existing buildings—and new rating systems will soon be available for health care facilities, retail buildings and neighborhoods.

Table 1. ***Different Types of LEED Building Rating Systems***

Existing Rating Systems	Year Adopted
New Construction	2000
Commercial Interiors	2004
Core & Shell	2006
Schools	2007
Homes	2007
Existing Buildings: Operations & Maintenance	2008
Pending Rating Systems	
Healthcare	In Review
Retail	Passed Ballot Phase
Neighborhood	Begins 2010

Since the initial rating system for new construction began in 2000, there have been roughly 35,000 LEED projects in all 50 states, totaling over 4.5 billion square feet.[6]

This report analyzes the LEED standards and credits for new construction and renovation projects. In the category of new construction and renovation, credits may be awarded by accumulating points in seven areas, as shown in Table 2.

LEED Minimum Project Requirements

The LEED program has adopted certain minimum requirements that must be met before any project may be considered for certification. These are extremely important, both for what is required, and what is neglected.

None of the minimum requirements explicitly addresses the need to reduce chemical exposures or to protect human health. While LEED requires compliance with "environmental laws, including all applicable federal, state, and local building-related regulations," these laws restrict the use and concentrations of very few chemicals in indoor environments. This is well demonstrated by the presence of many hazardous chemicals in human tissues, as shown in the additional case studies that follow.

LEED Indoor Air Quality Performance

Only 7 out of a possible 110 points have the primary intent to limit hazardous chemicals within the built environment.

The rating category intended to encourage protection of health is titled, "*Indoor Environmental Quality.*" A building can achieve a total of 15 points in the indoor environmental quality category among a possible total of 110 from all other rating categories. However, 8 of the 15 possible points may be awarded for lighting, daylight and views (3 points possible), thermal comfort (3 points possible), and air quality management planning during construction (2 points possible).

Thus, only 7 out of a possible 110 points have the primary intent to limit hazardous chemicals within the built environment. Since the highest building rating possible only requires a total score of 80 points, LEED certification is possible, even at the highest "platinum" level, without earning credits in the indoor air category, the category most likely to protect human health.

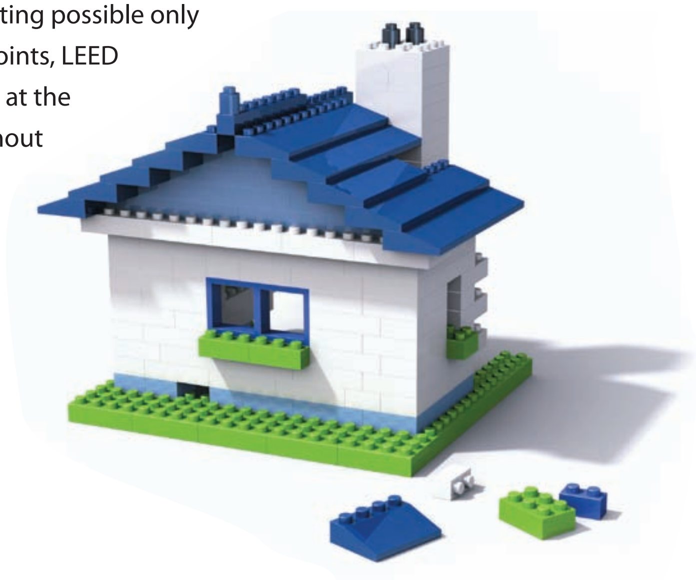

Table 2. ***Rating System Categories for New Construction and Renovations***

CATEGORY	TOTAL POSSIBLE POINTS	DESCRIPTION
Energy and Atmosphere	35	*Includes energy use monitoring, efficient design and construction, efficient appliances and systems, and use of renewable and clean sources of energy.*
Sustainable Sites	26	*Credits allocated to characteristics that minimize impact on ecosystems and waterways, encourage appropriate landscaping, utilize smart transportation choices, control stormwater runoff, and reduce erosion, light pollution, heat island effect and construction-related pollution.*
Indoor Environmental Quality	15	*Promotes strategies that "enhance indoor air quality," increase natural daylight and views, and improve acoustics.*
Materials and Resources	14	*Promotes waste source reduction, reuse and recycling; acknowledges sustainably grown, produced and transported materials.*
Water Efficiency	10	*Promotes efficient appliances, fixtures and fittings indoors, and rewards efficient water use in landscaping.*
Innovation in Design	6	*Points credited for using new/innovative technologies and strategies to improve a building's performance beyond LEED credits. Provides points for including a LEED Accredited Professional in the project.*
Regional "Bonus" Credits	4	*Specific credits available depending on building's region of the country. For example, additional credits in the southwest available for water efficiency; credits in the northeast for sustainable sites or insulation.*[7]
Total Points Possible	***110***	

If building projects meet the above requirements, they are assessed to determine their total allocation of credits. Four levels of certification are possible, depending on the number of credits earned: ***Certified 40–49 credits; Silver 50–59 credits; Gold 60–79 credits; Platinum 80–110 credits.***

Source: USGBC. LEED 2009 for New Construction and Major Renovations.

III. Health Threats Neglected by the LEED Rating System

The Green Building Council requires that all certified projects comply with existing environmental laws. The United States has one of the most complex bodies of environmental law in the world, and although many believe that these laws and regulations provide protection for human health, this is not the case. Hazardous chemicals are often used in consumer products, as well as in commonly used building materials.

Among many serious problems is the failure of the Toxic Substances Control Act (TSCA) that was adopted in 1976 to help EPA maintain an inventory of potentially toxic substances. The agency is not empowered to demand pre-market testing or to regulate the production of chemicals unless it has compelling evidence that these compounds have significant environmental or health risks. Therefore, the burden on government is to conduct the testing needed to justify regulation, and this task is now impossible given the staggering number of untested chemicals and combinations that have been released into the environment.

When TSCA went into effect, 62,000 chemicals were already in commerce and were therefore listed, but immediately exempted or grandfathered from any data submission requirements. Nearly 20,000 additional chemicals have been introduced into commerce since then, yet almost half were not reported to the EPA until after companies began to sell them. EPA has required companies to submit data to demonstrate product safety for only 200 of these chemicals, and it has used TSCA authority to ban only five compounds since 1976.

As a result of this neglect, 90 percent of U.S. chemicals produced in the highest volumes are exempt from federal review under TSCA. Moreover, in 1998 the EPA found that basic toxicity information was available for only seven percent of them, and no toxicity data was available for more than 40 percent. For chemicals produced at lower volumes, the agency had even less information.

Hazardous chemicals are often used in consumer products, as well as in commonly used building materials. Among many serious problems is the failure of the Toxic Substances Control Act that was adopted in 1976 to help EPA maintain an inventory of potentially toxic substances. The agency is not empowered to demand pre-market testing.

The LEED rating system does not pay sufficient attention to potential health effects of chemicals and other compounds used in building materials.

The EPA also has reported that 95 percent of the information submitted by manufacturers is classified as "confidential business information," and therefore is not accessible to the public — or to state, local or foreign governments.

For the first time in December 2009, EPA used TSCA's authority to list chemicals that "may present an unreasonable risk of injury to health and the environment." Once on the list, the chemical manufacturer can provide information to demonstrate that the "chemical does not pose an unreasonable risk."[1]

This EPA list, entitled "Chemicals of Concern," includes four classes of chemicals widely used in the building industry and accepted under the LEED rating system. These chemicals include phthalates (used as softeners in flexible vinyl products, such as floor and wall coverings); short-chain chlorinated paraffins (secondary plasticizers and flame retardants in plastics); PBDEs (used as flame retardants in textiles, plastics and wire insulation); and perfluorinated chemicals, including PFOA (used for non-stick cookware and stain resistant materials). Many LEED-certified buildings have been constructed using some of these compounds.

The LEED rating system does not pay sufficient attention to potential health effects of chemicals and other compounds used in building materials. The rating system assigns credits for building products that may contaminate indoor air and the environment, such as insulation materials or other materials that may contain flame retardants,[2] PVC materials containing phthalates, and artificial turf containing multiple contaminants.

This section describes how the LEED rating system falls short of protecting human health by failing to encourage health-protective indoor air and drinking water quality, and overlooks the use of hazardous substances in building materials and landscaping.

Indoor Air Quality

LEED Offers Little Assurance of Health Protection

New construction or renovation projects are eligible to receive a maximum of 110 total point credits. Only 15 credits are available for meeting LEED standards for indoor environmental quality, and seven of these credits are associated with thermal comfort and lighting. Since none of the eight remaining air quality credits are required, a building could earn no credits for air quality assurance and still be awarded the highest level of certification—"platinum."

The vast majority of chemicals in indoor environments remain unregulated under federal, state and local law. Moreover, if history is any guide, the situation will not improve soon. Without a comprehensive new approach, these already serious threats to health from air pollution will persist.

EPA's air quality regulations do not assure air quality for many reasons. The agency has spent most of its resources attempting to regulate only six "criteria pollutants" that are common in outdoor air. 'To a lesser extent, some attention is given to 189 others known as "hazardous air pollutants."

Thousands of additional chemicals are routinely released both outside and inside. It takes about 10 years after EPA becomes aware of a danger for it to revise a standard for a single air pollutant—such as ozone or fine particles—and even when tougher standards are set, manufacturers are granted a four-year period before the new rules apply.

Many factors can contribute to poor indoor air quality, including outdoor air pollution that flows into buildings. In addition, indoor air can contain pollutants from cleaning products, pesticides, formaldehyde in furniture and insulation, paints and other wood

Heating and cooling systems that recycle air rather than exchanging indoor and outdoor air, as well as windows that do not open, especially in rest rooms, often lead to an accumulation of chemical and biological agents that can trigger or exacerbate asthma and lead to other respiratory problems.

Tighter, more energy-efficient structures often have one-tenth the air exchange rates of older structures with windows, doors and walls that are less well-insulated and sealed.

finishes, cleaning agents, waxes and polishing compounds, fragrances, plasticizers in wallpaper, rugs, components of building structures (such as sealants, plastics, adhesives and insulation materials), animal and insect allergens, molds, fumes from household gas appliances and tobacco smoke.

Carbon monoxide, fine carbon particles, and polycyclic aromatic hydrocarbons emitted from poorly vented fireplaces, wood stoves, furnaces, water heaters, kerosene heaters, and idling vehicles in attached garages also may pose a serious threat to health indoors.

By 1994, several scientists had shown that severe asthma occurs more often than mild asthma among children living in areas that exceed federal outdoor air quality standards. In 2000, the EPA estimated that nine million children were living in areas where ozone standards were not met; 3.5 million children were living in areas where the particulate standards were exceeded; 2.8 million children were living in counties where the carbon monoxide standard was surpassed; and 1.4 million children lived in counties where the air limit for lead was not met.

In 2007, about 20 million children were living in areas of the United States that failed to meet at least one of the federal standards for air quality. This is especially sobering since indoor air is often more polluted than the air outside.

The 1974 Energy Policy and Conservation Act encouraged building standards to promote energy efficiency and reduce the exchange of indoor and outside air. Tighter, more energy-efficient structures often have one-tenth the air exchange rates of older structures with windows, doors and walls that are less well-insulated and sealed.

Heating and cooling systems that recycle air rather than exchanging indoor and outdoor air, as well as windows that do not open, especially in rest rooms, often lead to an accumulation of chemical and biological agents that can trigger or exacerbate asthma and lead to other respiratory problems.

Formaldehyde

Formaldehyde, a volatile organic compound (VOC) often used in building materials, is identified as a human carcinogen and is a serious airway irritant. It is designated a toxic air contaminant in California with no safe level of exposure. A significant association has been demonstrated between nasopharyngeal cancer and having lived 10 or more years in a mobile home, especially for mobile homes built in the 1950s to 1970s, when formaldehyde resin use increased.

Numerous studies indicate that leukemia and neoplasms of the brain and colon may be associated with formaldehyde exposure. There is a significant positive association between formaldehyde exposure and childhood asthma. Associations between residential or school exposure to formaldehyde and respiratory symptoms have been reported, and physician-diagnosed asthma and bronchitis are associated with increasing concentrations of formaldehyde.[3]

Inside buildings, formaldehyde can off-gas from pressed wood products, such as plywood, particleboard and fiberboard. Formaldehyde is also found in insulation, durable press drapes, other textiles and glues. One of the major sources of exposure is from inhalation of formaldehyde emitted from composite wood products containing urea-formaldehyde resins. Greater concentrations of formaldehyde have been associated with lower fresh air exchange, as well as painting, varnishing and acquiring new wooden or melamine furniture in the previous 12 months.[4]

LEED grants one point for documenting that composite wood and agrifiber products used on the interior of the building (defined as inside of the weather-proofing system) do not contain urea-formaldehyde resins *(EQ Credit 4.4, Low-Emitting Materials: Composite Wood & Agrifiber Products)*. Points are not awarded for using formaldehyde-free insulation, due to an assumption that the phenol-based formaldehyde binders used in batt fiberglass insulation do not emit formaldehyde at

Inside buildings, formaldehyde can off-gas from pressed wood products, such as plywood, particleboard and fiberboard. Formaldehyde is also found in insulation, durable press drapes, other textiles and glues.

The LEED rating systems for new construction and existing buildings permit smoking within designated rooms that exhaust the smoke outdoors.... A report from the U.S. Surgeon General concluded, "even sophisticated ventilation approaches cannot completely remove secondhand smoke from an indoor space."

levels of concern, and that drywall between the insulation and the indoor space protects building occupants from exposure to significant emissions. However, a memo from the Healthy Building Network recommends avoiding this material, noting that fiberglass insulation containing phenol-based formaldehyde binders may expose occupants to potentially hazardous levels of formaldehyde.[5]

Tobacco Smoke

The LEED rating systems for new construction and existing buildings allow smoking within designated rooms that exhaust the smoke outdoors—provided that a separate heating and ventilation system prevents smoke from entering other parts of the building.

This requirement implies that ventilation and air filtration techniques can remove secondhand smoke from the air, and protect people inside the building from secondhand smoke. But according to the U.S. Surgeon General and the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), ventilation systems cannot eliminate secondhand smoke, also called environmental tobacco smoke (ETS).

Secondhand smoke is a known human carcinogen. It contains over 4,000 chemical compounds, more than 60 of which are known to or suspected to cause cancer. The dangers of secondhand smoke are well known, but each year it is responsible for an estimated 46,000 deaths from heart disease in non-smokers who live with smokers; about 3,400 lung cancer deaths in non-smoking adults; breathing problems in non-smokers; up to 300,000 lung infections in children younger than 18 months of age, as well as increases in the number and severity of asthma attacks in children who have asthma.[6]

The workplace is a major source of secondhand smoke exposure for adults. Secondhand smoke exposure in the workplace has been linked to an increased risk for heart disease and lung cancer among adult non-smokers.[7] In 2006, Surgeon General Richard Carmona concluded, "separating smokers from nonsmokers, air cleaning technologies, and ventilating buildings cannot eliminate secondhand smoke exposure," since conventional air cleaning systems cannot remove all toxic particles and gases found in secondhand smoke. A report from the U.S. Surgeon General concluded, "even sophisticated ventilation approaches cannot completely remove secondhand smoke from an indoor space. Because there is no risk-free level of secondhand smoke exposure, anything less cannot ensure that nonsmokers are fully protected from the dangers of exposure to secondhand smoke."[8]

Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets. The potential to cause health problems is linked to particle size. Particles that are 10 micrometers in diameter or smaller can pass through the throat and nose and enter the lungs, harming the heart and lungs, and causing serious health effects.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), the international indoor air quality standard-setting body, unanimously adopted a position document on secondhand smoke, which states, "A total ban on indoor smoking is the only effective means of controlling the health risks associated with ETS exposure." The organization notes that selective location of supply exhaust vents and air cleaning and filtration may reduce exposure to ETS, but limited evidence is available on their effectiveness.[9]

Particulates

Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets. The potential to cause health problems is linked to particle size. Particles that are 10 micrometers in diameter (PM_{10}) or smaller can pass through the throat and nose and enter the lungs, harming the heart and lungs, and causing serious health effects. Fine particles 2.5 micrometers in diameter ($PM_{2.5}$) and smaller, are associated with an excess risk of both lung cancer and cardiopulmonary disease.[10]

Fine particles can penetrate most deeply into the lungs of children, who have small airways, acting as a nucleus and attracting other hazardous particles and gases, including carbon monoxide, formaldehyde, sulfur and nitrogen oxides, and PAHs (polycyclic aromatic hydrocarbons) that can be inhaled. These smaller particles may be capable of delivering a higher dose of toxic gases to the lung than coarser particles. Formaldehyde is noteworthy among toxins that can stick to these very small particles.

The limited testing required by LEED for PM_{10} may not adequately reflect the PM_{10} present in a building once it is occupied.

Scientists are increasingly concerned about the health effects of such tiny particles, as they are even found indoors. LEED standards require testing for only large-diameter particles (PM_{10}), providing a credit if it can be demonstrated that the contaminant maximum concentration for PM_{10} does not exceed 50 mcg/m^3 following construction (but only before occupation).

Research suggests that this limited testing may not reflect the actual PM_{10} levels inside a building once it is occupied. Researchers sampled the air in 142 new buildings seeking LEED certification after construction. The four-hour averages (the recommendation) were all within the LEED limit, but when the investigators ran a vacuum cleaner to simulate the effects of human activity, the PM_{10} readings spiked to as high as 60 mcg/m^3. Larger surges were seen when indoor sampling coincided with nearby outdoor construction activity.

Indoor PM_{10} readings spiked to 200 mcg/m^3 for about 15 minutes, and dropped back to less than 30 mcg/m^3 at the end of the workday. Spikes in the 200 mcg/m^3 range for PM_{10} are considered a potential health threat. The PM_{10} levels increased beyond the LEED limit in occupied schools, apartments, and offices, when people were inside behaving normally.[11]

Diesel exhaust particles, another example of fine particulate matter, are detected in most indoor environments—and their indoor concentrations are highest in buildings closest to intensely used traffic corridors. Nearly 90 percent of particles emitted as diesel exhaust are considered to be "ultrafine," less than 1 micrometer in diameter.

The limited testing required by LEED for PM_{10} may not adequately reflect the PM_{10} present in a building, once it is occupied. Furthermore, LEED neglects to test particles less than 10 micrometers in size, although these are considered more dangerous to health than larger particulates, particularly if people are exposed to them repeatedly.

Pesticides

The LEED certification for the existing building rating system does not require pesticide use reduction. Instead it offers 1 possible credit within the LEED "Sustainable Sites" category for developing an "Integrated Pest Management (IPM), Erosion Control and Landscape Management Plan"; and 1 additional possible credit in its "Green Cleaning-Integrated Pest Management" category. Thus, only 2 credits are possible in categories that have multiple additional objectives. It is possible to neglect pesticides totally and still receive the highest "platinum" level of certification.

It is possible to neglect pesticides totally and still receive the highest "platinum" level of certification.... There is no legal requirement to inform occupants about the chemicals that have been applied, their potential health effects, or their rate of dissipation.

Pesticides are deliberately toxic substances and more than 100 million pounds are released indoors in the United States each year. EPA has licensed nearly 107 separate pesticides for use in indoor settings. The agency has rarely requested experimental data on indoor chemical persistence, movement, or human exposures, before issuing permits to manufacturers. Rather than requiring these studies, EPA scientists inferred risks from data developed and submitted by manufacturers to support licenses for outdoor uses.

Pesticides are intentional additives to many consumer products, such as clothing, carpets, plastics, paints, stains, building materials, play equipment, furniture, some detergents, fuels, shampoos, pet products, cosmetics and pharmaceuticals—all of which end up within indoor environments.

Americans spend more than 90 percent of their time inside buildings. Pesticides released indoors can produce extended exposures, especially if indoor areas are poorly ventilated. There is no legal requirement to inform occupants about the chemicals that have been applied, their potential health effects, or their rate of dissipation, all of which are necessary to know in order to determine when it is safe to re-enter the structure following treatment.

Americans spend more than 90 percent of their time inside buildings.... Young children spend more time indoors within residential settings than adults, and this time is usually spent on or near floors, where dust, molds, pesticide residues and other contaminants settle.

Children are especially susceptible to pesticides applied indoors. Young children spend more time indoors within residential settings than adults, and this time is usually spent on or near floors, where dust, molds, pesticide residues and other contaminants settle.

Young children touch surfaces that may be treated with pesticides more frequently than adults do, and they tend to put their hands and objects in their mouths, crawl on floors and wear fewer clothes than adults, especially in warmer climates. More than half of the nearly 96,000 pesticide exposures reported to American Poison Control Centers in 2007 concerned children less than six years in age.

The allowed interval between spraying and building reentry has a significant effect on exposure levels. Farm worker exposure, for example, is normally managed by government required "reentry intervals," but most products registered for homeowner application are not. In fact, many products may legally be sprayed when rooms—including classrooms—are inhabited.

In the absence of evidence to the contrary, the EPA has long assumed that indoor residues dissipate and pose no significant health threat. Recent experiments, however, have shown that residues may persist for months and years following application. Residue levels are influenced by structural characteristics, such as the design and location of the heating and ventilation system (especially fresh-air exchange rates) and its quality of filtration, the location of windows and doors, and the tendency of homeowners to ventilate using open windows and doors. For some chemicals, residue levels in the air continue to rise for days following application—and are highest near the floor.

Several thousand pesticide products are available for outdoor lawn and garden uses, or to control termites near building foundations. These chemicals present a risk of well water contamination, and those who apply them face potential exposure while mixing, applying, cleaning up and storing the pesticides, as well as when reentering treated areas.

Each step carries additional risks if label warnings and directions are not followed perfectly or if other mistakes occur. In addition, children's exposure to pesticides applied outdoors may be much greater than those of adults: they love to roll, play and sit in the grass, and they enjoy touching and smelling colorful ornamental shrubs and flowers, which are sprayed more often than other plants.

A recent EPA survey found that 75 percent of U.S. households used at least one pesticide product indoors during the past year. Another study suggests that 80 percent of most people's exposure to pesticides occurs indoors and that measurable levels of up to a dozen pesticides have been found in the air inside homes.[12]

The Green Building Council's commitment to pesticide reduction in buildings is weak at best, relying on Integrated Pest Management (IPM), a pest management approach that means different things to different people. When the Government Accounting Office examined the status of IPM adoption in the United States, it discovered that the implementation rate "is a misleading indicator of the progress made toward an original purpose of IPM—reducing chemical pesticide use."

IPM includes a wide variety of pest management practices, without distinguishing between those that tend to reduce chemical pesticide use and those that may not. The Green Building Council's current reliance on IPM provides little assurance of health protection from pesticides used indoors.[13] There is little necessary government oversight to assure compliance with performance standards.

IPM originated with chemical manufacturers, formulators and applicators who hoped the standard would be accepted by EPA as an alternative to stricter federal regulations that might limit pesticide use and residues in air, water and food. Thus LEED's offer of 2 credits for employing IPM standards provides little assurance of pesticide exposure reduction.

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Articles often treated with the flame retardant polybrominated diphenyl ether (PBDE) include carpets, upholstery fabric, cushions, and plastics used as components in electrical appliances and equipment.

Flame Retardants

Brominated flame retardants (BFRs) are a large chemical group that includes tetrabromobisphenol A (TBBPA), polybrominated diphenyl ethers (PBDEs), polybrominated biphenyls (PBBs) and hexabromocyclododecane (HBCD or HBCDD). Data demonstrate that flame retardants are in most people's bodies, are ubiquitous in the environment, and that low-level exposures may cause liver toxicity, thyroid toxicity, neurodevelopmental toxicity and fertility problems.[14,15]

Articles often treated with the flame retardant PBDE include carpets, upholstery fabric, cushions, and plastics used as components in electrical appliances and equipment. Three commercial PBDE mixtures have been produced and used in the US and abroad: (1) commercial pentabromodiphenyl ether (c-pentaBDE), used in foam for furniture and mattresses; (2) commercial octabromodiphenyl ether (c-octaBDE) used in electric and electronic devices); and (3) commercial decabromodiphenyl ether (c-decaBDE), whose primary use is in high-impact polystyrene.

Manufacture and import of c-pentaBDE and c-octaBDE were phased out in 2004, but articles treated with c-pentaBDE and c-octaBDE may still be imported. In the United States, c-decaBDE is still manufactured and used as an additive flame retardant in textiles, electronic equipment, and building and construction materials. Its primary use is in high-impact polystyrene (HIPS) based products.[16]

Concerns about PBDEs led to the use of HBCD, used as a flame retardant primarily in polystyrene insulation foam, as well as in upholstery textiles, video or audio equipment housings and high-impact polystyrene. More than 85 percent of HBCD is used in polystyrene insulation, which is likely the primary source of global contamination.[17,18]

Like its predecessor, HBCD is not chemically bound to the material it protects, and the compound has been detected in both the environment and in people. Human health data suggest thyroid effects, which may present potential concerns for developmental neurotoxicity. Potential reproductive effects have only begun to be studied.[19]

Environmental monitoring programs have found traces of PBDEs and HBCD not only in wildlife, but also in human breast milk and body fluids. For both children and adults, dust is the primary source of exposure to flame retardants. Young children come into contact with higher levels of flame retardants because they are closer to the floor, where chemicals persist in carpets and furniture.[20, 21]

Despite concerns about the use of HBCD and other flame retardants in polystyrene insulation, such insulation can earn multiple points under the LEED rating system. Dow Chemical Co. claims in its advertising that its STYROFOAM™ brand extruded polystyrene insulation, spray polyurethane foam insulation and similar products can potentially contribute 25 to 51 points to "LEED for Homes" certification, particularly in the area of energy and atmosphere.[22]

The Green Building Council's *Green Home Guide* states, "Polystyrene foams contain brominated flame retardants that raise serious health and environmental concerns."[23]

Despite concerns about the use of hexabromo-cyclododecane (HBCD or HBCDD) and other flame retardants in polystyrene insulation, such insulation can earn multiple points under the LEED rating system.

Drinking Water

The LEED program for new construction neglects drinking water quality. LEED's water credits are predominantly allocated to encourage reduced use of water and the energy necessary to acquire, distribute and sanitize it. LEED assigns no credit for drinking water quality assurance, and establishes no minimum requirements or goals for testing or filtration. The Green Building Council relies on the federal Safe Drinking Water Act (SDWA) to provide sufficient health protection.

Many buildings deliver water to taps via plastic piping that can leach chemical components into water supplies. Subtle variations in water chemistry, such as a change in acidity or alkalinity, can affect the rate of chemical leaching, as can water temperature and the time that water remains stagnant within the piping before being used. Furthermore,

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many studies demonstrate that some water supplies contain residues of synthetic chemicals, including pesticides, fuels, pharmaceuticals and metals.

Other studies have shown that the piping that delivers water is often cracked, leading to both water loss and potential intake of contaminants. Older supply lines, water mains, solders used to join metal pipes, and even some brass faucets contain lead, a well recognized toxin that has often been found to leach into tap water.[24]

National responsibility for defining acceptable levels of drinking water contamination lies with EPA, which derives its authority from SDWA. When EPA sets a new contaminant limit for a maximum contaminant level (MCL) for drinking water, municipalities around the country must routinely demonstrate that their water is not contaminated beyond the MCL.

The statute requires that EPA set MCLs for a number of toxic substances. The legal strategy of "listing" contaminants has caused water suppliers and potential polluters to resist addition of new chemicals to the list, due to the costs of monitoring, filtration and liability. Congress was dissatisfied by EPA's slow progress in regulating contaminants, and in 1988 amended the statute, demanding that 83 chemicals be regulated within three years.

Water deemed "clean" as it leaves a water filtration plant—according to SDWA standards—may become contaminated after treatment, since chemicals are tested only when water leaves a treatment plant. Some chemicals, such as bromates, can be formed when water containing certain contaminants is combined with cleaning chemicals and exposed to sunlight.

Other chemicals may leach into water supplies. Tap water samples have been found to contain not just one contaminant, but dozens. More than half of the water systems in a recent study had at least seven contaminants in their water, yet the SDWA does not regulate mixtures of pollutants in drinking water.[25]

EPA has understood the extent of pesticide contamination of drinking water supplies for decades, but has neglected to regulate chemical use, or to warn consumers about effective filtration technologies.

Plastics

Other chemicals may leach into water after traveling through plastic pipes.... No law in the United States requires labeling of the chemical ingredients in plastics, and their use is not restricted in LEED-certified buildings.

No law in the United States requires labeling of chemical ingredients in plastics, and their use is not restricted in LEED-certified buildings. Plastics now comprise nearly 70 percent of the synthetic chemical industry in the U.S., where each year more than 100 billion pounds of resins are formed into building materials, window and door casings, furnishings, electrical wiring, piping, insulation, water and waste conduits, floor coverings, wood sealants, wallpaper, paints, packaging materials, appliances, countertops, lighting fixtures and electronics.

The chemical contents of plastics have always been a mystery to consumers. Ingredients are not labeled under federal law, and most manufacturers are unwilling or unable to disclose these contents or their sources. Some products are labeled to facilitate recycling but not to identify chemicals used in their manufacture.

There are many chemicals used to manufacture plastics, some of which are harmless and others toxic. Several well-researched compounds may harm human health and the environment, including bisphenol-A (BPA), polyvinyl chloride (PVC), phthalates, perfluorooctanoic acid (PFOA) or chemicals in the rubber infill in artificial turf. Use of these chemicals in building materials is not restricted by LEED, nor are credits awarded for avoiding these products.

Bisphenol-A (BPA)

Each year several billion pounds of BPA are produced in the U.S. The Centers for Disease Control and Prevention (CDC) found that over 90

BPA is found in building conduits that distribute water and air, and both are plausible routes of human exposure. The absence of federal regulation, together with the growing trend of governments to adopt LEED's standards, foretells a long future of exposure to chemicals such as BPA in the built environment.

percent of human urine samples tested have measurable BPA levels. BPA has also been detected in human serum, breast milk, maternal and fetal plasma, amniotic fluid and placental tissue at birth.

BPA, a primary component of hard and clear polycarbonate plastics and epoxy resins, is used in a wide range of building materials, including paints, sealants, adhesives and fillers (caulk, grout, mortar, and putty). The resins are used as lacquers to coat metal products and water supply pipes. Substantial migration of BPA from PVC hoses into room-temperature water has been documented, yet PVC pipe is approved for use in residential water supply lines in many cities.

In addition to exposure to BPA via PVC pipes in buildings, BPA has also been measured in dust and air. It is difficult to identify BPA in building materials since the epoxy resins used in these materials may be listed on a material safety data sheet as a proprietary mixture, with no disclosure that the resin is made from BPA.[26]

BPA is suspected of affecting normal human hormonal activity. Scientists' growing interest in hormone disruption coincided with a consensus within the National Academy of Sciences that children are often at greater risk of health effects than adults because of their rapidly growing but immature organ systems, hormone pathways and metabolic systems. In addition, young children breathe more air, consume more food, and drink more water per pound of body weight than adults, and thus have greater exposure to any chemicals present in their environments.

Since 1995, scientists have reported that BPA caused health effects in animals similar to numerous illnesses growing in prevalence in the United States. These conditions include breast and prostate cancer, declines in sperm counts, abnormal penile or urethra development in males, early sexual maturation in females, neurobehavioral problems, obesity and type 2 diabetes, and immune system disorders. Many of the studies link low-dose BPA exposure to health effects. BPA can bind with estrogen receptors in cell membranes following low doses measured in parts per trillion—that is, at exposures nearly 1,000 times lower than the EPA's recommended acceptable limit.[27]

In 2007, the U.S. National Institutes of Health issued a strong warning about the chemical's hazards: "There is chronic, low level exposure of virtually everyone in developed countries to BPA. The published scientific literature on human and animal exposure to low doses of BPA in relation to *in vitro* mechanistic studies reveals that human exposure to BPA is within the range that is predicted to be biologically active in over 95 percent of people sampled. The wide range of adverse effects of low doses of BPA in laboratory animals exposed both during development and in adulthood is a great cause for concern with regard to the potential for similar adverse effects in humans."[28]

Use of BPA is so widespread that it is difficult to identify the most important sources of exposure. BPA is found in building conduits that distribute water and air, and both are plausible routes of human exposure. The absence of federal regulation, together with the growing trend of governments to adopt LEED's standards foretells a long future of exposure to chemicals such as BPA in the built environment.

Several well-researched compounds may harm human health and the environment, including bisphenol-A, polyvinyl chloride, phthalates, perfluorooctanoic acid or chemicals in the rubber infill in artificial turf. Use of these chemicals in building materials is not restricted by LEED, nor are credits awarded for avoiding these products.

PVC and Phthalates

PVC plastics pose a problem at least as serious as BPA, but they are also neglected by LEED standards. Products that contain PVC can be used in LEED-certified buildings—and no credits are available for avoiding them.

More than 300 different types of plasticizers have been identified in PVC, with phthalates among the most common. Phthalates, added to soften and make PVC more pliable, are recognized as global pollutants and major constituents of indoor air. Di(2-ethylhexyl) phthalate (DEHP) constitutes roughly 50 percent of global consumption of phthalates, and about 95 percent of the current production of DEHP is used in PVC. Another phthalate, DnBP, is used in latex adhesives, and is also a plasticizer in PVC. BBzP is a plasticizer for vinyl tile, carpet tiles and artificial leather and is also used in certain adhesives.[29]

The building industry is responsible for 75 percent of the polyvinyl chloride (PVC) used in the United States.... PVC is the leading pipe material in the United States today, accounting for more than 70 percent of all the water and sewer pipe currently being installed.[31]

Many of the chemicals used to make PVC are toxic, while other chemicals are created during the production and manufacturing process. One of the most toxic chemicals created during the production and manufacturing process is dioxin, a persistent bioaccumulative toxicant targeted for elimination by the Stockholm Convention of Persistent Organic Pollutants.

Vinyl chloride is classified as a human carcinogen by numerous scientific and regulatory bodies. Non-cancerous adverse effects are documented on the nervous system, liver, lungs, blood, immune system, cardio-vascular system, skin, bones and reproductive organs. Occupational exposure to PVC is a risk factor for scleroderma, a widespread connective tissue disease, and testicular cancer. Additives to PVC, such as phthalates and BPA, may contribute to these health effects.[30]

The building industry is responsible for 75 percent of the PVC used in the United States. Pipes and fittings compose the largest portion (44 percent) of PVC used for building and construction. It is the most popular material for large diameter buried pipelines installed by both water and wastewater utilities, as well as for smaller-diameter drain waste and vent piping and indoor water plumbing. PVC is the leading pipe material in the United States today, accounting for more than 70 percent of all the water and sewer pipe currently being installed.[31]

Phthalates may affect development and reproduction, increase the risk of infertility, and lead to testicular damage, reduced sperm count and suppressed ovulation. Studies in children note associations between indicators of phthalate exposure in the home and risk of asthma and allergies. Some phthalates (BBzP and DEHP) found in indoor dust have been associated with allergies and asthma. Studies suggest a link between asthma and the concentration of phthalates in indoor dust associated with the use of plasticized products such as PVC flooring and wall material.[32]

Plastic wall materials in homes have been associated with lower respiratory tract symptoms and asthma in children, while use of plastic wall material in the workplace is associated with asthma in adults. A clinical diagnosis of bronchial obstruction has been shown to be more common among children living in homes with PVC flooring than in homes with wood flooring, and more common among children in homes with textile wallpaper than with painted walls. If the PVC flooring gets wet, it can lead to elevated indoor air concentrations of 2-ethyl-1-hexanol (2E1H), a volatile organic compound (VOC) that is a hydrolysis product of DEHP.[33]

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A growing list of companies has committed to a PVC phase-out, and the American Public Health Association has called for an industrial chlorine phase-out. Other nations have also taken action: Denmark has called for the minimization of PVC use in public buildings; Norway's second largest city, Bergen, made the decision in 1991 to phase out PVC; and in the United Kingdom, numerous local authorities have policies banning vinyl windows in public buildings.[34]

Some groups advocate for vinyl-free alternative purchasing policies in construction. Several U.S. municipalities—including Portland, Seattle, New York and San Francisco—are also developing policies to reduce the use of vinyl. These movements are not without challenges from the vinyl industry. When New York State began offering a green building tax-credit program designed to encourage sustainable building materials, and excluded vinyl flooring, the vinyl flooring industry filed a lawsuit contesting the State's refusal to recognize vinyl flooring as a green building material.[35]

In 2000, a LEED credit was proposed to award the avoidance of PVC in building products used in new construction to "Eliminate the use of virgin PVC and any chemical listed in the OSHA Toxic & Hazardous Substances."[36]

In response to criticism from industry groups, the Green Building Council appointed a committee to evaluate whether PVC-based materials are consistently among the worst of the alternative materials studied in terms of environmental and health impacts. The committee concluded that the credit should not be offered, noting that alternative

PVC plastics pose a problem at least as serious as BPA, but they are also neglected by LEED standards. Products that contain PVC can be used in LEED-certified buildings—and no credits are available for avoiding them.

building products carry other risks to the environment and human health, missing an opportunity to encourage demand for less toxic alternatives to PVC.[37]

The PVC controversy demonstrates the influence industry has over the LEED decision-making process and, ultimately, the definition of "green building." Does the Green Building Council have the expertise to judge comparative environmental and human health threats among chemicals employed in building materials? A review of the credentials of its board and staff suggests that the organization does not. Should the Green Building Council's standards then be adopted as law or be used by governments to guide tax policy?[38]

Perfluorooctanoic Acid (PFOA)

Perfluorooctanoic acid (PFOA) is a synthetic chemical that does not occur in nature. PFOA is most commonly known for its use in Teflon™ cookware, and is also used in the manufacture of fluoropolymers—high-performance plastic and synthetic rubber materials used in the manufacture of fabric and carpet treatment products, such as Scotchgard™, Stainmaster™ and other nonstick and stain-resistant products.

Upholstery, stone, rock and tile sealants, carpet treatments, floor waxes and water-repellent fabrics are likely to be the most significant sources of human exposure to PFOAs. The federal Agency for Toxic Substances and Disease Registry (ATSDR) notes that carpets treated with PFOAs are an important source of exposure for children, and that workers in facilities that make PFOA or similar molecules called fluorotelomers have increased levels of these chemicals in their blood.[39]

PFOA never breaks down in humans or in the environment, which explains its widespread presence in humans and wildlife. It has been detected in 95 percent of Americans tested and in breast milk and babies. PFOA has also been found in the blood of people in four continents, and in workers who make fluorotelomers.

As regulators continue to review the chemical, scientists continue to publish reports of disturbing health risks: PFOA has been associated with testicular, pancreatic, mammary and liver tumors in male and female mice, as well as developmental toxicity in rodent models. Studies in workers have shown changes in sex hormones and cholesterol associated with the levels of PFOA in blood, as well as increases in prostate and bladder cancer.

Perfluorooctanoic acid (PFOA) never breaks down in humans or in the environment.... Newborn babies exposed to low levels of PFOA in utero had lower birth weights.

The discovery that arctic animals double the amount of PFOA in their blood every four years demonstrates the persistence of this ubiquitous chemical. The discovery of PFOA in dogs—animals tested had PFOA levels 2.4 times higher than those found in humans—demonstrates the possibility that frequent contact with household wall-to-wall carpeting, furniture and other PFOA-treated items may also have implications for human exposures.[40]

Newborn babies exposed to low levels of PFOA *in utero* had lower birth weights. Pregnant women with high levels of PFOA report a higher incidence of preeclampsia and birth defects, while women with high PFOA levels may be twice as likely to be diagnosed with infertility. More than 10 percent of all women are estimated to exceed a 1 in 1000 excess lifetime cancer risk from their exposures to PFOA, and nearly 7 percent of all women exceed a safe dose for ovarian effects.

In a preliminary risk assessment of the developmental toxicity associated with exposure to PFOA, EPA estimated that health risks to young girls and women of childbearing age are higher than levels considered acceptable. No studies are available on health effects in babies exposed to PFOA-contaminated breast milk.[41]

Potential health effects associated with PFOAs have been researched for decades. DuPont scientists issued internal warnings in 1961 about the health risks of PFOA, which led to further studies demonstrating that PFOA accumulates in human blood, does not break down in the environment and may cause liver damage. Elevated levels of the chemical in DuPont workers were documented by 1980. DuPont's

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secrecy led to civil administrative actions by EPA against DuPont in 2004 and 2005, leading to a settlement with DuPont for the largest civil administrative penalty EPA has ever obtained under any federal environmental statute.[42]

Despite decades of research and global concern about health risks associated with PFOA, and its widespread presence in both humans and animals, no enforceable health standards exist. The only federal regulation governing PFOA exposure is a provisional drinking water advisory. Hundreds of PFOA-related chemicals that may degrade to PFOA are also not regulated in the United States.[43]

Although EPA has released several draft hazard assessments and risk assessments for PFOA in the last nine years, none of them have been finalized. The Agency for Toxic Substances and Disease Registry (ATSDR) publicly stated years ago that it was working on an evaluation of health risks—including risks associated with PFOA contamination of human breast milk, arising from PFOA-contaminated drinking water—but no report has been released.[44]

The EPA's PFOA Stewardship Program proscribes PFOAs from emissions and products by 2015. While DuPont announced its intent to end the production and use of PFOA by 2015, it has not declared an intent to end the production or use of fluorotelomers.

The company's reports to EPA on current production are kept secret as confidential business information, so current production is a mystery to curious consumers. Fluorotelomer-based carpet coating products are reported to be widely used in Dalton, Georgia, the carpet production "capital" of the United States. Carpets are dipped in vats of stain repellents containing chemicals that may contain or break down into PFOA.[45]

Buildings that use carpets that do not contain PFOAs receive no bonus points from LEED, and the Green Building Council has published no statements concerning the potential risks of PFOAs or recommendations regarding avoidance of the chemical. There is no certification program that guarantees that PFOAs are not used.

The Carpet and Rug Institute (CRI) has launched a Green Label program to test carpeting and certify that it meets stringent criteria for low chemical emissions. The Green Label Plus testing program, adopted by LEED, does not test carpet for PFOA. CRI claims that the carpet industry has ceased using the chemistry that produced the PFOA found in carpet treatments and notes that "… even when the industry did utilize the process that produced these very small traces of PFOA, based on all the information available, there was never any health or safety risk."[46]

Both DuPont and 3M have produced PFOAs—and are members of CRI. DuPont has claimed that exposures to PFOA do not present a human health risk. Three years ago DuPont committed to no longer make, use or buy PFOA by 2015, or earlier "if possible."[47]

Buildings that use carpets that do not contain PFOAs receive no bonus points from LEED, and the USGBC has not published statements concerning the potential risks of PFOAs or recommendations regarding avoidance of the chemical.

Artificial Turf

Artificial turf is manufactured from synthetic fibers made to resemble natural grass. The material is used in sports arenas, residential landscaping and commercial applications. Most synthetic turf systems include a drainage layer, a multi-layered backing system, and plastic or nylon grass blades that are infilled with a granular filler to resemble natural turf. This "infill" is often granulated recycled rubber tires.

Despite debate over whether plastic grass is safe or a health risk, artificial turf can earn multiple points toward LEED certification. Hazardous chemicals contained in the crumb rubber can volatilize, and be tracked into buildings and homes on clothes and gear.

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EHHI analyzed the ground-up rubber tire infill and found it to contain a number of toxic compounds, including *benzothiazole* (a skin and eye irritant and harmful if swallowed); *butylated hydroxyanisole* (a recognized carcinogen, suspected endocrine toxicant, gastrointestinal toxicant, immunotoxicant and neurotoxicant); *n-hexadecane* (a severe irritant based on human and animal studies); and *4-(t-octyl) phenol* (corrosive and destructive to mucous membranes). The full extent of the health effects associated with these chemicals is not known, and data are lacking on the health effects from human exposure to these chemicals.[48]

The Norwegian Institute of Public Health showed that volatile organic compounds (VOCs) from rubber infill can be aerosolized into respirable form during sports play, but little or no toxicological information is available for many of the VOCs that are found in artificial turf. Studies are lacking on the potential for the development of asthma and airway allergies in response to exposure to the latex in the tires used in synthetic turf.[49]

Recently, scientists found harmful chemicals in every sample of artificial turf tested, including polycyclic aromatic hydrocarbons (PAHs), chromium and lead. Arsenic and cadmium were detected in most samples. Levels of many PAHs exceeded health-based standards for soil, especially in newer artificial turf fields.

Exposure to PAHs can cause cancer, while studies have shown that metals can damage the brain, kidney, liver, skin and bladder. Even more important, tests showed that some of the contaminants were biologically available, which means that they can be absorbed by the body.[50]
Lead has been detected in some synthetic turf made of nylon or nylon-polyethylene blend fibers. Lead is added to the turf to keep the color vibrant. In 2008, the CDC noted that some turf contains levels of lead that "pose a potential public health concern" and warned, "As the turf ages and weathers, lead is released in dust that could then be ingested or inhaled, and the risk for harmful exposure increases."[51]

Lead can cause irreversible neurological damage, renal (kidney) disease, cardiovascular effects and reproductive toxicity. Blood lead levels once believed to be safe are now considered hazardous, with no known threshold.

In addition to concerns about exposures to chemicals in the crumb rubber, some synthetic turf contains antimicrobial agents used to minimize bacterial growth.[52]

Additional health and environmental concerns surrounding artificial turf include:

- **Worker Exposure:** Health data from workers in rubber fabrication and reclamation industries indicate the presence of VOCs, semi-volatile hydrocarbons and harmful particulates in the air. Occupational studies reveal health effects ranging from severe skin, eye and respiratory irritation to three kinds of cancer. Companies that manufacture and supply synthetic turf are responsible for assessing the risks to humans. The previous case study about PFOAs demonstrates that it may be decades before these data are revealed and reviewed.

- **Disposal:** Most synthetic turf needs to be replaced after about 10 years, yet the turf is not biodegradable. Most synthetic turf fields are composed of crumb rubber infill made from recycled tires. Used tires have been banned by landfills in all but eight states, partly because of concerns about the risk of tire fires, which release toxicants such as arsenic, cadmium, lead, nickel, PAHs and VOCs.[53]

- **Heat Island Effect:** Replacing natural turf with artificial turf contributes to the "urban heat island effect" by absorbing sunlight and emitting heat. Urban heat islands increase demand for energy (particularly air conditioning), intensify air

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The LEED rating system awards points for using synthetic turf, as many as 4 points for water efficiency alone. Points may also be available for materials selection and innovation in design.

pollution, and increase heat-related health problems. Summer temperatures in New York City are about seven degrees higher than in surrounding areas because of this effect. Researchers at Pennsylvania State University note that the difference between surface and air temperatures on artificial turf can be as much as 37 degrees.[54]

- **Habitat Loss:** Natural turf offers habitats for insects, plants, and animals and provides food for birds. Synthetic fields do not contain microorganisms that can break down pollutants, and do not absorb rainwater—it simply drains through the field and runs into storm sewers.

The LEED rating system awards points for using synthetic turf, as many as 4 points for water efficiency alone. Points may also be available for materials selection and innovation in design, as shown in Table 3 (opposite).

For example, the first LEED Platinum-certified aviation facility—Hangar 25 at the Bob Hope Airport in Burbank, California—was landscaped with 6,500 square feet of artificial grass. The synthetic turf was manufactured by SYNLawn.

California's Attorney General filed suit against SYNLawn and other turf companies, under California's Proposition 65, for excessive lead levels after testing showed high amounts in artificial turf products. An agreement was subsequently reached to limit the amount of lead in turf products sold in California.[55]

Table 3. ***LEED 2009 for New Construction: Credits Available for Artificial Turf***

Description	***LEED New Construction/Major Renovation***	***Point Value***
	Water Efficiency	
WE Credit 1.1:	Water Efficiency Landscaping – **50%** Reduction	**1 point**
WE Credit 1.2:	Water Efficiency Landscaping *No Potable Water Use or No Irrigation*	**1 point** **in addition to point from above**
Water Use Reduction:	**20%**	**1 point**
Water Use Reduction:	**30%**	**1 point** **in addition to point from above**
	Materials and Resources	
MR Credit 2.1:	Construction Waste Management *Divert* ***50%*** *From Disposal*	**1 point**
MR Credit 2.2:	Construction Waste Management *Divert* ***75%*** *From Disposal*	**1 point** **in addition to point from above**
MR Credit 3.1:	Materials Reuse – **5%**	**1 point**
MR Credit 3.2:	Materials Reuse – **10%**	**1 point**
MR Credit 4.1:	Recycled Content – **10%** *(post-consumer + ½ pre-consumer)*	**1 point**
MR Credit 4.2:	Recycled Content – **20%** *(post-consumer + ½ pre-consumer)*	**1 point**
MR Credit 5.1:	Regional Materials – **10%** Extracted, Processed & Manufactured	**1 point**
MR Credit 5.2:	Regional Materials – **20%** Extracted, Processed & Manufactured	**1 point**
	Innovation in Design	
Credit 1-1-4 of Innovation in Design:	Products of a recyclable nature + water saving benefits	**4 points**

Source: Based on LEED 2009 for New Construction and Major Renovations. Adapted from LEED and Credits for Artificial Turf Projects. *http://blog.artificialturfsupply.com/leed-certification-and-credits-for-artificial-turf-projects/*

IV. Government Adoption of LEED Standards

Green Building Council standards have been incorporated into federal, state and local law through legislation, executive orders, resolutions, policies, loan-granting criteria and tax credits. LEED is now the most widely accepted national standard for defining "green" development and architecture.

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LEED performance requirements have been adopted as laws or regulations at various governmental levels in 44 states, including 198 localities (132 cities, 33 counties and 33 towns), 33 state governments, 12 federal agencies or departments, 16 public school districts and 39 institutions of higher education.[1]

Local and Municipal Adoptions

Hundreds of cities and towns have adopted incentives to encourage "green" building, some of them specifically tied to the LEED system. The city council of Alexandria, Virginia, adopted a Green Building policy that requires all new development needing a development site plan or special use permit to achieve a LEED Silver or equivalent rating for non-residential development, and a LEED-certified or equivalent rating for residential development.[2]

All new municipal buildings must either follow LEED guidelines or be certified under the LEED Rating System in Anchorage, Alaska; Providence, Rhode Island; and Cambridge, Massachusetts. Smaller towns, such as Greenwich, Connecticut, require all new and renovated town buildings to achieve LEED Silver certification.

Other cities require buildings of a certain size or cost to meet LEED certification standards. Atlanta, Georgia, and Berkeley, California, require buildings over 5,000 square feet to achieve minimum LEED certification; Washington, DC, and Boston codes require buildings over 50,000 square feet to be LEED-certified; and New York city requires all municipal construction costing more than $2 million to earn a minimum LEED Silver certification.[2]

Many colleges and universities, as well as schools ranging from kindergarten to twelfth grade, have instituted policies or set goals to meet LEED standards. Most of the efforts target LEED Silver certification, or 50–59 out of 100 points. New York City requires schools and hospitals to earn LEED certification.

Hundreds of cities and towns have adopted incentives to encourage "green" building, some of them specifically tied to the LEED system.

State Adoptions

Some states require their state buildings to achieve LEED Silver certification. Other states have adopted more general standards, with performance guidelines relating to the efficient use of water and energy. Some states, such as California, are transitioning from voluntary standards to mandatory standards. States like Hawaii require state agencies to design and construct buildings over 5,000 sq. ft. to meet LEED Silver certification and the same for public schools.[3]

Other states issue tax credits for achieving LEED certification, as shown in Table 4 (next page). For example, New Mexico's tax credits for commercial buildings range from $3.50 per square foot—for buildings that achieve LEED New Construction Silver certification—to $6.25 for buildings that achieve LEED New Construction Platinum certification. New York provides an income-tax incentive for commercial development that incorporates specific green strategies informed by LEED. In addition, Oregon offers a LEED Business Energy Tax Credit (BETC) for New Construction, Core and Shell, or commercial interiors projects that achieve a minimum Silver certification.[4]

Table 4. *State Efforts to "Green" Buildings* *(See Notes, page 70)*

State	State Buildings	Public Schools	Private/ Commercial Buildings	Mandate	Action	Minimum LEED Certification
Arizona	x			Executive Order #2005-05	Requirement	Silver
Arkansas	x				Encouragement; Office of Sustainability created	LEED or other
California	x			Executive Order #S-20-04	Requirement	Silver
Colorado [1]	x			Senate Bill 51 (signed)	Requirement	LEED or other
Connecticut [2]	x	x	x	House Bill 7432 (signed)	Requirement	Silver or equivalent
Florida [3]	x	x		HB 7135 (signed); Executive Order #07-126 (LEED NC)	Requirement	LEED or other Strive for Platinum
Hawaii [4]	x	x		HB #2175, amended with HRS 46 19.6	Requirement	Silver or equivalent
Illinois [5]	x	x	x	HB 1013; Public Act #95-0416 (schools); Public Act 95-0325 (neighborhoods)	Requirement; grants; financial incentives	Silver or equivalent
Indiana	x	x	x	Executive Order 08-14	Requirement	Silver
Kentucky [6]	x			HB2 (signed)	Requirement	Varies with cost of project
Maryland [7]	x	x		High Performance Building Act	Requirement; financial incentive	Silver
Massachusetts [8]	x			Executive Order 484	Requirement	LEED certification
Michigan [9]	x			Executive Order #2005-4	Requirement	LEED guidelines
Nevada [10]	x		x	SB 395; AB621, signed; AB3, signed	Requirement; tax-exemption plan	Silver
New Jersey [11]	x	x		Senate Bill 843, signed; Executive Order #24, signed	Requirement	Silver or equivalent

State	State Buildings	Public Schools	Private/ Commercial Buildings	Mandate	Action	Minimum LEED Certification
New Mexico[12]	x		x	Executive Order #06-001; Sustainable Building Tax Credit; SB543, signed	Requirement; tax credits based on size	Silver/ Platinum
New York[13]	x		x	State Green Building Construction Act A10684; The New York State Green Building Tax Credit	Requirement; Incentives to homeowners; commercial tax credit	LEED and other; Silver; LEED rating with points in Energy and Atmosphere Credit
North Carolina[14]	x			Senate Bill 581, enacted	Financial incentives for cities and counties	LEED or other
Ohio		x		Resolution #07-124	Requirement	Silver required/ gold encouraged
Oklahoma[15]	x			HB 3394, signed	Requirement	LEED or Green Globes
Oregon[16]			x	Business Energy Tax Credit	Tax credit	Silver
Pennsylvania[17]		x		Act 46 of 2005	Financial incentives	Silver
Rhode Island	x			Executive Order #05-14	Requirement	Silver
South Carolina[18]	x			H3034	Requirement	Silver; credits earned in Energy and Atmosphere Credit 1
South Dakota[19]	x			SB 188, signed	Requirement	LEED Silver, two Green Globes or a comparable standard
Tennessee			x	SB 1919	Financial incentives	LEED or other
Virginia[20]	x		x	Executive Order 82, signed; HB 239	Requirement; tax incentives; other incentives	LEED or other; EPA's Energy Star rating
Washington[21]	x	x		Chapter 39.35D of the Revised Code of Washington	Requirement	Silver
Wisconsin	x			Executive Order 145	Guideline development; Government support	LEED for new construction

V. False Sense of Security

The public has no ability or right to participate in the standard-setting process of trade organizations. Secrecy about ingredients prevents anyone from understanding the chemical composition of the building materials employed.

The U.S. Green Building Council (USGBC) is a membership-based, non-profit organization with a board of directors composed of executives and technical experts in corporations that specialize in the property development industry. Engineers, architects, building product manufacturers, real estate and construction companies make up the majority of the Green Building Council's board of directors.

The Council does not set its own standards to manage chemicals, but instead relies upon many other trade organizations, including the American National Standards Institute (ANSI), the American Society for Testing Materials (ASTM), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA). These are all organized as trade associations of companies within the building sector of the economy. The public has no ability or right to participate in the standard-setting process of trade organizations. Secrecy about ingredients prevents anyone from understanding the chemical composition of the building materials employed.

The primary purpose of trade organizations is to certify product performance and set production standards rather than to assess chemical toxicity or potential health effects. The building industry is succeeding in having its product-performance and quality-control standards adopted as green laws and regulations, yet the standards have little relevance to environmental quality or human health. The manufacturers and developers benefit economically from the "green" label while withholding information about ingredients that is crucial to any determination about the safety of indoor environments. The Green Building Council's declaration that a building is "green" provides an unwarranted assurance of environmental health protection for those who manufacture, construct and occupy

LEED-certified buildings. The passage of laws that simply adopt LEED's standards by reference has become so commonplace that the passage of truly health-protective building laws will soon be extremely difficult. As described in the previous section on indoor chemical hazards, LEED's requirement for compliance with federal, state and local environmental laws similarly offers insufficient protection, given the limitations of the Clean Air Act, Safe Drinking Water Act, federal pesticide law and the Toxic Substances Control Act.

Hazardous Chemicals in Human Tissues and Indoor Environments

The passage of laws that simply adopt LEED's standards by reference has become so commonplace that the passage of truly health-protective building laws will soon be extremely difficult.

Tens of thousands of chemicals are traded in international commerce, most of them unregulated. Many chemicals enter indoor environments as ingredients in building materials, furnishings, insulation, electrical conduits, plastic piping, sealants, floor covering, plastic mats, solvents, adhesives, paints, preservatives, pesticides and consumer products.

Many hazardous chemicals have been detected in human tissues, providing proof of environmental exposures. The National Health and Nutrition Examination Survey (NHANES) analysis of hazardous chemicals in human tissues is conducted periodically by the Centers for Disease Control and Prevention (CDC). This effort, begun in 1999, documents widespread exposure to commonly used industrial chemicals.

The CDC's findings reflect the increasing chemical complexity of indoor environments and the fact that Americans, on average, spend most of their time indoors. The CDC's 2009 assessment of human exposure to chemicals measured more than 200 chemicals in 2,500 participants. Chemicals used in building materials—and also detected in human tissues—include BPA, metals, VOCs, PBDEs, PFOAs, pesticides, phthalates and dioxins, all recognized as toxic substances.[1]

Carcinogenic and endocrine-disrupting pesticides were detected in more than 50 percent of those tested.[2] The CDC's findings demonstrate

The CDC findings demonstrate widespread and chronic exposure to pesticides, fire retardants, plastics, metals and many other chemicals routinely found in building products.... Many of these chemicals are recognized by the government to be carcinogens, neurotoxins, reproductive toxins and substances that can alter normal growth and development of fetuses, infants and children.

widespread and chronic exposure to pesticides, fire retardants, plastics, metals and many other chemicals routinely found in building products. Fire retardant chemicals (PBDEs) are known to accumulate in human fat tissue. One type, BDE-47, was found in the serum of nearly all people sampled. Bisphenol-A (BPA) was found in more than 90 percent of urine samples in a representative U.S. population. PFOA, a component of the manufacture of some fabric and carpet treatments, was also detected in most study participants. Each of these chemicals may be present in a LEED-certified building, even one awarded a "Platinum" status.

Although the CDC study is the most comprehensive yet available, researchers have tested only a fraction of the chemicals used in thousands of building products. Still, the CDC studies are important because of the large number of people who participated, the diversity of chemicals studied and detected, and a sampling design large enough to identify exposure differences by age, ethnicity and U.S. region.

In another study, scientists at New York's Mt. Sinai Hospital detected an average of 91 chemicals—of a total of 167 industrial compounds, pollutants and other chemicals—in the blood and urine of a small group of volunteers. Many of these chemicals are recognized as carcinogens, neurotoxins, reproductive toxins and substances that can alter normal growth and development of fetuses, infants and children. None of these studies considered damaging additive or synergistic effects that might occur after exposure to chemical mixtures.[3]

The absence of any federal requirement to disclose ingredients in building products makes it impossible to understand the chemical composition of the built environment. Similarly, the failure of the federal government to require toxicity and environmental fate testing of chemicals in building products makes it impossible to certify "indoor environmental quality." For these reasons, the USGBC should encourage the federal government to require the identification of hazardous, persistent and non-recyclable chemicals within building materials, furnishings and cleaning products. It should also encourage Congress to demand chemical toxicity and environmental fate testing.

VI. Summary of Findings

LEED Standards Are Being Adopted into Many Laws

Green Building Council standards are being incorporated into federal, state and local laws through legislation, executive orders, resolutions, policies, loan-granting criteria and tax credits. As demonstrated in this report, LEED standards are clearly insufficient to protect human health, yet they are being adopted by many levels of government as law. Thus the Green Building Council, a trade association for the building industry, is effectively structuring the regulations. The number of jurisdictions adopting these standards as law is growing, which will make them difficult if not impossible to change, unless federal law and regulation supersede the "green" standards with health-protective regulations.

No Federal Definition or Regulation of Green Building Standards

There is no federal definition of "green building standards" analogous to federal "organic food standards" or drinking water standards. Given regulatory neglect, many trade organizations have worked to create their own certification programs, hoping to capture growing demand for environmentally friendly and heath-protective buildings.

Energy Efficiency Given Priority Over Health

The LEED credit system is heavily weighted to encourage energy-efficient building performance. Nearly four times as many credits are awarded as energy conservation technologies and designs (35 possible credits) as for protection of indoor environmental quality from hazardous chemicals (8 possible credits).

Green Building Council Board Has Little Expertise in Environmental Health

Directors of the LEED Program are predominantly engineers, architects, developers, real estate executives, chemical industry officials and building product manufacturers. One medical doctor representing Physicians for

Social Responsibility was recently appointed to sit on the board, which has 25 directors.

False Impression of Healthy Buildings

The Green Building Council's award of "platinum," "gold", and "silver" status conveys the false impression of a healthy and safe building environment, even when well-recognized hazardous chemicals exist in building products.

Time Spent Indoors

Americans today are spending more than 90 percent of their time indoors. The EPA spends the majority of its resources working to manage outdoor threats to environmental quality and human health.

Tighter Buildings Increase Human Exposure

Energy conservation efforts have made buildings tighter, often reducing air exchange between the indoors and outdoors. Since outdoor air is often cleaner than indoor air, the reduction of outdoor-indoor exchange tends to concentrate particles, gases and other chemicals that can lead to more intense human exposures than would be experienced in better-ventilated environments.

However, the LEED program has been effective in encouraging more efficient heating and ventilation techniques, such as solar panels, geothermal wells, window placement and building orientation.

Toxic Chemicals in Built Environments

Tens of thousands of different building materials and products are now sold in global markets. Many of these products contain chemicals recognized by the U.S. National Toxicology Program, the CDC, or the World Health Organization to be hazardous.

These products include pesticides, chemical components of plastics, flame retardants, metals, solvents, adhesives and stain-resistant applications.

Some are carcinogens, neurotoxins, hormone mimics, reproductive toxins, developmental toxins, or chemicals that either stimulate or suppress the immune system.

Chemicals in Buildings Are Often Found in Human Tissues

The CDC began testing human tissues to determine the presence of some chemical ingredients of building materials. Most individuals whose tissues were tested carried dozens of these chemicals in their hair, blood or urine. Children often carry higher concentrations than adults. Chemicals released by building materials to indoor environments may be inhaled, ingested or absorbed through the skin.

No Level of LEED Certification Assures Health Protection

It is possible for new construction to be certified at the "platinum" level with no credits awarded for air quality assurance in the category "indoor environmental quality."

LEED Neglects Drinking Water Quality

The only drinking water quality assurance that LEED requires is compliance with federal Safe Drinking Water Act (SDWA) standards. Yet these standards are widely recognized to allow human exposure to hazardous chemicals above "maximum contamination limits" set to protect human health.

In addition, the SDWA standards do not apply to wells that provide water to fewer than 15 households, as these require no water testing, leaving nearly 40 million people with no legal protection. Similarly, pesticides may be used within buildings and on grounds, with no regard for groundwater contamination.

LEED Neglects Workers' Occupational Risks

LEED neglects to address the occupational chemical risks faced by workers who manufacture building products, cleaning products and furnishings.

The Central Problem: Federal Failure to Test and Regulate

Hazardous chemicals have become components of LEED-certified indoor environments primarily due to the failures of the Toxic Substances Control Act (TSCA) and EPA's neglect of the problem. Congress has provided EPA with limited authority to require testing of likely hazardous chemicals in building products.

Among nearly 80,000 chemicals in commerce, EPA has required toxicity testing of only 200 in nearly 25 years since TSCA was passed. These test results led EPA to ban or phase out only five chemicals. The overwhelming majority of chemicals in the built environment remain untested individually or as chemical mixtures that are routinely released to indoor environments.

Thus new products may incorporate tens of thousands of untested chemicals with no government oversight. This absence of regulation contrasts sharply with more stringent federal statutes that govern pesticides, industrial emissions to outdoor environments, pharmaceuticals and food. Since TSCA places the burden of proof of hazard on EPA before it may regulate, nearly all chemicals in building materials have escaped federal testing and regulation.

LEED Credit System—Something For All, Guarantees for None

LEED provides credits in many categories unrelated to human health. In establishing such a diverse set of criteria—energy, materials and resources, site reuse, and so forth—each category accounts for a relatively small percentage of the total credit award. The design of the existing credit system provides opportunities for awards in many different categories.

The outcome is that low performance, or omissions in one or more categories, can result in even the most prestigious certification level.

Recommendations

Recommendations for LEED Reform

Simplify the Scoring System

The Green Building Council (GBC) should simplify the LEED scoring system within categories. Rather than issuing awards of "platinum," "gold" and so on, the GBC should require performance within each category (health, energy, sites, neighborhoods, etc.) on a 0–100 scale. These scoring changes would provide a more accurate reflection of project performance, while encouraging developers to improve within all categories—and scoring standards would be more easily understood.

Diversify Certification Categories

Offer separate certification in the fields of health, energy, sites and neighborhoods. All of these categories are now grouped together, and some are more heavily weighted than others in the overall scoring system. If the GBC judged and scored a project's performance in separate categories, developers would have an incentive to score high in all categories. This requirement would also correct the current and common misimpression that certified LEED buildings perform well in all categories.

Green Building Council Board Expertise

The GBC Board should have significantly greater professional expertise in health and environmental science. For example, only one director among 25 has formal medical, epidemiological and toxicological training. This imbalance on the board reflects LEED's present priorities of energy conservation, site planning, comfort and innovative design—with health components trailing way behind. The limited importance that the GBC has placed on environmental health is also reflected in the scoring system, in which less than 7 percent of the total score may be earned in this category.

Encourage Use of Building Products Made From Safe Chemicals

LEED credits should be offered for the use of products made from chemicals known to be safe, while credits should be deducted for use of products containing known hazardous substances.

Create and Update Minimum Health Protective Requirements

Create and routinely update minimum health protective requirements, now within LEED's "indoor environmental quality" category. The following are suggested:

- Prohibit the use of chemicals that are persistent and those that bioaccumulate.
- Prohibit the use of tobacco products within and near all LEED-certified buildings.
- Prohibit indoor use of the more toxic "restricted-use" pesticides, unless a public health authority finds that a more significant health threat would be created by using a less toxic but less effective compound.

Performance Data Transparency

Maintain a database that tracks project performance in all categories through the period of certification. These data should be freely available on the internet.

Environmental Testing

Indoor air quality testing of $PM_{2.5}$, PM_1, ozone and VOCs should occur at specified intervals following occupancy. Special attention should be paid to areas with non-operable windows. No such testing is now required post-occupancy. Require drinking water quality testing for metals, pesticides, plastic resins and chlorination by-products at specified intervals. No LEED testing of drinking water is now required. The results of all testing should be available on the internet at no additional cost.

Pesticides

Indoor applications of registered pesticides should occur only if physical and biological control has been attempted and found to be ineffective, and if a public health authority has determined that the health risks from the pesticides would be less than the target pests. The GBC should also require that occupants receive prior notification of the pesticide used, its chemical content and toxicity, as well as timing and methods of chemical application.

GBC Should Encourage Federal Testing of Chemicals in Building Products

The absence of any federal requirement to disclose ingredients in building products makes it impossible to understand the chemical composition of the built environment. Similarly, the failure of the federal government to require toxicity and environmental fate testing of chemicals in building products makes it impossible to certify "indoor environmental quality."
For more information about chemical hazards, see Appendix III, page 60.

For these reasons, the GBC should encourage the federal government to require the identification of hazardous, persistent and non-recyclable chemicals within building materials, furnishings and cleaning products. It should also encourage Congress to demand chemical toxicity and environmental fate testing.

Agencies that maintain peer-reviewed lists of known hazardous products include the EPA, the National Center for Environmental Health, the National Toxicology Program and the Agency for Toxic Substances and Disease Registry (ATSDR). EPA also maintains a list of insufficiently tested chemicals. Without federal testing, LEED has no authority or ability to deduct points for the use of unlabelled building products or those that have been insufficiently tested, making a determination of hazard or safety impossible.

Recommendations for the Federal Government

The effectiveness of the Green Building Council's (GBC) LEED program and the legitimacy of LEED certification critically depend upon the ability of developers to be able to identify hazardous chemicals in the built environment, and to prevent dangerous exposures. New federal law will be necessary to accomplish this. The failures of the Toxic Substances Control Act (TSCA), described previously in this report, must be corrected. We suggest the following key provisions for a national healthy building policy.

National Building Product Chemical Registry

The Green Building Council could not possibly be expected to keep track of the chemical content of all available building materials. The federal government should assume this responsibility and maintain a national registry of the composition of building products, furnishings and cleaning products.

The registry should also be used to record and update chemical testing status and product recyclability. The federal government should also create and maintain a single database that identifies chemical toxicity, level of hazard, common sources of exposure, and an assessment of the adequacy of data used to support these classifications. The best model for keeping these records is the Agency for Toxic Substances and Disease Registry's "Toxicological Profiles."

Chemical Testing

All chemicals used to form building products should be tested to understand: a) the hazards they pose to human health; and b) their environmental fate. New chemicals should be tested to be sure they meet safety standards before entering commerce. Existing chemicals should also be tested, while nearly 60,000 are currently exempted from testing under TSCA provisions.

Given the enormity of the chemical testing problem, EPA should focus on those chemicals that meet most of the following: a) basic toxicity testing; b) persistence and bioaccumulation; c) demonstrated and common presence in indoor air, water supplies, building products and human tissues; d) volume of chemical produced annually; e) plausibility of relation to human illness; and f) structural similarity to substances known to induce illness in humans.

Burden of Proof

The burden of proof and expense of chemical safety should rest with the chemical manufacturer, and should be evaluated by federal experts within the EPA, CDC and other agencies with relevant expertise. Today, the burden instead rests on EPA to demonstrate significant danger before the agency may demand testing or regulate chemicals in commerce. The testing should be conducted by scientists who are independent from the manufacturers, and responsible to EPA. The Green Building Council does not have, and should not be expected to have, the expertise necessary to evaluate chemical safety.

Safety Standards

Some chemicals are inherently dangerous, yet they are bound in such a way as to prevent human exposure. Even if a hazardous chemical is not released into the indoor environment and human exposure is unlikely, the source products should not be allowed if the ultimate fate of the chemical, once discarded, will be harmful to the environment.

A clear environmental safety standard should be adopted to prevent further development and sale of persistent and bioaccumulating compounds. Currently, the Green Building Council is certifying products with little understanding of the chemical content, persistence, human exposure, the potential to harm human health or ultimate environmental fate.

Chemical Classification System

The government should categorize building products to identify: a) those that contain hazardous compounds; b) those that have been tested and found to be safe; and c) those that have been insufficiently tested, making a determination of hazard or safety impossible. This database should be freely available on the internet.

Product Content Disclosure

The chemical contents of building materials and their country of origin should be identifiable on labels.

Appendix I.

LEED Categories and Point Values

CATEGORY	**Maximum Points**
Energy and Atmosphere	**(35 points)**
Sustainable Sites	**(26 points)**
Indoor Environmental Quality	**(15 points)**
Materials and Resources	**(14 points)**
Water Efficiency	**(10 points)**
Innovation in Design	**(6 points)**
Regional "Bonus" Credits	**(4 points)**

Energy and Atmosphere **(35 points)**

These credits are earned through energy use monitoring, efficient design and construction, efficient appliances and systems, and use of renewable and clean sources of energy, among other innovative strategies.

Sustainable Sites **(26 points)**

Developing undeveloped land is discouraged. As a result, credits are allocated to characteristics that minimize a building's impact on ecosystems and waterways, encourage regionally appropriate landscaping, utilize smart transportation choices, controls stormwater runoff; and reduces erosion, light pollution, heat island effect and construction-related pollution.

Indoor Environmental Quality **(15 points)**

The "IEQ" category promotes strategies that indoor air as well as increasing natural daylight and views and improving acoustics.

Materials and Resources **(14 points)**

These credits promote waste source reduction, reuse, and recycling. They also acknowledge sustainably grown, produced, and transported materials.

Water Efficiency **(10 points)**

Water Efficiency promotes the use of efficient appliances, fixtures and fittings indoors, and rewards water-wise landscaping outside.

Innovation in Design **(6 points)**

This category awards bonus points for projects using new and innovative technologies and strategies that improve a building's performance beyond LEED credits. This category also provides points for including a LEED Accredited Professional on the project team, who guarantees a holistic approach to the design and construction phase.

Regional "Bonus" Credits **(4 points)**

USGBC has identified specific credits that can be earned depending on the building's region of the country. 4 out of 6 LEED credits can be earned in each zip code. For example, credits in the southwest are more concerned with water efficiency, while credits in the northeast may be concerned with sustainable sites or insulation.

Source: USGBC. LEED 2009 for New Construction and Major Renovations Rating System

- **Certified** ***40–49 credits***
- **Silver** ***50–59 credits***
- **Gold** ***60–79 credits***
- **Platinum** ***80–110 credits***
- **Total Points Possible** ***110 credis***

Appendix II.

U. S. Green Building Council Board of Directors

Seat/Title	Name	Affiliation	Location
Executive Committee			
Chair	Tim Cole	Forbo Flooring Systems	Hazleton, PA
Chair-elect	Mark MacCracken	CALMAC Manufacturing Corporation	Fair Lawn, NJ
Immediate Past Chair	Gail Vittori	Center for Maximum Potential Building Systems	Austin, TX
*President, CEO & Founding Chairman***	S. Richard Fedrizzi	U.S. Green Building Council	Washington, DC
Treasurer	Anthony Bernheim	AECOM Design	San Francisco, CA
Secretary	Vivian Loftness	Carnegie Mellon University	Pittsburgh, PA
Directors			
	Maria Atkinson***	Lend Lease Corporation	Sydney, NSW, AU
	Carlton Brown ***	Full Spectrum Development	New York, NY
	Walter Cuculic ***	Pulte Homes	Las Vegas, NV
	Mick Dalrymple	Desert Moon Productions	Phoenix, AZ
	John Dalzell ***	Boston Redevelopment Authority	Boston, MA
	Nathan Gauthier	Harvard University	Cambridge, MA
	Bob Harris	Lake/Flato Architects	San Antonio, TX
	Elizabeth J. Heider	Skanska USA Building, Inc.	Alexandria, VA
	Mike Hess	X-nth	Maitland, FL
	Ann Archino Howe	Sustainable Design Studio	Portland, ME
	Punit Jain	Cannon Design	St. Louis, MO
	Dennis Maloskey	PA Governor's Green Government Council	Harrisburg, PA
	Michael McCally***		Santa Fe, NM
	Mark Robertson	MESA Landscape Architects	Little Rock, AR
	Tom Scarola	Tishman Speyer	New York, NY
	Lisa Shpritz	Bank of America	Charlotte, NC
	Alan Skodowski	Transwestern	Milwaukee, WI
	Charlie Tomlinson	WRT Architects	Philadelphia, PA
	Ted van der Linden	DPR Construction	San Francisco, CA
	Elizabeth Whalen	CalAg	Portland, OR
Founders			
Founder	David A. Gottfried	Worldbuild	Oakland, CA
Founder	Mike Italiano	Sustainable Products Corporation	Washington, DC
*President, CEO & Founding Chairman***	S. Richard Fedrizzi	U.S. Green Building Council	Washington, DC

** Denotes a non-voting member of the Board*
*** Denotes a non-voting member of the Board and a voting member of the Executive Committee*
**** Denotes a member of the Board representing a special perspective and filling an appointed seat*
See: http://www.usgbc.org/About

Appendix III. *Chemicals Often Found in Buildings and Their Health Effects — Not Necessarily in LEED Buildings*

Chemical	Potential Indoor Building Sources	Potential Health Risks
Asbestos	Deteriorating, damaged or disturbed insulation, fireproofing, acoustical materials and floor tiles.	Long-term risk of chest and abdominal cancers and lung diseases.[1]
Arsenic	Pesticides, wood preservatives, paint; natural water; smoke from burning arsenic-treated wood; chromated copper arsenate (CCA) — a chemical wood preservative — in decks or playground sets.	Long-term exposure to high levels of inorganic arsenic in drinking water has been associated with skin disorders and risks for diabetes, high blood pressure, and several types of cancer.
BPA[3,4]	Residential water supply lines, hoses and many other plastics. BPA is found in building conduits that distribute water and air.	Hormone-like effects on the developing reproductive system and neurobehavioral changes in the offspring.
Bromated flame retardants[5]	Furniture foam; consumer electronics; wire insulation; back coatings for draperies and upholstery; and plastics for television cabinets and small appliances.	Animal studies show effects on the thyroid and liver in doses much higher than people would encounter; EPA has classified certain PBDEs as a possible carcinogen.
Formaldehyde	Pressed wood products, wood products. Urea-formaldehyde foam insulation (UFFI). Durable press drapes, other textiles, and glues. Average concentrations in older homes without UFFI are generally below 0.1 ppm; in homes with significant amounts of new pressed wood products, levels can be greater than 0.3 ppm.[6]	Respiratory irritation; Fatigue; skin rash; severe allergic reactions; cancer.

Source: The table was developed using EPA's indoor air quality website and CDC websites, NHANES 1999–2000, 2001–2002 and 2003–2004. Available: http://www.cdc.gov/exposurereport (See Notes, page 72).

NHANES Findings	***Population Subgroups At Risk***
N/A	N/A
Seven forms of arsenic were examined by the study; DMA (metabolite of ingested inorganic arsenic) and arsenobetaine (ingested organic form of arsenic found in seafood) were the major contributors.	Urinary arsenic levels greatest in **Mexican-American males;** among non-Hispanic participants, **females** had higher levels of total urinary arsenic than males; for both total urinary arsenic and total DMA levels, the 12- to 19-year-old age group had lower levels than either the 6- to 11-year-old age group or the 20 years and older age group.
BPA is found in the urine of nearly 93% of the people tested (age 6 years and older).	**Females** had significantly higher levels of BPA in their urine than males; **children** had the highest levels, followed by teens and adults; **non-Hispanic blacks and non-Hispanic whites** had higher levels of BPA than Mexican Americans; people with the **lowest household incomes** had higher levels than people in the highest income bracket.
Among the polybrominated diphenyl ethers (PBDEs), BDE-47 was detected in almost all of the people in the study, and at higher levels than the other PBDEs measured; BDE-28, BDE-99, BDE-100 and BDE-153 were detected in more than 60% of the population.	BDE-28, BDE-99, BDE-100, BDE-153 and BDE-47 **decreased with increasing age.** Levels of BB-153 (the discontinued polybrominated biphenyl, PBB) increased with age, either due to the longer time that BB-153 stays in the body or to past exposures that were greater among older people; Mexican Americans and those born in other countries had lower levels of BB-153.
N/A	EPA is investigating the potential health risks of formaldehyde emissions from pressed wood products.[7]

Chemicals Often Found in Buildings and Their Health Effects — Not Necessarily in LEED Buildings (cont'd)

Chemical	Potential Indoor Building Sources	Potential Health Risks
Lead[8]	Paints, enamels, surface coatings on furniture.	Adverse health effects of lead on the nervous system are well-documented, and there is no "safe" level of exposure.
Mercury	Fluorescent lamps, high intensity discharge lamps, mercury-containing switches, mercury-containing thermostats, silent wall switches, commercial/industrial HVAC equipment, freezers, sensors, switches, meters, manometers/barometers, pipes, thermometers, rubber floors, sump pumps and septic tanks.	Tremors, emotional changes; insomnia; neuromuscular effects, sensory disturbances, headaches; devices can break and release mercury vapor to the air, particularly in warm or poorly ventilated indoor spaces.[9]
Pesticides	75% of U.S. households used at least one pesticide product indoors during the past year.[10]	Headaches, dizziness, muscle twitching, weakness, tingling sensations, and nausea; may cause long-term damage to the liver and the central nervous system, and increased risk of cancer.
Phthalates	Phthalates are added to soften and make PVC more pliable; also used in latex adhesives, vinyl tiles, carpet tiles, fragrances and air fresheners; widespread in indoor air.	Developmental and reproductive effects; infertility; sperm damage; childhood studies link phthalate exposure to risk of asthma and allergies.[11] Prenatal exposure and reduced anogenital distance in boys.[12]
Polyfluoroalkyl chemicals (PFCs)[13]	Produced since the 1950s to make products that resist oil, stains, heat, water and grease, including stain-resistant carpets and fabrics.	Limited animal studies available; not all PFCs have been tested. Some studies show that some types of PFCs can cause tumors, damage to the liver and other organs, and developmental and reproductive effects.
Volatile organic chemicals (VOCs)	Found in a wide variety of commercial, industrial and residential products, solvents, cleaners and degreasers and pesticides. Estimated that indoor air concentrations of VOCs are much higher than concentrations found outdoors.	Asthma[14], headaches; nausea; damage to liver, kidney and central nervous system. Some organics are suspected or known to cause cancer in humans.[15]

NHANES Findings	***Population Subgroups At Risk***
The prevalence of elevated blood lead levels (BLLs) among children decreased 84% from 1988 to 2004, but the majority of U.S. children still have some low-level exposure to lead.	Elevated blood lead levels (BLLs) in U.S. children continue to decrease, and disparities have lessened; the mean BLLs and distribution of BLLs continue to be higher for low-income children; **non-Hispanic black children,** and children living in older housing stock (built before 1950).[8]
Residues of banned pesticides chlordane, aldrin, dieldrin, and heptachlor persist in humans and in the environment. Insecticide urinary metabolites are found in those not occupationally exposed.	
Detectable levels of metabolites MEP, MBP, MBzP and MEHP found in more than 75% of the samples, suggesting widespread exposure to phthalates in the United States.	Metabolites found in adults, adolescents and children. **Females of all ages** had significantly higher concentrations of the reproductive toxicant MBP; **non-Hispanic blacks** had significantly higher concentrations of MEP.
PFOS, PFOA, PFHxS and PFNA detected in more than 98% of the samples.	In 2003-2004, PFOS, PFOA, PFHxS, and PFNA serum concentrations were measurable in all population group studied. Concentrations differed by race/ethnicity and sex.
CDC measured 212 volatile organic chemicals in people's blood or urine, including VOCs such as benzene, chlorobenzenes, halognated solvents, nitrobenzene, styrene, toluene and xylenes.[16]	Socioeconomic, demographic and behavioral factors have been shown to influence personal exposures to air pollutants.

Appendix IV.

LEED Indoor Environmental Quality Standards

EQp1 Minimum IAQ Performance

EQp2 *Environmental Tobacco Smoke (ETS) Control*

EQp3 Minimum Acoustical Performance (Schools)

EQc1 Outdoor Air Delivery Monitoring

EQc2 Increased Ventilation

EQc3.1 Construction IAQ Management Plan: During Construction

EQc3.2 Construction IAQ Management Plan: Before Occupancy

EQc4.1 Low-Emitting Materials: Adhesives and Sealants

EQc4.2 Low-Emitting Materials: Paints and Coatings

EQc4.3 Low-Emitting Materials: Flooring Systems

EQc4.4 Low-Emitting Materials: Composite Wood and Agrifiber Products

EQc4.5 Low-Emitting Materials: Ceiling and Wall Systems (Schools)

EQc5 Indoor Chemical & Pollutant Source Control

EQc6.2 Controllability of Systems: Thermal Comfort

EQc7.1 Thermal Comfort: Design

EQc7.2 Thermal Comfort: Verification

EQc8.1 Daylight and Views: Daylight

Source: http://www.documents.dgs.ca.gov/DGS/OPSC/LEED_Referenced.pdf

LEED Minimum Project Requirements

The LEED project building must:

- **Comply with environmental laws.**
- **Be a complete, permanent building or space.**

  All Rating Systems: must be designed for and constructed and operated on a permanent location on already existing land. May not be a temporary residence.

  New Construction, Core & Shell, Schools: must include the new, ground-up design and construction, or major renovation, of at least one building in its entirety.

  Commercial Interiors: interior space must be distinctly separate from other spaces within the building with regards to ownership, management, lease, and/or party wall separation.

  Existing Buildings: O&M: must include at least one existing building.
- **Use a reasonable site boundary.**

  New Construction, Core and Shell, Schools, Existing Buildings: Operations and Maintenance:

  1. Must include all contiguous land associated with and supporting normal building operations for the LEED project building.
  2. Project boundary may not include land owned by a party other than the LEED project party.
  3. LEED projects located on a campus must have boundaries in which all buildings on campus become LEED-certified, then 100% of the gross land area on the campus would be included within a LEED boundary.
  4. Any given parcel of real property may only be attributed to a single LEED project.
  5. Boundaries may not unreasonably exclude sections of land to create boundaries in unreasonable shapes for the sole purpose of complying with prerequisites or credits.

  Commercial Interiors: If any land was or will be disturbed for the purpose of undertaking the LEED project, then that land must be included within the boundary.
- **Comply with minimum floor area requirements.**

  New Construction, Core and Shell, Schools, Existing Buildings: Operations and Maintenance: minimum of 1,000 square feet of gross floor area.

  Commercial Interiors: minimum of 250 square feet of gross floor area.
- **Comply with minimum occupancy rates.**

  New Construction, Core & Shell, Schools, and Commercial Interiors:
  Full-Time Equivalent Occupancy

  Existing Buildings: O&M
  Full-Time Equivalent Occupancy
  Minimum Occupancy Rate
- **Commit to sharing whole-building energy and water use data.**
  For at least five years, beginning on the day of physical occupancy.
- **Comply with a minimum building area to site area ratio.**
  Floor area must be no less than 2% of the total land area

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Notes to Table 4.

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2 New state facilities (>$5 million) and renovations (> $2 million); new public school construction (>$5 million) and renovations (>$2 million); private buildings (>$5 million); all renovations in 2010 (>$2 million). Residential buildings of 4 units or less and certain other buildings exempt.

[3] State buildings, municipalities, school districts, water management districts, state universities, community colleges, and Florida state courts.

[4] State-owned construction > 5,000 sq. ft. including K-12 public schools.

[5] New buildings and major renovations of 10,000 sq ft or more must achieve at minimum LEED Silver or equivalent certification. New buildings and major renovations under 10,000 sq. ft. must strive to meet the highest standard of the LEED rating system or equivalent but are not required to achieve certification. Schools Neighborhood Development (fund up to 1.5% of total development costs for up to 3 applicable neighborhoods per year; new state-funded building construction and renovation of state-owned facilities.

[6] New public facilities and renovations using 50% or more of state funding achieve LEED certification. Projects of $25 million or more must achieve LEED Silver certification or higher. Projects between $5 and $25 million must achieve LEED Certified and earn a minimum of seven points under the Energy and Atmosphere Credit 1, Optimize Energy Performance standards. All projects between $600,000 and $5 million shall use the LEED rating system as a guide.

[7] New public construction and renovation projects of > 7,500 sq ft intended for occupation must earn LEED Silver certification or two Green Globes; public schools using state funds earn LEED Silver certification or two Green Globes. State will pay half of any extra costs incurred in building green public schools.

[8] State agencies (> 20,000 sq. ft.)

[9] State-funded new construction and major renovation projects > $1,000,000

[10] Three-tiered property tax exemption plan, maximum of 35% for any private building, excluding single-family homes and residential structures 3 or fewer stories; state-funded buildings; tax abatements and exemptions for products or materials

[11] New state-owned buildings >15,000 sq. ft.; New school designs

[12] All public buildings over 15,000 sq. ft. to be LEED Silver certified. Commercial buildings: tax credits from $3.50 sq. ft. (Silver) to $6.25 sq. ft.; Residential building: $5.00 sq. ft. to $9.00 sq. ft.; public buildings > 15,000 sq. ft. The credit applies to LEED for New Construction, Silver and higher; LEED for Existing Buildings, Silver or higher; LEED for Core and Shell, Silver and higher; LEED for Commercial Interiors, Silver or higher; and LEED for Homes, Silver or higher. The credit increases commensurate with the level of LEED certification achieved.

[13] Income tax incentive to commercial developments; Incentives for new homes/renovations increasing with size.

[14] Reduced permitting fees/partial rebates for construction projects.

[15] State buildings over 10,000 sq. ft.

[16] New Construction, Core and Shell, or Commercial Interiors.

[17] Construction reimbursement rates for public schools.

[18] State owned or funded construction > 10,000 sq. ft.; major renovation projects > 50% of total building space or value.

[19] Construction and renovations of state-owned buildings > $500K or 5,000 sq. ft.

[20] Reduced taxes on energy efficient buildings; state-owned facilities > 5,000 sq. ft., and renovations valued at 50% of assessed building value for energy performance standards.

[21] Public buildings > 5,000 sq. ft.; public projects > 25,000 sq. ft.; K-12 schools.

Notes to Appendix III.

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[16] cdc.gov/exposurereport/data_tables/chemical_group_18.html

Design and Layout
By Jane M. Bradley

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