Sustainability and Brick

Abstract: This *Technical Note* discusses sustainability and sustainable design and their relationship to brick manufacturing, use and recycling. Sustainable practices in manufacturing are identified, as are ways to utilize brick as part of sustainable design strategies. Ways that brickwork can be used to earn points in the LEED and other green building rating systems also are identified.

Key Words: environmental impacts, green building, LEED, life cycle assessment (LCA), recycled content, resources, sustainability, sustainable design, thermal mass, volatile organic compounds (VOCs).

SUMMARY OF RECOMMENDATIONS:

- Sustainable design balances environmental, economic and societal goals. It is more than just a certification from a rating system
- Brick is made from abundant natural resources (clay and shale) and is readily recycled for use in the manufacturing process or other uses
- Brick manufacturers address sustainability by locating plants in close proximity to mines; incorporating waste products and recycled materials into brick; reducing energy use, water use and atmospheric emissions; and utilizing landfill gas and other wastes for fuel
- Brickwork used in sustainable designs can provide structure, finish, acoustic comfort, thermal comfort, good indoor air quality, fire resistance, impact resistance and durability, all in one product
- Brickwork can help meet requirements of many certification rating systems in the areas of development density, storm water management, heat island effect, improved energy performance, building reuse, construction waste management, materials reuse, recycled content and regional materials
- Brickwork can contribute to improved indoor air quality by eliminating the need for paints and the resulting volatile organic compounds (VOCs) and by eliminating a food source for mold
- Brickwork is durable, having a life expectancy of hundreds of years. Brick buildings can be and are reused, thereby distributing their environmental impact over an extended life span

INTRODUCTION

“Sustainable design” is a term that has entered the vernacular of building design and construction. As more buildings are designed and constructed using sustainable design principles, the need for information on building products and their sustainable design features also grows. In assessing the sustainable attributes of building products, consideration must be given to how the product is manufactured, used and disposed of. This *Technical Note* provides information on brick usage, manufacturing and recycling as it relates to sustainability.

WHAT IS SUSTAINABILITY?

Sustainability is defined as “*meeting the needs of the present without compromising the ability of future generations to meet their own needs*” [Ref. 2]. Sustainable buildings are designed in a way that uses available resources efficiently and in a responsible manner, balancing environmental, societal and economic impacts to meet the design intents of today while considering future effects. Sustainably designed buildings are energy-efficient, water-efficient and resource-efficient. They address the well-being of the occupants by considering thermal comfort, acoustics, indoor air quality and visual comfort in the design. They also consider the impact of a building’s construction, operation and maintenance on the environment, and the environmental impact of the building’s constituent materials. A sustainably designed building considers all of these aspects through the entire life cycle of the building, including its operation and maintenance.

Often the tendency is to focus on one aspect of sustainable design, such as energy use or environmental impacts. This approach leaves out other equally important elements necessary for true sustainability. Truly sustainable design is best described as achieving the “triple bottom line,” that balance of environmental goals, societal goals and economic goals.

A high-performance, sustainable building design should include accessibility, aesthetics, cost-effectiveness, durability, functionality/operation, productivity of occupants, security and safety, and environmental performance.

THE NEED FOR SUSTAINABLE BUILDING DESIGN

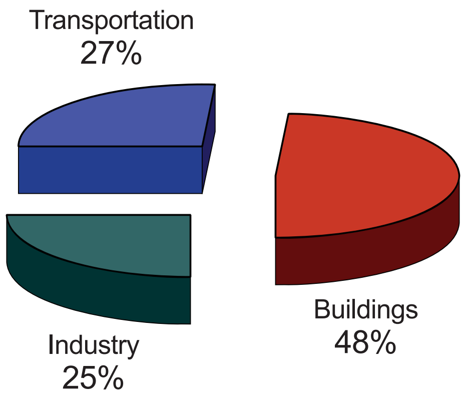

Figure 1
U.S. Energy Consumption [Ref. 12]

Each year building construction accounts for 25 percent of the virgin wood used globally, and 40 percent of the raw stone, gravel and sand used. Buildings also use 48 percent of the energy and 16 percent of the water used annually worldwide (see Figure 1). In the United States, about as much construction and demolition waste is produced as municipal garbage [Ref. 14].

Architect Edward Mazria, who founded Architecture 2030, a nonprofit organization dedicated to research and solutions in architecture to address global climate change, determined that "*Combining the annual energy required to operate residential, commercial, and industrial buildings along with the embodied energy of industry-produced building materials like carpet, tile, glass, and concrete, exposes buildings as the largest energy consuming and greenhouse gas emitting sector*" in the United States [Ref. 12].

This focus on energy use of buildings is one of many aspects of evaluating sustainable building design that has multiple impacts. Reduction in building energy use has a positive impact on the environment because most energy is generated by processes that negatively impact the environment. A reduction in building energy use has positive economic impacts for building owners and occupants. Because any negative impact on the environment concerns all of society, a reduction in energy use also has positive societal impacts. This limited example illustrates the interrelated nature of sustainable design.

Another aspect to be considered in sustainable design is the indoor environment. Improvements in this area can increase productivity and provide an economic benefit—salaries are the largest cost of occupied buildings—as well as a societal health benefit. The environmental impacts of the building location and construction process, as well as the environmental impacts of the manufacture and use of building materials, also must be considered.

There are as many ways to achieve this "triple bottom line" as there are design possibilities. Understanding general sustainable design issues helps identify areas in which design has an impact.

SUSTAINABLE DESIGN WITH BRICK

While there is general agreement on many of the elements of sustainable building design, defining and measuring it poses a challenge. The first step is to define sustainable design for buildings. As discussed earlier, to be sustainable a design must consider more than just environmental impacts. A holistic approach is necessary. The Whole Building Design Guide developed by the National Institute of Building Sciences discusses sustainable design in terms of "whole building design." In their words, "*Whole Building design in practice requires an integrated team process in which the design team and all affected stakeholders work together throughout the project phases and to evaluate the design for cost, quality-of-life, future flexibility, efficiency; overall environmental impact; productivity, creativity; and how the occupants will be enlivened. The 'Whole Buildings' process draws from the knowledge pool of all the stakeholders across the life cycle of the project, from defining the need for a building, through planning, design, construction, building occupancy, and operations*" [Ref. 15].

Sustainable Design Elements

Every sustainable building is unique, designed specifically for its site and the programming requirements of the user. However, all high-performance, sustainable buildings should consider the following components of design [Ref. 14]:

- Environmentally responsive site planning
- Energy-efficient building shell
- Thermal comfort
- Energy analysis
- Renewable energy
- Water efficiency
- Safety and security
- Daylighting
- Commissioning
- Environmentally preferable materials and products
- Durability
- Efficient use of materials
- High-performance HVAC
- High-performance electric lighting
- Life cycle cost analysis
- Acoustic comfort
- Superior indoor air quality
- Visual comfort

The versatility and durability of brick facilitate its use as part of many elements of sustainable design.

Photo 1
Reused (left) and New Brick Buildings

Photo 2
Permeable Clay Pavement

Environmentally Responsive Site Planning

Environmentally responsive site planning includes consideration of site selection, site disturbance, storm water management and effect of the building on its surroundings. The use of brick masonry is an appropriate choice for achieving several elements of environmentally responsive site planning.

Reuse and Renovation. The first step in site planning is selection of the building site. Reuse or renovation of an existing building (see Photo 1) can result in significant reductions in environmental impacts as compared with new construction. Because of aesthetic appeal and durability, brick masonry buildings often are chosen for reuse. In many cases, load-bearing brick buildings are reused in their entirety. In other cases, the brick façade is retained while a new structure is constructed.

Using Brick in Urban Areas. When locating new construction, it is desirable to select sites near existing infrastructure. Utilizing brick masonry in urban development can help meet requirements for fire resistance and limitations on site accessibility and can also accommodate irregularly shaped lots.

Maximizing Open Space. On any site it is desirable to maximize the amount of open space on the site, either by limiting the building footprint or by minimizing the extent of site disturbance adjacent to the building. Because brick masonry construction does not require large staging areas or large equipment for placement, the amount of site disturbed can be kept to a minimum. In addition, brick paving in an open space can provide a pedestrian-friendly surface.

Managing Storm Water Runoff. By managing storm water runoff, increasing on-site filtration and eliminating contaminants, the disruption and pollution of natural water flows are limited. Flexible brick pavements can be designed as permeable pavements to allow percolation of storm water through the pavements, thereby reducing runoff, recharging groundwater aquifers and removing contaminants from surface water (see Photo 2).

Reducing the Heat Island Effect. Building projects have an effect on their surroundings, particularly in urban areas. The use of light-colored materials can help reduce the heat island effect. Light-colored brick pavers can be used on vegetated roofs to provide access paths or on non-roof pavements as part of a strategy to reduce this effect.

Energy-Efficient Building Shell, Thermal Comfort and Energy Analysis

Energy-Efficient Building Envelope. An energy-efficient building envelope is a key component in sustainable building design. Incorporation of brick masonry's thermal mass provides numerous energy benefits, including the reduction of peak heating and cooling loads, moderation of indoor temperature swings (improved thermal comfort), and potential reduction in the size of the HVAC system. The benefits of thermal mass have been demonstrated when brick is used as a veneer, and are even more pronounced when brick masonry also is exposed on the interior of the building.

Energy Analysis. In order to thoroughly account for the thermal mass benefits of masonry, energy analysis using simulation software is necessary. BLAST [Ref. 4] or EnergyPlus [Ref. 5] are the most suited to analysis of buildings with masonry.

Brick Rain Screen Wall. A brick rain screen wall is another example of a high-performance brick wall. Moisture penetration is one of the most common causes of problems in buildings. Rain screen walls minimize rain infiltration by applying principles of drainage and pressure equalization. A brick masonry pressure-equalized rain screen wall utilizes intentional openings in the brick masonry and compartmentation of the cavity to equalize the pressure in the cavity behind the exterior brick and thus minimize rain penetration. Details of the design of pressure-equalized rain screen brick masonry walls can be found in *Technical Note* 27.

Safety and Security

Brick masonry promotes occupant health and safety through fire-resistant construction and resistance to impacts and wind-borne debris. In addition, the durability of brick masonry gives long-lasting results.

Life Cycle Cost Analysis

Due to durability of brickwork construction, a life cycle cost analysis can often demonstrate the long-term benefits of building with brick.

Acoustic Comfort

Acoustic comfort is a key element in a superior indoor environment. Brick masonry walls provide superior resistance to sound penetration with a sound transmission class (STC) of 45 or greater.

Renewable Energy

Incorporation of renewable energy sources into a building design can significantly reduce reliance on fossil fuels used by the building during operation. Passive solar energy is a free resource, and brick masonry can be utilized as part of several passive solar design strategies. Brick paving can be used in interior applications to store heat and moderate temperature swings.

Environmentally Preferable Materials and Products

Life Cycle Assessment. Consideration of the environmental impact of building materials and products is an important element in a sustainable design, though it is only one of several criteria to be considered for product selection. Materials should be evaluated over their entire life cycle, from raw material extraction to end of useful life. This life cycle assessment (LCA) of a building material or product must include accurate evaluation of product service life.

Construction Waste. Building construction can generate significant amounts of waste. Because of the small, modular nature of brick, on-site construction waste can be dramatically reduced through careful design and detailing. In addition, scrap brick is easily crushed and recycled for new uses, thus avoiding the landfill. Packaging from brick is minimal and easily recycled.

Salvaged Materials. Use of salvaged materials avoids the environmental impacts associated with new products. Salvaged brick, especially sand-set units, can be reused when care is taken to determine material performance characteristics.

Recycled Content. Many environmentally preferred product listings focus on materials that incorporate recycled content. By utilizing recycled materials, the assumption is that the environmental impact is lowered. Recycled materials can come from either postconsumer or postindustrial (preconsumer) sources. Brick masonry can contain many recycled products. Brick units may incorporate recycled materials such as sawdust and metallic oxides. Mortar and grout can include recycled materials, such as fly ash, and most steel reinforcement used in reinforced brick masonry has a high recycled content.

Regional Sources. By selecting materials from regional sources, environmental impacts associated with the transport of materials can be reduced. Most brick are manufactured from materials obtained from within a few miles of the manufacturing plant. Of the 50 largest metropolitan statistical areas (MSAs) in the United States, there are more than 25 plants on average within 500 miles of each, and there are at least two brick plants within

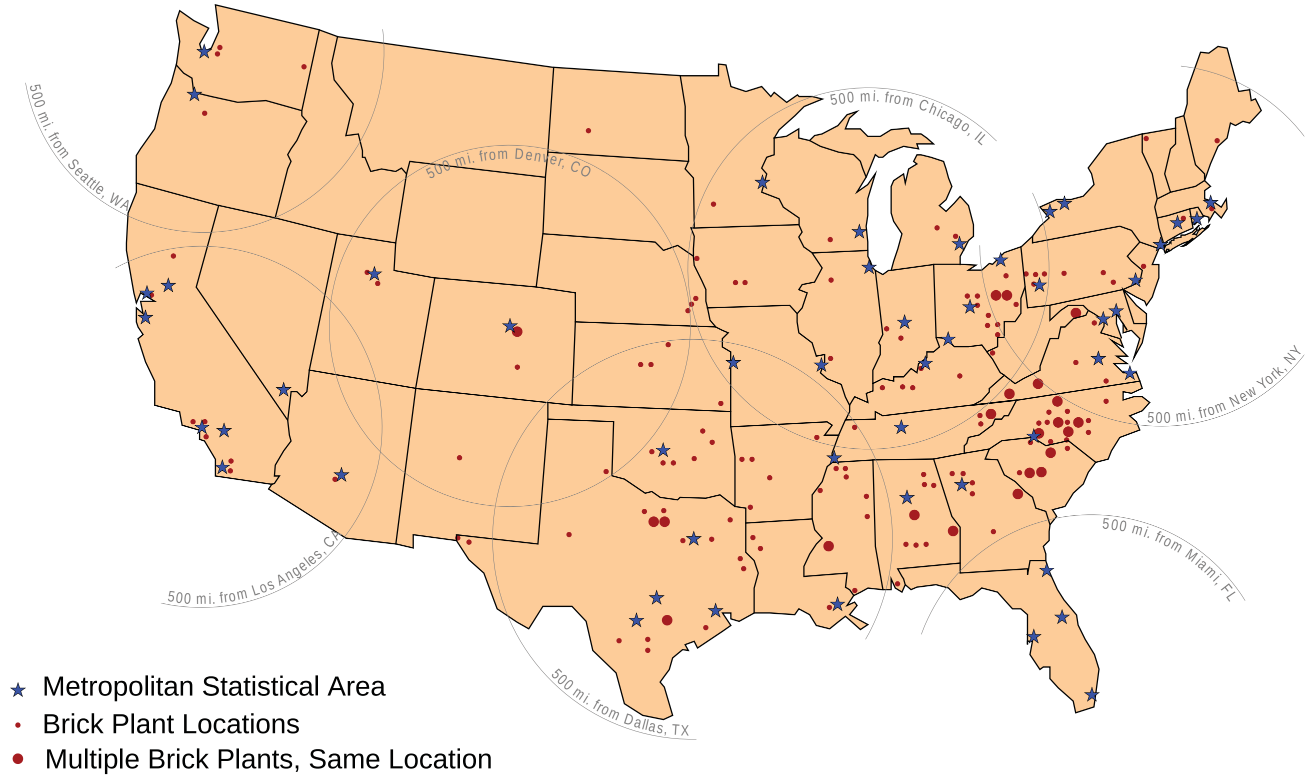

Figure 2
Brick Plant Proximity to 50 Largest Metropolitan Statistical Areas

500 miles of 49. More than 70 percent of these MSAs have at least one plant within 200 miles (see Figure 2).

Durability and Designing for Longer Life Expectancy

Designing a high-performance wall considers not only the multiple functions a wall can perform, but also the different life expectancies of those elements that make up the wall. It is important "*when designing systems with many components, such as curtain walls, endeavor to make all components equally durable to prevent premature failure of one part of the system. When possible, provide for easy inspection, maintenance, and/or replacement of less durable components*" [Ref. 13].

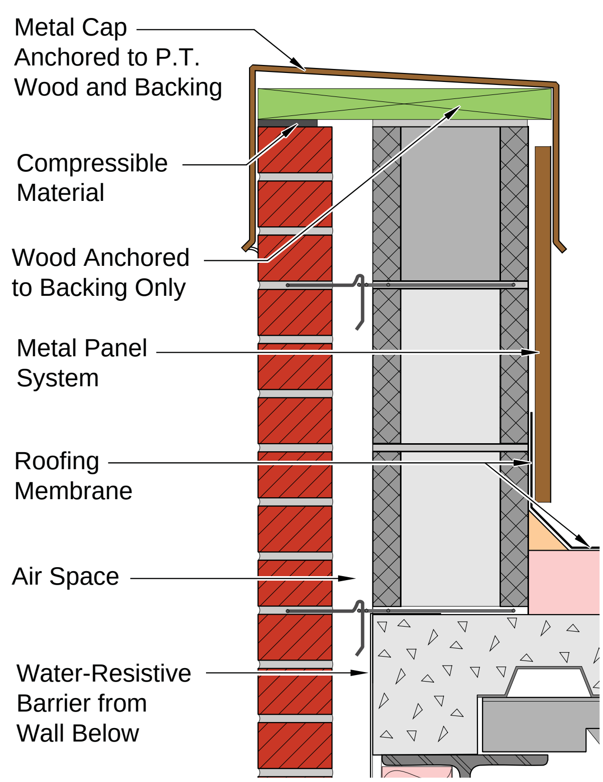

Figure 3
Detailing for Longer Life Expectancy

This approach is especially important in achieving a sustainable building design. Brickwork is extremely durable, having a life expectancy of hundreds of years. Repointing may be required only every 50 years or more. Thus it is important to recognize this fact when detailing those elements that interface directly with brick masonry that have shorter life expectancies or require more frequent maintenance. One example of this is flashing. Some flashing materials, such as stainless steel and copper sheet, have been documented to have a life expectancy of more than 100 years. The detail shown in Figure 3 is designed with service life in mind. The metal cap and roof membrane will require periodic replacement. By utilizing separate components, they can be replaced without damage to or repointing of the brick masonry wall. Such a detail is not required by the building code, but can extend the service life of a wall.

Efficient Use of Materials

Multiple Functions. How a building material is used also should be considered when examining the sustainability of a material. Brick masonry walls are able to perform multiple functions that often require several components in other wall systems. By designing walls that serve multiple functions, materials are used efficiently. This translates into reduced environmental impacts for the building. A single brick wythe can do all of the following:

- Serve as a load-bearing structural element.
- Provide an interior or exterior finish without the need for paints or coatings.
- Provide acoustic comfort with a sound transmission class (STC) rating of 45 or greater.
- Regulate indoor temperatures as a result of thermal mass.
- Provide fire resistance (a nominal 4-in. (100 mm) brick wall has a one-hour fire rating).
- Provide impact resistance from wind-borne debris or projectiles.
- Improve indoor air quality by eliminating the need for paint and coatings (no VOCs).
- Provide a non-combustible material which does not emit toxic fumes in fires.
- Provide an inorganic wall that is not a food source for mold.
- Serve as a heat-storing element in a passive solar design.
- Last for generations.

In addition, other innovations in brick masonry design can further decrease the raw materials used. The use of prestressed brick walls capitalizes on the inherent compressive strength of brickwork, resulting in typically thinner, taller walls.

Reduced Thickness. Brick manufactured to a reduced thickness use less raw material. Brick manufactured to meet ASTM C1088, *Specification for Thin Brick Veneer Units Made from Clay or Shale*, have a maximum thickness of 1¾ in. (44 mm). When adhered to a load-bearing wall substrate, these units can provide a brick finish with minimal thickness. For more information on thin brick construction, refer to *Technical Note* 28C.

Anchored masonry veneer can be as little as 2⅝ in. (67 mm) thick, according to the *Building Code Requirements for Masonry Structures*, which is referenced by the International Building Code. Such brick are available from most brick manufacturers and most often are used in residential applications.

Hollow Brick. Brick units meeting the requirements of ASTM C652, *Specification for Hollow Brick*, utilize less raw material than other brick used in anchored veneers while performing the same function. In addition, these units can be used in reinforced or prestressed brick masonry walls.

Superior Indoor Air Quality

Avoiding Volatile Organic Compounds. Because brick masonry can be used on the interior of a building, serving as structure and finish material without the need for paints or coatings, brick can contribute to improved indoor air by avoiding volatile organic compounds (VOCs). In addition, because the appearance of brick will last a lifetime without costly paints or other maintenance, this benefit continues for the life of the building.

Resisting Mold. Mold is another area of concern for indoor air quality. Brick masonry is not a food source for mold. As a result, it does not promote mold growth, even if wetted, and is easily cleaned if needed. Other interior wall materials can be literally eaten up by mold if moisture problems occur.

In addition, interior brick paving can be used in lieu of carpeting, particularly in high-traffic areas, thereby reducing indoor VOC content associated with carpet and adhesives and eliminating the need for regular replacement of flooring.

BRICK MANUFACTURING AND SUSTAINABILITY

In order to understand how brick can contribute to sustainable building design, it is important to consider how brick is made, as well as how it is used. Brick manufacturing is a highly efficient process incorporating many sustainable practices as described below. *Technical Note* 9 discusses the manufacture of brick in detail.

Raw Material Use

Brick is made primarily from clay and shale, which are abundant natural resources [Ref. 6]. Most of the clays and shales used in brick making are mined in open pits located near brick manufacturing facilities — many of which are less than a mile away. Most plants use material from the same pit extracted through multiple soil layers for a minimum of 50 years, thus minimizing their impact to the surface area. Conveyors and other power equipment typically are used to transport the clay from the mine to the plant. Brick manufacturing plants are located throughout the country, putting them within a short distance of most urban areas.

Storm water runoff from clay pits is controlled by regulations from the Mining Safety and Health Act. Manufacturers use techniques such as settling ponds, filtration through marshes and wetlands and catch basins. Dust is controlled by spraying organic, biodegradable oils or water.

Once the clay is mined, it is ground to suitable particle size and then mixed with water. This mixture is then formed into brick. Non-hazardous waste products are sometimes incorporated into the mixture. For example, petroleum-contaminated soil or sludge can be used. Recycled waste from other industries, such as bottom ash and fly ash from coal-fired generators, glass, stone dust, and ceramic tile may be incorporated. Reclaimed industrial metallic oxides can be used as colorants in brick. Because fired brick are inert, brick can safely encapsulate many materials.

Additionally, nearly all of the mined, raw materials result in finished brick product. Nearly 95 percent of all the mined clay and shale goes to the plant, and an average of 3½ percent of the manufactured product ends up as scrap — most of which is returned to the manufacturing process or recycled for secondary uses such as structural fill.

Sustainable Practices in Manufacturing

One of the results of today's manufacturing process is that brick manufacturing is more energy efficient now than it was a few short decades ago. In the 1970s, a standard brick required 14,000 Btu of energy to mine, manufacture and transport [Ref. 6]. Today, the average embodied energy for U.S.-manufactured brick is about 4300 Btu per standard brick [Ref. 3]. The reason for this significant change is that the contemporary brick manufacturing process incorporates many practices intended to conserve resources and promote sustainability.

For example, the majority of brick plants use renewable materials within the brick-making process. Lubricants made from a waste by-product derived from processing organic materials can be used in the forming of brick. Heat required for dryer chambers usually is supplied from the exhaust heat of kilns to maximize thermal efficiency. Water used in brick production is recycled and reused. Improvements in automation result in even less energy being used.

Additionally, more than 35 percent of brick plants have investigated alternative energy sources. Many manufacturers are using waste products such as methane gas from landfills and sawdust. While natural gas is the most frequently used fuel for firing brick, utilizing waste materials enables brick plants to reduce their consumption of fossil fuels as well as provide a beneficial means of disposal for potential wastes. Brick manufacturers also are taking steps to further improve their efficiency by using sawdust and petroleum coke as a burnout material in the clay or shale mixture, producing lower-weight units with less raw material. In fact, more than 80 percent of brick manufacturers have made recent improvements to reduce the energy used by their plants. These improvements include providing more energy-efficient kilns, forming more energy-efficient brick and installing energy-efficient lighting.

Also, the majority of brick today are packaged in self-contained, strapped cubes, which can be broken down into individual strapped sections for ease of handling on the jobsite. Layers of brick are separated by wooden or paper strips to reduce chippage and breakage. Such packaging does not use wooden pallets. Plastic straps and wood dividers can be recycled, resulting in little or no waste. Approximately 15 percent of brick are transported to the distributor's yard or jobsite by rail and 85 percent by truck, often less than 500 miles. About half of U.S. brick manufacturing facilities accept unused brick that was shipped to a distributor or end user.

Another result of today's brick manufacturing is that the embodied energy per pound required to make brick is much less than for other materials. Most of the energy required for brick production is used in the firing of the kilns. The 1998 AIA Environmental Resource Guide states that the energy used to mine, manufacture and transport brick (known as "embodied energy") is approximately 4000 Btu per pound. That's less per pound than concrete, glass, steel or aluminum [Ref. 6]. This number has decreased since then, with most manufacturers increasing the energy efficiency of existing plants or constructing new plants that operate more efficiently. The current industry average is approximately 1239 Btu per pound [Ref. 3].

With today's environmental concerns, the brick industry recognizes the need for compliance with state and federal regulations for clean air and the environment. Air emissions are minimized with controls such as scrubbers installed on kiln exhausts. Lime waste that accumulates in scrubbers often is recycled as a beneficial additive to soil. Dust in brick plants is controlled through the use of filtering and containment systems, vacuums, additives and water mists. Even vehicular emissions are being addressed, with brick manufacturers monitoring truck emissions; recycling waste oil, antifreeze and hydraulic oil; and regulating truck speeds for improved fuel efficiency [Ref. 7].

As part of a commitment to sustainability and good community citizenship, mined areas are reclaimed for future use by replacing overburden and topsoil so the resulting property can be used for a wide variety of functions, including farmland, residential and commercial sites, and even wetlands. In this way valuable clay and shale resources are obtained while still allowing for land to be reused for a different purpose later.

Environmental Information

Information on the environmental impacts of brick manufacturing can be provided in several ways. The simplest of forms is an environmental audit report. An environmental audit examines and identifies the environmental impact of the various manufacturing processes in a qualitative manner. Exact quantification of effects is not determined. A more thorough examination of the manufacturing process is conducted in an environmental life cycle assessment (LCA). In an LCA, quantitative data are collected on the effects of the manufacturing process in a prescribed number of assessment areas, which are then attributed to corresponding environmental impacts such as global warming potential, stratospheric ozone depletion and eutrophication (the gradual increase in the concentration of plant nutrients in an aging aquatic ecosystem). The boundaries of a typical building product LCA as conducted by a manufacturer consider all impacts during the manufacturing process, from resource extraction to final production, or "cradle to gate." Transport to the project site also may be included.

As sustainable building design and standardization of LCA grow, it is anticipated that more U.S. brick manufacturers will undertake this process. It is important to recognize that environmental assessments can be done for industries as a whole and also for individual manufacturing facilities. Environmental assessments for individual manufacturing facilities reflect the environmental impacts of the different choices in fuel type, water conservation, etc. for that particular plant or product.

BRICK RECYCLING AND REUSE

Brick can be recycled in many ways. As discussed previously, raw brick and fired brick are recycled in the manufacturing process. Scrap brick and brick from demolition can be crushed and recycled into new brick or used as brick chips for landscaping (see Photo 3), baseball diamonds and tennis courts. Recycled brick also can be used as subbase material for pavements, on quarry roads or even as aggregate for concrete.

Photo 3
Recycled Brick Chips

Brick also can be reused. Individual brick units can be salvaged and reused with proper precaution. Sand-set brick pavers are the easiest to reuse because they are easily removed and typically remain physically unaltered. These units can be reused in a variety of new ways: for flooring, in pavements and in other landscape elements. Mortared units, pavers and facing units must be carefully cleaned of old mortar before reuse. In addition, care must be taken when reusing older brick units, as they may not be as durable as those currently manufactured. Reused brick should be tested to verify that they meet the requirements of the current specification for their intended use. Units that will be laid in mortar must have adequate open pores to ensure proper bonding.

Perhaps the best example of brick's sustainability is the reuse of brick masonry buildings. Because of the durability of brick masonry construction and the historic value often associated with brick buildings, reuse of brick masonry buildings is increasingly popular. By adapting existing structures to new uses, both resources and energy are saved and environmental impacts are reduced. This adaptive reuse of brick masonry buildings is a testimony to the longevity and durability of brick masonry.

OTHER MATERIALS IN BRICKWORK

Brick masonry includes not only brick, but also mortar, grout, metal anchors and ties, reinforcement, flashing, and drainage systems. Not all projects will use all of these other materials, and generally they constitute a relatively small percentage of brick masonry construction. However, it is important to understand how they fit in sustainable design as well. This *Technical Note* serves as an introduction to sustainable issues surrounding these other materials. Readers are encouraged to contact product manufacturers for further information on these materials.

Mortar and Grout

The majority of brick masonry is constructed using mortar. For a typical brick masonry wall built with modular size brick laid in running bond, about 20 percent of the surface is mortar. Mortar is composed of cementitious materials, sand and water. Cementitious materials for mortar include portland cement, blended cement, lime, masonry cement and mortar cement, or a combination of these. Details on mortar properties and proportions are found in *Technical Note* 8.

Grout, like mortar, is composed of cementitious materials and aggregate. Lime is used in much smaller quantities in grout than in mortar, if used at all. Depending on project requirements, the aggregate may be coarse (gravel-sized particles) or a combination of fine and coarse aggregate (sand and gravel).

Cement. Cements are high embodied energy materials. Increases in fuel efficiency and use of waste fuels have reduced the environmental impact of cement production. Mortar and grout may incorporate fly ash, a waste product from the burning of coal, as a partial replacement for cement. By reducing the amount of cement, the embodied energy and environmental impact of the mortar or grout is reduced, and an industrial waste is recycled.

Hydrated Lime. Hydrated lime is also a high embodied energy material. Softer mortars that contain only lime or high proportions of lime with a small amount of portland cement were common before the early part of the 20th century, so they are now used for historic restoration of buildings from that era. Mortars with high lime content can be more easily removed from brick when masonry is deconstructed and can be crushed and used as a beneficial additive to soil.

Sand and Aggregates. Sand and other aggregates are naturally occurring materials. They are available in almost all geographic locations and require little processing, and as such, they typically have a low embodied energy and a small environmental impact. Sand is sometimes considered a renewable material, being constantly formed from the erosion of rock.

Metal Anchors, Ties and Reinforcement

The majority of metal anchors, ties and reinforcement used in brick masonry construction are made from steel. Stainless steel and other metals are sometimes used, but to a lesser extent. The quantity of metal elements found in brick masonry is dependent on the type of construction. Brick veneer typically contains only metal anchors and possibly metal flashing. Reinforced brick masonry often will contain reinforcing bars and wire reinforcement in addition to ties and flashing.

Steel is made from iron ore and is a high-embodied energy material. However, steel is commonly recycled. Increasingly, anchor and tie manufacturers are utilizing raw materials that contain recycled content. The Concrete Reinforcing Steel Institute estimates that nearly 100 percent of feedstock for reinforcing bars is recycled scrap. Wire joint reinforcement also may contain recycled steel. Product manufacturers should be contacted for specific information.

ASSESSING SUSTAINABLE DESIGN

Many organizations have developed programs to measure various attributes of sustainable design. Some focus on the entire picture of sustainable design. Others focus primarily on the environmental aspects, so-called “green building.” Still others apply sustainable design metrics to a particular type of construction, such as schools. Though these rating systems are extensive, they are still limited in scope.

Green Building Rating Systems

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the United States Green Building Council (USGBC), is currently the most widely used green building rating system in the United States. As its name implies, the focus of the LEED rating system is on the energy use and environmental impact of a building. There are a number of different LEED rating systems focusing on different types of building construction, such as commercial interiors, core and shell, homes and existing buildings. The oldest and most widely used is the LEED for New Construction and Major Renovation Rating System (LEED-NC) [Ref. 10], and all of the other rating systems follow the general categories of LEED-NC.

Green Globes is another national green building rating system promulgated by the Green Building Initiative. Based originally on the British Research Establishment Environmental Assessment Method (BREEAM) rating system developed in the United Kingdom, Green Globes was created in Canada. Introduced in the United States in 2004, Green Globes is not as well known or as widely used as LEED-NC. Though many aspects of Green Globes are similar to those found in LEED, Green Globes differs in that it is an online tool that allows for self-certification. As a Web-based tool, Green Globes also provides interactive, educational links to information on sustainable design strategies and systems.

LEED-NC and Green Globes focus on commercial construction. There are rating systems for residential construction as well: LEED for Homes developed by USGBC, and the 2008 National Green Building Standard, developed by the National Association of Home Builders (NAHB). These guidelines are tailored to new home construction and contain many elements unique to that market. However, the general categories and goals of this program are similar to those found in LEED-NC.

These and many other green building rating systems are available for use, including programs developed by states and local jurisdictions. Though specifics of each vary, there is general agreement in categories and scope. The matrix shown in Table 1 correlates sustainable design strategies with brick and the various rating system credits. It is important to recognize that revisions to the rating systems are ongoing, and the credits indicated are based on the following versions:

- LEED-NC: version 3 (LEED 2009) (110 total points) [Ref. 11]
- Green Globes: Green Building Assessment Protocol for Commercial Buildings (April 10, 2009, Draft) (1000 total points) [Ref. 8]
- LEED for Homes: January 2008 (136 total points) [Ref. 10]
- 2008 National Green Building Standard: January 2009 (approximately 2000 total points) [Ref. 1]

Specific criteria and requirements for each of the rating systems can be found in the publications referenced.

Limitations of Rating Systems

The focus of these and other green building rating systems is energy use and the environment. All contain numerous requirements and credits intended to reduce building operational energy use, to promote the use of building products with lower environmental impacts and to provide a healthy indoor environment. However, what is often lacking in all of these rating systems is a means by which to promote and measure the avoidance of negative impacts. Only one of these systems currently contains methods to measure the avoidance of construction waste. All measure the diversion of waste from landfills, but only the NAHB effort recognizes materials that have little or no onsite waste to begin with. Similarly, efficient use of materials is not well-recognized. Materials such as brickwork that perform multiple functions avoid the use of other materials, such as paints, sound insulation, etc. At present, efficiencies such as these are included only in the NAHB rating system. Only a whole-building, holistic approach can capture the true intent of sustainable design.

TABLE 1

Potential Sustainable Design Contributions from Brickwork

	LEED-NC[1]	Green Globes[2]	LEED for Homes[3]	2008 National Green Building Standard[4]
Environmentally Responsive Sites				
Reuse Existing Buildings. Brick masonry buildings can be renovated and reused.	*Materials & Resources (MR)* 1 – 3 points	*Resources/ Materials* 10.4.1.1, 10.4.2.1 and 10.4.3.1 – up to 18 points		*Site Design and Development (SD)* 403.9 – 6 points, and *Resource Efficiency (RE)* – up to 12 points
Urban Development. Brick masonry is suitable and highly adaptable to urban infill projects.	*Sustainable Sites (SS)* 2 – 5 points	*Site* 7.1.1.4 – 2 points or *Site* 7.1.2.2 – 3 points	*Location & Linkage (LL)* 3.1 – 1 point or *LL* 3.2 – 1 point	*SD* 401.1 – 4 points; and *Lot Design, Preparation and Development (LD)* 501.1 – 4 points
Location on Site. Site building to optimize solar radiation (passive solar heating and cooling possible). Maintain open space (brick construction requires minimal disruption of site).	 SS 5.2 – 1 point		*Innovation & Design (ID)* 1.5 – 1 point	*SD* 403.2 – 6 points
Storm Water Design. Reduce quantity and improve quality of runoff with permeable brick pavements.	*SS* 6 – 2 points	*Site* 7.3.1.1 – up to 10 points	*SS* 4.1 – 4 points	*SD* 403.5 – up to 5 points and *LD* 503.4 – up to 5 points
Heat Island Effect. Light-colored pavers can help reduce heat build-up.	*SS* 7.1 – 1 point	*Site* 7.2.2.3 – up to 10 points	*SS* 3 – 1 point	*LD* 505.2 – 4 points
Energy Efficiency, Thermal Comfort and Energy Analysis				
Improved Energy Performance. Thermal mass of brick helps reduce heat transfer; pressure-equalized brick rain screen walls.	*Energy & Atmosphere (EA)* 1 – up to 19 points (about 2-4 points from brick)	*Energy* 8.2.1.1, 8.2.1.2 and 8.2.1.3 – up to 12 points	*Energy & Atmosphere (EA)* 1 – up to 34 points (about 1-2 points from brick)	*Energy Efficiency (EE)* 703.1.3 – up to 6 points and *EE* 704.3.1 – up to 10 points
Thermal Comfort. Thermal mass of brick helps reduce indoor temperature swings.	*EA* 1 – up to 19 points (about 2-4 points from brick)	*Energy* 8.2.1.1, 8.2.1.2 and 8.2.1.3 – up to 12 points	*EA* 1 – up to 34 points (about 1-2 points from brick)	*EE* 703.1.3 – up to 6 points and *EE* 704.3.1 – up to 10 points
Energy Analysis. Energy modeling reflects benefits of thermal mass of brick.	*EA* 1 – up to 19 points (about 2-4 points from brick)	*Energy* 8.2.1.1, 8.2.1.2 and 8.2.1.3 – up to 12 points	*EA* 1 – up to 34 points (about 1-2 points from brick)	*EE* 703.1.3 – up to 6 points and *EE* 704.3.1 – up to 10 points
Environmentally Preferable Materials				
Life Cycle Assessment.	*Innovation & Design (ID)* 1.2 – 1 point	*Resources/ Materials* 10.1.1.1 – up to 33 points		*RE* 609.1 – 3 points per product

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2. Green Globes: Green Building Assessment Protocol for Commercial Buildings (April 10, 2009, Draft) – Total possible points = 1000
3. LEED for Homes (January 2008) – Total possible points = 136
4. 2008 National Green Building Standard, January 2009 – Total possible points = approximately 2000

TABLE 1 (continued)

Potential Sustainable Design Contributions from Brickwork

	LEED-NC[1]	Green Globes[2]	LEED for Homes[3]	2008 National Green Building Standard[4]
Environmentally Preferable Materials				
Avoidance of Construction Waste. Use modular designs to avoid waste.			*Materials & Resources (MR)* 1.2, 1.3 – 2 points	*RE* 601.3 – 3 points
Recycling of Construction Waste. Brick and packaging are 100% recyclable.	*MR* 2 – 2 points	*Resources/ Materials* 10.5.1.1, 10.5.2.1 – up to 7 points	*MR* 3.2 – 3 points	*RE* 605.2, 605.3 – 8½ points
Salvaged Materials. Salvaged brick and pavers can be reused.	*MR* 3 – 2 points	*Resources/ Materials* 10.3.1.1 – up to 6 points	*MR* 2.2 – ½ point per product	*RE* 603.2 – 3 points
Recycled Content. Brick may contain recycled sawdust, sludge, metallic oxides. Mortar/grout may use fly ash.	*MR* 4 – 2 points	*Resources/ Materials* 10.1.2.1, 10.2.2.1 – up to 10 points	*MR* 2.2 – ½ point per product	*RE* 604.1 – up to 6 points
Regional Materials. Brick manufacturing plants are located near raw materials and available throughout the United States.	*MR* 5 – 2 points	*Resources/ Materials* 10.1.3.1, 10.1.4.1, 10.2.3.1, 10.2.4.1 – up to 14 points	*MR* 2.2 – ½ point per product	*RE* 608.1 – 2 points per material
Materials That Do Not Require On-site Finishes. No finishes are required of brickwork, can be used inside as well.				*RE* 601.7 – 2 or 5 points for each material
Materials Made with Renewable Energy. Several brick manufacturers use landfill gas or sawdust to fire their brick.				*RE* 606.3 – 2 for each material
Durability and Design for Service Life				
Durability. Brick has a useful life of more than 100 years.		*Resources/ Materials* 10.6.1.1, 10.6.2.1 – up to 4 points		
Termite Resistant Materials in Areas of Termite Infestation. Insects do not eat brick.			*SS* 5 – up to 1 point	*RE* 602.8 – up to 6 points
Weather-resistant Barrier or Drainage Plane Inside Siding or Veneer. Brick veneer introduced the drainage wall.		*Resources/ Materials* 10.7.6.1 – 5 points		
Flashing. Flashing is always present in well-detailed brick buildings.		*Resources/ Materials* 10.7.2.1 – 5 points		*RE* 602.12 – 6 points

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TABLE 1 (continued)

Potential Sustainable Design Contributions from Brickwork

	LEED-NC[1]	Green Globes[2]	LEED for Homes[3]	2008 National Green Building Standard[4]
Renewable Energy				
Renewable Energy. Thermal mass of brick walls and floors can be used in passive solar designs.	*EA* 1 – up to 19 points (about 2-4 points from brick)	*Energy* 8.2.1.1 – 4 points, 8.2.1.2 – 4 points, 8.2.1.3 – 4 points		*Energy Efficiency (EE)* 703.1.3, 704.3.1 – up to 16 points
Safety and Security				
Fire-resistant Construction. Brick will not burn or emit toxic fumes.				
Impact-resistant Construction. Brick masonry resists damage from wind-borne debris and other impacts.				
Efficient Use of Materials				
Materials with Multiple Functions. Brick walls can serve as structure and finish, provide acoustic separation, and provide thermal mass.				*RE* 601.9 – 4 points
Materials Made with Less Content. Thinner brick units use less material and weigh less; hollow brick units use less material and can be reinforced.				*RE* 607.1 – 3 for each material
Foundations that Require Less Material. Pier and panel foundations of brick meet this practice.				*RE* 601.8 – 3 points
Structural Systems That Optimize Material Use. Engineering design, rather than empirical design, of brick walls provides better utilization of materials.				*RE* 601.2 – 3 points
Acoustic Comfort				
Acoustic Comfort. Brick walls provide an STC of 45 or higher	*ID* Credit 1.1 – 1 point	*Indoor Environment (IE)* 12.6.1.2 – 2 points		
Superior Indoor Air Quality				
Avoid VOCs. Interior brick walls avoid paints. Interior brick floors avoid carpets and adhesives.	*ID* Credit 1.3 – 1 point	*IE* 12.2.1.1 – up to 10 points	*ID* 3.1 – 1 point	*Indoor Environmental Quality (EQ)* 901.8 – 5 points
Masonry Fireplaces and Heaters. Fireplaces with gasketed doors, outside combustion air and a means of sealing the flue provide heat without compromising indoor air or heat loss. Masonry heaters of brick are energy efficient and clean burning.			*Indoor Environmental Quality (EQ)* 2.2 – 2 points, masonry heaters only	*EE* 703.2 – up to 15 points and *EQ* 901.2.1 – 4 points for fire-places; 6 points for heaters
Mold. With moisture-tolerant materials and finishes, brick is not a food source for mold and can be easily cleaned.		*IE* 12.2.2.1 – up to 5 points		
Miscellaneous				
Product manufacturer is ISO 14001 certified.				*RE* 610.1 – 1 point per percent up to 10 points

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SUMMARY

This *Technical Note* provides information on sustainability and sustainable design as it relates to brick manufacturing, use and recycling. The Brick Industry Association is committed to sustainable design and has adopted the following environmental policy statement:

> The brick industry recognizes that the stewardship of our planet lies in the hands of our generation. Our goal is to continually seek out innovative, environmentally friendly opportunities in the manufacturing process and for the end use of clay brick products. As demonstrated over time, we are committed to manufacturing products that provide exceptional energy efficiency, durability, recyclability, and low maintenance with minimal impact on the environment from which they originate. We will ensure that our facilities meet or exceed state and federal environmental regulations, and we will continue to partner with building professionals to help them in using our products to create environmentally responsible living and working spaces for today's and future generations.

REFERENCES

1. "2008 National Green Building Standard" National Association of Home Builders, www.nahb.org, Washington, DC, January 2009.
2. ASTM E2114-06a, "Standard Terminology for Sustainability Relative to the Performance of Buildings," Vol. 4.12, ASTM International, West Conshohocken, PA, 2006.
3. "Building for Environmental and Economic Sustainability, BEES 4.0," National Institute of Standards and Technology, Gaithersburg, MD, www.nist.gov, May 2007.
4. "Building Loads Analysis and System Thermodynamics (BLAST)," University of Illinois, Building Systems Laboratory, Urbana, IL, www.wbdg.org/tools/blast.php, June 2007.
5. "EnergyPlus, U.S. Department of Energy", Washington, DC, www.eere.energy.gov/buildings/energyplus/, June 2007.
6. "Environmental Resource Guide," American Institute of Architects, John Wiley & Sons, New York, NY, 1998.
7. "Environmental Stewardship & Employee Health and Safety Programs Awards," Brick Industry Association, Reston, VA, April 1, 2007, press release.
8. "Green Globes: Green Building Assessment Protocol for Commercial Buildings, Public Review Draft," Green Building Initiative, Portland, OR, www.thegbi.org, April 10, 2009.
9. "High Performance School Buildings Resource and Strategy Guide," Second Edition, Sustainable Buildings Industry Council, Washington, DC, www.sbicouncil.org, 2003.
10. "LEED for Homes," U.S. Green Building Council, Washington, DC, www.usgbc.org, January 2008.
11. "LEED Reference Guide for Green Building Design and Construction," U.S. Green Building Council, Washington, DC, www.usgbc.org, 2009.
12. Mazria, Edward, AIA, "2030 Challenge," Architecture 2030, Santa Fe, NM, www.architecture2030.org, April 2007.
13. Rand, J. Patrick, AIA, "Designing Masonry for Durability and Sustainability," as presented to the University Professors' Masonry Workshop, Louisville, KY, March 2007.
14. Roodman, D.M., and N. Lenssen, "A Building Revolution: How Ecology and Health Concerns are Transforming Construction," Worldwatch Paper 124, Worldwatch Institute, Washington, DC, www.world-watch.org, March 1995.
15. "Whole Building Design Guide," National Institute of Building Sciences, www.wbdg.org, April 2007.