Honeywell

Environmental Benefits of Closed-Cell Spray Polyurethane Foam: A Preferred Insulation for High-Performance and Green Building Design

Key attributes associated with high-performance and green building designs include energy efficiency, occupant comfort and material durability. A focus on green building standards and more stringent code requirements have led to adoption of best practices in construction materials and methods. Among those is the use of more efficient insulation systems, air barriers and seamless monolithic roofing systems. Use of closed-cell spray polyurethane foam (ccSPF) can help architects, engineers, contractors and owners/developers more easily meet the stringent requirements of modern, sustainable building design. CcSPF provides excellent performance and environmental benefits as outlined in the following.

Growth in Green Building Practices

Volatile and increasing energy prices, concern over environmental impact, and occupant health and comfort — these are just some of the drivers of green building today. In fact, these trends are of paramount importance for residential, commercial and institutional building owners. Many building performance experts believe that the current state of energy consumption and carbon emissions in the United States requires a stark redirection of current design and construction approaches. Therefore, green building practices continue to grow in importance and acceptance by architectural and design communities.

For example, in March, 2012, The American Institute of Architects (AIA) announced its support for the International Green Construction Code (IgCC), a new code expected to help conserve energy in both commercial and residential buildings while providing direction for safe and sustainable building design and construction. According to a McGraw-Hill Construction outlook[1], the green building market is growing dramatically:

- Nonresidential green building will be 48 percent of new construction by 2015.
- Single family green homes will comprise up to 38 percent of new homes by 2016.
- Tangible business benefits — such as ROI, occupancy and rent increases — from "green" are reported by commercial building owners…and consistent over time.

In February 2013, McGraw-Hill Construction announced its latest SmartMarket Report[2], "World Green Building Trends — Business Benefits Driving New and Retrofit Market Opportunities in Over 60 Countries." This report aims to discern trends and drivers of the global green building marketplace. According to the study:

- 89 percent of global industry professionals report using or specifying a green building product in 2012, and even more — 91 percent — expect to do so by 2017.
- The most significant green building product opportunities are in the categories of electrical, mechanical, and thermal and moisture protection with at least 60 percent of survey respondents stating that they had installed or specified products in these categories in 2012, with a slightly higher percentage expecting to do so by 2017.
- Firms are shifting their business toward green building, with 51 percent of respondents planning more than 60 percent of their work to be green by 2015. This is a significant increase from the 28 percent that said the same for their work in 2013 and double the 13 percent in 2008.
- This growth is not a trend localized to one country or region.

Despite increased demand for environmental performance, quantifying the green building benefits of specific technologies can be complex. It requires the evaluation of a long list of criteria in a full life cycle analysis (LCA) to determine overall product performance (related to manufactured products) and full system performance (related to buildings as a whole).

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Green Building Standards and Certifications

How do you know what is considered "green" or not? A number of organizations are available to assist with this determination, offering various standards and certification systems to the construction industry. These organizations provide a framework for selecting, using and evaluating materials and processes for building design and renovation with a goal of minimizing environmental impact. Some of these programs include:

U.S. Green Building Council – LEED

The U.S. Green Building Council (USGBC) offers the LEED Green Building Rating System™. Building projects earn points for satisfying green building criteria. LEED (Leadership in Energy and Environmental Design) is a voluntary, consensus-based, market-driven program that provides third-party verification of green buildings.

The Green Building Initiative – Green Globes

The Green Building Initiative (GBI) is a nonprofit organization whose mission is to promote credible and practical green building approaches for residential and commercial construction. Much like LEED, Green Globes is a performance-based green building rating system.

U.S. Environmental Protection Agency – Energy Star®

The U.S. Environmental Protection Agency (EPA) introduced ENERGY STAR as a voluntary labeling program designed to identify and promote energy efficient products to reduce greenhouse gas emissions. This voluntary program helps home and building owners save money and protect the environment through energy efficient products and practices.

In addition to these programs, other green programs are available. Also, a number of federal and state tax incentives are available to homeowners and builders who take measures that contribute to reducing energy consumption.

Closed-Cell Spray Polyurethane Foam: An Excellent Choice for Green Building

With many of these green building programs focusing on energy efficiency, it is not surprising that the choice of insulation materials/air barrier systems can have a significant impact. One such insulation that has proven to be a preferred choice for green building initiatives is closed-cell spray polyurethane foam (ccSPF). As you consider ccSPF for new construction or retrofit projects, it's important to examine what makes it so unique.

What is ccSPF Insulation?

CcSPF is spray-applied on site to air seal and insulate wall cavities, crawl spaces, attics and basements. It is also used to insulate exterior walls and as a roofing system. Professional SPF contractors mix the foam ingredients at the job site. It is sprayed as a liquid that immediately expands to approximately 30 times its original volume upon installation. As it expands into foam, it adheres and contours to the spray surface, filling in cracks and crevices that can cause air and water infiltration. It is used extensively for both commercial and residential projects.

How Does ccSPF Offer Environmental Benefits?

There are many factors to consider when selecting high-performance and "green" insulation systems. CcSPF stands apart from alternative insulations due to its unique combination of thermal and air sealing performance, water resistance, self-adhesion and structural strength. This combination allows ccSPF to:

- Provide superior thermal performance, including unparalleled air sealing which improves overall building envelope performance.
- Lower energy use in buildings, which in turn can reduce carbon emissions and lower costs.*
- Prevent air leakage, reducing the load on heating and cooling systems (HVAC sizing can be reduced providing cost savings and environmental benefits without the loss of efficiency and comfort)[3]
- Provide moisture protection, which can improve indoor air quality (helping prevent mold and mildew issues).
- Add structural integrity, which can increase building durability and longevity.
- Be applied to commercial roofs as a recoat vs. tear-off. Because ccSPF roofing systems are so durable, they can have a serviceable life of more than 30 yrs. versus a traditional roof of 10–20 yrs. They can be recoated easily, at a minimal cost, diverting very little material to landfills.
- Rate very well in life cycle analysis studies.

As an added environmental benefit, polyols (a key ingredient in ccSPF production) are increasingly being made with renewable resource-based content, e.g., soy-based polyols. Another key component of ccSPF that enables many of its attributes is the use of a high-performance foam blowing agent.

Advancements in ccSPF Foam Blowing Agents

What causes ccSPF to expand? It expands through the use of a foam blowing agent, which helps create tiny bubbles or cells in the foam. High-performance foam blowing agents help provide excellent insulating properties, similar to the way insulating gas is used in double-pane glass for windows. An example is Honeywell's Enovate® foam blowing agent (HFC 245fa), a nonflammable, non-ozone depleting blowing agent used in many ccSPF products worldwide. It is approved by the EPA under the Significant New Alternatives Policy[4] (SNAP) to replace ozone depleting substances.

Honeywell also offers an exciting fourth-generation product — Solstice™ Liquid Blowing Agent (LBA) — a low global warming potential (LGWP) foam blowing agent. Solstice LBA is an important alternative to help meet evolving requirements for green codes and standards. While many of its properties are similar to current ccSPF blowing agents, Solstice LBA has a low global warming potential (GWP) of 1. This GWP is equal to that of CO_2 and orders of magnitude lower than current HFCs used in the industry. As a near drop-in replacement for other liquid blowing agents (e.g., HFC 245fa or 365mfc/227ea), Solstice LBA is not only a preferred environmental choice, but also a cost-effective one.

Closed-Cell SPF Compared to Open-Cell SPF

When selecting spray polyurethane foam, it is important to note that closed-cell foam (ccSPF) is different than open-cell spray polyurethane foam (ocSPF). CcSPF is generally preferred for air barrier applications. It is significantly more dense and rigid when compared to ocSPF. Due to its rigidity, ccSPF can improve building durability and structural strength. It can be applied in all climates and is also the preferred material for severe weather conditions. CcSPF also provides higher insulating properties (typical R-value** > 6.0 per inch at 75°F) than ocSPF (typical R-value** of about 3.5 per inch at 75°F). In addition, ccSPF is water resistant which enables its use on exterior continuous wall installations, as well as roofing applications. In fact, ccSPF is the only FEMA[5] approved insulation for extended moisture exposure and contact.

OcSPF is susceptible to moisture absorption and typically is used for air sealing. OcSPF is not suitable for below-grade or flood-prone sites because it will absorb water. For more information about closed-cell and open-cell SPF, visit the Center for the Polyurethanes Industry (CPI) or the Spray Polyurethane Foam Alliance (SPFA). You can also visit **www.whysprayfoam.org.**

Life Cycle Analysis for ccSPF

To fully assess the environmental impact of insulation, one must consider the overall impact of manufacture, service and disposal. A common tool for evaluating this impact is life cycle analysis (LCA) and a common measure for this is the embodied energy (often expressed as carbon footprint) associated with that product. Although there are many ways to evaluate the carbon footprint of a product, the ISO 14040 series of standards are the current internationally recognized LCA method. The LCA comparison avoids pitfalls associated with current single attribute measures, which often do not provide a measure of true environmental impact.

Spray Polyurethane Foam Alliance (SPFA) LCA Study

The SPFA completed an LCA for spray polyurethane foam insulation in 2012 which conformed to the ISO 14040/44 standards. This study is the first comprehensive LCA of spray foam insulation conducted in North America and evaluated both open-cell and closed-cell SPF products. Specific to ccSPF, the SPFA analysis evaluated the environmental impact of using current ccSPF products in single-family residential, as well as commercial roofing structures in three different climate zones of the U.S. **Figure 1** depicts the basic components of a comprehensive ccSPF LCA. Note that in the "building and use" phase, the benefit of energy savings attributed to ccSPF offsets any product environmental impact.[6]

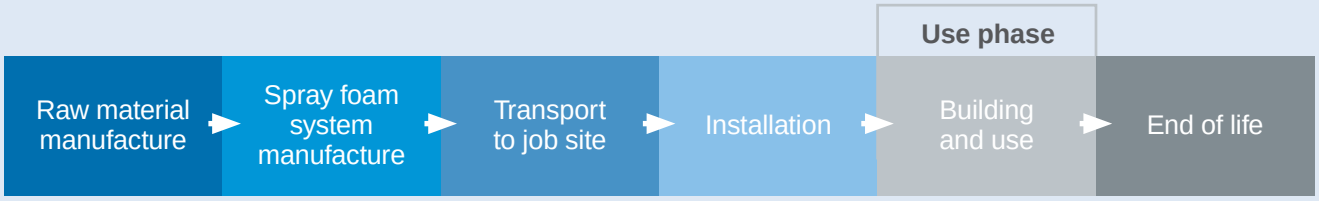


Fig. 1: Basic components of an LCA for ccSPF

SPFA LCA Results

According to the LCA results, the SPFA concluded:[7]

- Spray foam products save significantly more energy and prevent more environmental impacts during the life of the insulation in a building compared to the relatively minor energy and environmental impacts associated with making the insulation.
- Primary energy investment is recovered in less than two years for ccSPF.
- Greenhouse Gas (GHG) releases are recovered in less than eight years for ccSPF.
- For all environmental categories studied, embodied environmental impacts from manufacturing are minimal when compared to environmental impacts avoided during insulation use over a 60-year period.

To view the SPFA's complete LCA analysis, visit **www.sprayfoam.org**.

Honeywell ccSPF Blowing Agent LCA Study

To expand on the SPFA LCA study, Honeywell repeated the study[8] and substituted data for Solstice LBA as a replacement low global warming potential (LGWP) blowing agent in the application. Therefore, the assumptions used in the embodied energy and use phase of the Honeywell study are identical to those used in the SPFA study except for the blowing agent data.† The findings focused on two main parameters of ccSPF containing Solstice LBA: the total embodied energy and GWP payback.

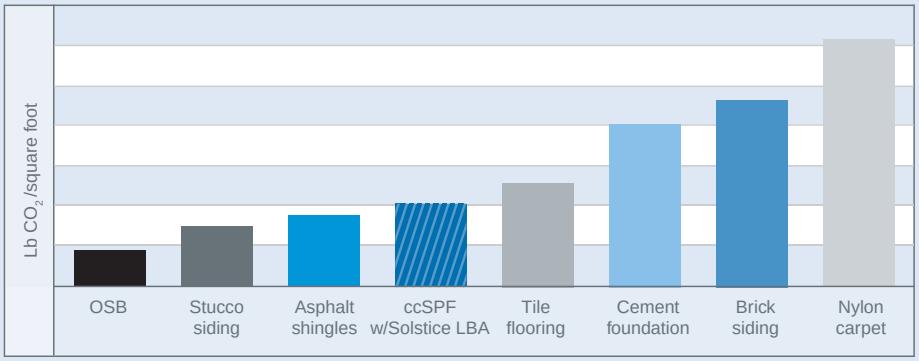


Fig. 2 Relative environmental impact of common construction products

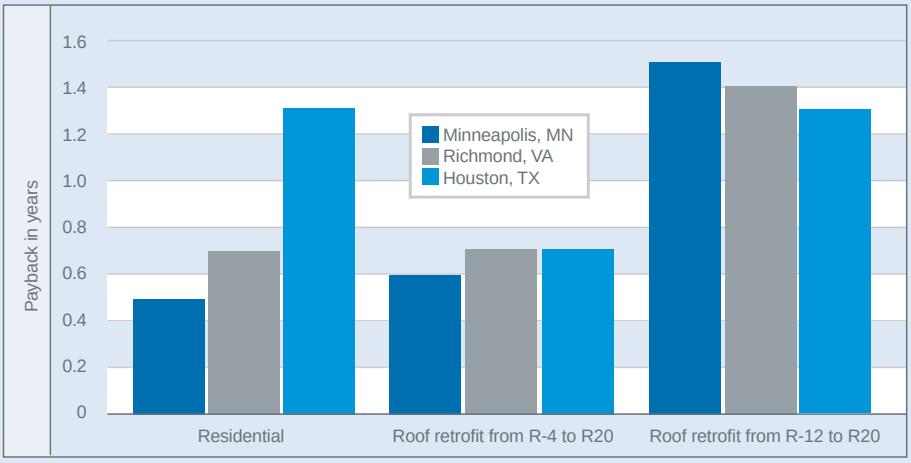


Fig. 3: CcSPF with Solstice LBA – GWP payback period

Honeywell LCA Results

Figure 2 provides a relative comparison for the carbon footprint of general materials used in construction. The study shows that ccSPF with Solstice LBA has a relative lower environmental impact (CO_2 equivalence per square foot) compared to commonly used construction materials, such as nylon carpeting or brick siding.

In addition to having a lower carbon footprint than commonly used construction materials, ccSPF insulation containing Solstice LBA provides considerable energy savings over the life of a project. The GWP payback is a measure of the time in which the environmental impact of a product is paid back through a benefit offered, in this case energy savings. **Figure 3** shows the GWP payback periods associated with using ccSPF with Solstice LBA in the residential and commercial roofing applications. Within as few as six months, ccSPF with Solstice LBA starts providing a net environmental benefit for the remainder of the project service life.

To view LCA details, visit **www.honeywell-blowingagents.com.**

General LCA Findings Compared to Other Insulations

Many spray foam manufacturers have commissioned LCAs for their specific products, and results vary based on the formulation. However, generally speaking, these LCAs show that ccSPF in comparison to other insulation systems:

- Increased energy efficiency by providing twice the R-value** of traditional materials, along with serving as an integrated air and moisture barrier
- Protected against “thermal bridging” commonly found in commercial buildings which often contain steel framing (see Energy Efficiency section). This can reduce energy consumption and lower operating costs.*
- Reduced landfill diversion and cost, as installation of ccSPF produces little waste to be diverted to landfill.
- Reduced transportation cost, as ccSPF is transported as a liquid precursor and is therefore compact and lightweight to transport.
- Increased durability when compared to traditional systems, as ccSPF provides superior protection against moisture, as well as increased racking strength and wind resistance. This can help prolong building life and improve occupant comfort. Research demonstrates that ccSPF can add from 75 to 200 percent racking strength to walls of OSB, plywood, light gauge metal, vinyl siding or gypsum board.[9]

Cleveland Airport Roofing Project utilizing Honeywell Solstice™ LBA

Green Building Drivers

In addition to the LCA method, other models (e.g., LEED and Green Globes) typically focus on a number of green building drivers: Energy Efficiency; Site Selection and Sustainability; Material and Resource Use; Indoor Environmental Quality and Innovation/Design. Let's take a brief look at these topics.

Energy Efficiency and the Building Envelope

Generally, energy efficient construction begins with building envelope performance. A high-performance building envelope involves two significant factors: high levels of effective insulation and a superior air barrier system. The effectiveness of air barrier systems vary depending on many factors, including the type of air barrier assembly, material choices, installation quality and how well the system is integrated into the overall building enclosure.

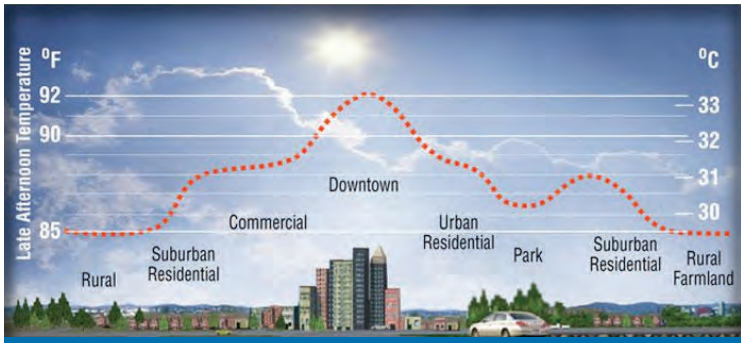
Not only does ccSPF provide the highest R-value** per inch of any insulation system, it also acts as an air barrier that provides a solution to "thermal bridging." In commercial buildings, this is particularly significant. "In commercial buildings, you're often dealing with steel studs, and steel conducts energy and heat about 1,000 times faster than wood or vinyl," says Steve Easley, a building science consultant. In steel stud walls, thermal bridges generated by steel components reduce thermal performance by up to 55 percent.[10] This reduced insulation effectiveness can lead to lower wall cavity temperatures, which may lead to condensation and moisture problems. The Department of Energy recommends using "thermal blocks" to combat issues with thermal bridging. Because ccSPF systems do not require metal fasteners and can continuously cover existing thermal bridges, this can reduce or eliminate thermal bridging effects.

Site Selection and Sustainability

The urban heat island effect is a considerable issue in metropolitan areas, where the lack of vegetated ground cover can lead to temperature differentials of 6–8° F.[11] **See Figure 4.**

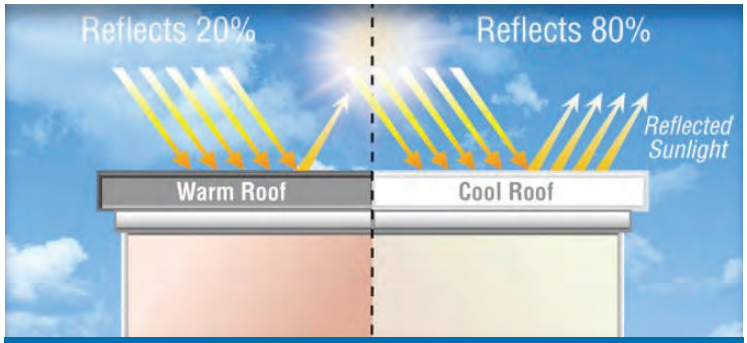
This temperature increase dramatically impacts energy use, mechanical system operation, indoor air quality, and comfort. Lawrence Berkeley National Laboratory (LBNL) studies to reduce the urban heat island effect have focused largely on cool roofs – systems that use light-colored, reflective roof coatings that can dramatically reduce energy use and, if widely used, can help reduce temperatures in urban areas. **See Figure 5**.

CcSPF roofing systems provide an excellent commercial cool roof solution because they can be combined easily with high-reflectivity, low-emissivity (low-E) roof coatings. They can also be used under vegetated roofs to reduce roof surface temperature and increase building performance. In addition, ccSPF roofing systems are very effective for reroofing over existing standing seam metal and other (built-up, modified bitumen, or single-ply) roof systems.



On a sunny summer afternoon, urban air can be 1–3°C (2–5°F) warmer than nearby rural air. The elevated air temperatures associated with this "urban heat island" (UHI) make air conditioners work harder to keep buildings cool, which can strain the power grid. They also accerlerate the formation of smog, degrading air quality.

Fig. 4 LBNL Heat Island Group



On a typical sunny summer afternoon, a clean white roof that reflects 80% of sunlight will stay about 30°C (55°F) cooler than a gray roof that reflects only 20% of sunlight.

Fig. 5 LBNL Heat Island Group – Cool Roofs

Material and Resource Use

Another significant green building driver centers on reducing or diverting construction waste and the associated issue of material durability. The EPA estimated that 136 million tons of building-related construction and demolition materials were generated in the U.S. in 1996.[12] This has grown considerably. The majority of this waste comes from building demolition and renovation, and the rest comes from new construction. Because ccSPF is applied on site by professionals who use only as much material as is needed, construction waste is greatly minimized. More significantly, prolonging building life can reduce resource consumption and waste generation resulting from building replacement.

Surveys[13] conducted by Dr. Dean Kashiwagi have documented the exceptional durability of ccSPF roofing systems. The studies evaluated thousands of ccSPF roofing systems in six U.S. climate zones and concluded that of all the roofs:

- 97.6 percent did not leak
- 93 percent had less than one percent deterioration
- 70 percent were applied over existing roofs

The oldest performing roofs were more than 26 years old. Fundamentally, the studies demonstrated that the physical properties of ccSPF roofs did not diminish over time and highlighted their sustainability.

Advancements in ccSPF Foam Blowing Agents Durability and Green Building: Texas A&M Case Study

Building(s): Texas A&M University

Location: College Station, TX

Profile: With ccSPF covering over 90 percent of the 10 million square feet of roofing on their buildings, Texas A&M is an outstanding example of proven sustainability and energy efficiency. In the 1970s, the university was looking for alternatives to its traditional built-up roof systems, which had suffered significant leaks after only a few years of service. CcSPF roof systems were used on many Texas A&M buildings, with energy savings being monitored on the 27 buildings that had been retrofitted with SPF roofs between 1980 and 1984. Results showed a payback in energy savings of 4.5 years on average. The systems, many still in place today, boast high energy savings, low maintenance and replacement costs, and minimal disruption in occupant productivity.

Indoor Environment

HVAC system performance, human activities, and emissions from building components and furnishings can dramatically impact indoor air quality (IAQ). Building envelope performance is paramount to good air quality. A poorly insulated, leaky envelope can result in condensation and mold growth, as well as invasion by outside contaminants into the conditioned space — not to mention reductions in energy efficiency. An airtight building envelope, in conjunction with controlled ventilation and fresh air make-up, is key to controlling pollutants, VOCs and other contaminants that may affect IAQ. The use of ccSPF can improve IAQ because it acts as an integral air barrier and also functions as a vapor retarder. Also, it can help meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy.

Innovation and Design Process

Under LEED, for example, Innovation and Design credits provide architects, engineers and specifiers an opportunity to promote the merits of ccSPF roof systems. CcSPF can contribute to innovation credits for acoustical performance, reducing construction waste (e.g., reuse of existing roofs), variable and renewable raw materials sources (e.g., soy polyols), superior energy efficiency and reduced freight. These are just some of the ways that ccSPF contributes to sustainability in innovation and design.

CcSPF Insulation: A Preferred Choice for Green Building

As we've seen, the choice of insulation/air barrier systems is critical to green building design and construction. As designers, builders and owners strive to improve building performance and sustainability, ccSPF is an essential part of the solution. Although there are many materials that claim to provide environmental or "green" benefits, ccSPF's unique combination of superior air sealing/insulating capabilities, moisture resistance, strength and durability make it a preferred choice. CcSPF insulation helps address core issues associated with the energy, moisture and durability of a building in an all-in-one solution. Along with its environmental benefits, ccSPF continues to grow in popularity due to its ability to simplify the insulation/air barrier design process, compatibility with other materials and ease of application.

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*Savings vary. Find out why in the seller's fact sheet on R-values. Higher R-values mean greater insulating power.
**Check your SPF seller's fact sheet for specific R-values when comparing SPF to other insulations.
® Energy Star is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy.
† At the time of the LCA, Solstice LBA had a GWP of <5. It has now been shown to have a GWP of 1. Therefore, LCA results may be even more favorable.

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November 2013 Printed in U.S.A.