American Plastics Council®

The Technology of Plastics

*One in a Series*

# Enjoying the Energy Efficiency of Plastics

*Photo courtesy Custom Remodeling Ltd.*

*In a marketplace where customer demands for higher performance and lower costs are ever increasing, architectural and construction firms are continually striving to improve the quality of the building envelope. The remarkable insulating properties of plastics are being used in a variety of ways to help commercial and residential customers keep a lid on the high costs of heating and cooling buildings.*

*Construction materials that make extensive use of plastic include roofs, windows, house wrap, structural insulated panels, insulating concrete forms, and exterior insulation and finish systems.*

With the price of petroleum reaching record levels, energy efficiency in the built environment becomes increasingly important. The Department of Energy reports that 40% of the cost of heating and cooling a building can be wasted by uncontrolled air leakage through the building envelope.

Infiltration through walls, roofs, and windows can result in higher operating costs, loss of comfort, poor indoor air quality, and premature building deterioration.

An estimated 54% of energy consumption in the U.S. is related to buildings and their construction. The escalating price of petroleum has brought the issue of energy-efficient construction into sharper focus, but equally important is the fact that many of the world's major energy fuels are nonrenewable resources. Energy-efficient, or "green," construction is a growing trend and a key aspect of the conservation effort.

## How Plastics Help

Plastics are very poor conductors of thermal energy, a feature that makes them superb insulators. When specified properly as part of roofs, walls, and foundations—the building envelope—plastics can help architects, engineers and contractors create much more energy-efficient buildings, which can, in turn, reduce the consumption of fuels needed to heat those structures and to produce the electricity powering the air conditioning equipment that cools them.

Improving the quality of the building envelope is one of the best ways to improve specific elements of overall building performance. While one of the primary reasons for tightening the building envelope is energy efficiency, the goal of durable buildings with healthier indoor environments is driving the trend toward plastics-engineered building envelopes.

Strong thermal insulating properties, virtual air impermeability, solid environmental and fire characteristics, durability, and low maintenance are just a few of the reasons behind the growing use of plastics in all types of building applications. In a one-year study, plastics saved 467.2 trillion Btu's of energy over alternative construction materials, which is enough energy to meet the average annual needs of 4.6 million households.

## The Nature of Plastics

To appreciate the role of plastics in modern construction, it helps to first understand the innovative chemistry behind these advanced materials. Fundamentally, all plastic materials are made up of large molecules called polymers. A polymer is essentially a series of structural units, called monomers, linked together to form a chain. By selecting different monomers and linking them in different ways, scientists have found they can create products with widely varying sets of attributes.

Much of polymers' value lies in their incredible diversity. Interestingly, no matter what other properties they may possess, plastics are universally characterized by three traits that can be extremely valuable in construction: 1) excellent insulation properties; 2) very high strength-to-weight ratios; and 3) formability. These features make plastics especially useful in helping contractors make more energy-efficient buildings that require fewer resources and are easier to maintain.

## Plastic Construction Materials

There are 40 different categories of plastic—and multiple grades of each type. Some of these plastics are extremely well suited to energy-conserving construction applications. The majority of plastic materials employed in construction fall into one of the following categories: polyvinyl chloride, polyurethane, expanded polystyrene, or polyolefin.

## Polyvinyl Chloride

More polyvinyl chloride, or simply vinyl, is used in construction than any other plastic and, as such, is often referred to as the "infrastructure plastic." Vinyl is used so widely in construction because of its durability, easy installation, and cost-effectiveness. What's more, the chlorine content in vinyl makes it inherently flame resistant.

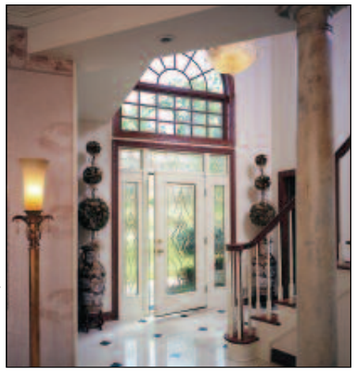

Photo courtesy ThermaTru

*Fiberglass entry doors and windows offer durability, safety and architectural beauty.*

Vinyl is also highly energy efficient. A 1991 study conducted by Franklin Associates found that the use of vinyl in eight major building applications saved an estimated 260 trillion Btu's per year, which is the equivalent of 44.2 million barrels of oil, or 260 billion cubic feet of natural gas. In construction, three applications in which vinyl can provide energy conservation solutions for the business envelope are roofing, windows, and siding. Some products carry the ENERGY STAR designation from the U.S. EPA and Department of Energy, meaning that these products perform as well as or better than comparative products while using less energy and saving money.

Vinyl membrane roofs—a clean, safe, energy-efficient and less costly alternative to asphalt built-up roofs—can withstand years of wear and tear and remain watertight under demanding weather conditions while reducing a building's energy consumption. They are also naturally fire retardant. All ENERGY STAR-qualifying vinyl roofing systems have a solar reflectivity of at least 0.65—meaning that 65% of the solar heat is reflected. Some manufacturers offer roofs reflecting in excess of 80%. Asphalt built-up roofs, by comparison, reflect between 6-12% solar heat.

Vinyl windows offer the same performance characteristics of windows made of traditional materials, with the added benefits of high thermal energy efficiency, low maintenance and high durability. The American Architectural Manufacturers Association certifies window products through an independent laboratory. Window profiles must also pass accelerated outdoor exposure tests in South Florida, Arizona and northern industrial climates for impact strength, wind load resistance, and heat buildup. In addition, the National Fenestration Rating Council qualifies windows for the ENERGY STAR rating based on the products' U-factor and solar heat gain coefficient.

Photo courtesy Certainteed

*Windows made of polyurethane and PVC can provide good insulation, rich architectural detail.*

Vinyl siding is a popular material choice for residential and commercial projects due to its durability, affordability, attractiveness, low maintenance and design versatility. ASTM D3679 standard for rigid PVC siding includes 12 different tests to evaluate the quality of vinyl siding, measuring such performance attributes as weathering, wind load resistance, impact resistance, surface distortion, and heat shrinkage. Certified products ensure that the quality standards established by ASTM D3679 are confirmed by Architectural Testing, Inc., a company specializing in comprehensive testing services for building envelopes.

## Polyurethanes

Polyurethane products most commonly employed in construction applications are adhesives and sealants, rigid foams, and flexible foams. In all types of buildings, polyurethane foam plays the role of maintaining continuity of the air barrier plane across the roof and walls and through the transition between both major components of the building envelope.

Most of the rigid polyurethane foam products are employed for insulating a variety of surfaces. Sheets of urethane foam can be attached to walls or roofing; they can also be used as the cores in insulated doors and panels, as moldings, and as decorative architectural accents. Some polyurethane foams are also designed to be sprayed in place, after which they dry and harden. The spray foam products are used on roofs and to a lesser extent on walls. They are particularly appealing on rough or irregular surfaces because they conform to the contours of the wall or roof and so form a seamless, uniform barrier.

Photo courtesy SPFA

*SPF forms a seamless layer of insulation and offers the potential for impressive energy savings.*

The insulating properties of polyurethane foams offer the potential for impressive energy savings. A study by Texas A&M University scientists found that the cost of applying spray polyurethane foam was completely offset by savings in fuel expenditures in less than three years.

## Polystyrene

Expanded polystyrene (EPS) and extruded polystyrene (XPS) foam possess superb insulating qualities. In construction applications, the original use for polystyrene foam was as a nonstructural sheathing material. More recent applications include insulated concrete forms, structural insulated panels, and exterior insulation finish systems. All three products have the potential for providing outstanding savings in energy costs.

Insulating concrete forms (ICFs) are essentially permanent molds for poured concrete walls. Conventional concrete walls are typically constructed with temporary forms that hold the

concrete in place until it has dried and cured sufficiently to stand on its own. At that point, the forms, a combination of steel frames and wood panels, are removed. The process is similar in walls made with ICFs, except the forms, which are either preformed blocks or panels of EPS or XPS foam attached to each other, remain as part of the wall structure.

Constructing a building with ICFs offers the potential for significant savings in heating and cooling costs. The Insulating Concrete Form Association estimates that ICF structures consume 44% less energy in heating and 32% less energy in cooling. This means that a homeowner with a 2000-ft$^2$ house in the Midwest would save $200 in heating costs and $65 in air conditioning costs if the structure were built with ICFs instead of conventional concrete walls.

Structural insulated panels (SIPs) are made by sandwiching a core of EPS or XPS (or in some instances, polyisocyanurate) between two thin slices of oriented strand board (OSB). The resulting composite is a strong, light building material with exceptional insulation properties. Contractors use SIPs in floors, walls, and roofs of residential and industrial buildings. SIPs also provide a barrier that helps to prevent the infiltration of outside air. As a result of both properties, experts project that building owners will be able to reduce energy usage by as much as 50% with SIPs.

Incidentally, the OSB panels that form the skins of the SIPs also make use of a plastic (polymeric) binder. OSB is an engineered, mat-formed panel product made of strands, flakes or wafers sliced from small diameter, round wood logs and bonded with an exterior-type binder under heat and pressure. The resin binder helps provide internal strength, rigidity and moisture resistance.

*Photo courtesy Reward Wall Systems*

*IFCs provide the potential for quicker construction practices and increased energy savings.*

Exterior insulation and finish systems (EIFS) consist of three main elements: 1) a layer of EPS or XPS insulation is adhesively or mechanically attached to the sheathing or structural substrate; 2) a durable acrylic-modified cement base coat applied to the foam and reinforced with a glass fiber mesh; 3) a finish very similar to a conventional architectural coating. As in the case of ICFs and SIPs, EIFS constructions have the potential for significant savings on energy costs. They reduce air infiltration by 55%, and they can increase an exterior wall's R insulation value by as much as 50%.

## Polyolefins

Polyolefins are used mostly as woven fiber sheets fastened to the outside of the frames of new buildings to help reduce air infiltration. Studies have shown that house wrap can reduce air infiltration by anywhere from 10 to 50%, potentially helping to achieve a significant savings in energy cost and possibly reducing the amount of air pollutants that find their way into the structure.

## Conclusion

Clearly, plastics are playing pivotal roles in modern construction. Their superb insulating properties help reduce operating costs, improve occupant comfort and safety, and make construction "greener." Not only do they conserve energy, but they also last longer and so put less of a burden on scarce natural resources, and they often make for easier, simpler, and less expensive construction. For more information on their use in sustainable design and construction, visit www.greenbuildingsolutions.org.