THE ENERGY AND ENVIRONMENTAL BENEFITS of PVC

PVC building products have numerous energy and environmental benefits. Since the late 1980s, more than 20 life-cycle evaluations have been completed on PVC building products, many of them comparing those products to similar products made of other materials. PVC products were found to perform favorably in terms of energy efficiency, thermal-insulating value, low contribution to greenhouse gases and product durability, which means using fewer resources.

EXAMPLES:

Energy efficiency and reduced greenhouse gas emissions. PVC saves energy and reduces CO_2 emissions. PVC takes less energy to produce than many competing products, and 20 percent less than other plastics. PVC also saves fossil fuels. Its principal raw material (nearly 60 percent) is chlorine derived from common salt. PVC building products are highly energy-efficient. For example:

· ENERGY STAR roofing membranes made of PVC reflect solar energy

· ENERGY STAR vinyl window frames conserve energy

· PVC pipe requires less energy to pump water

Durability. PVC building products are highly durable, which conserves resources. They will not rot or corrode like many other materials and do not need cleaning with harsh chemicals or frequent painting.

Recycling. PVC is inherently recyclable. More than 1 billion pounds are recycled annually (mostly post-industrial), according to a recent study. Many carpet manufacturers using PVC backing have highly successful recycling programs, including C&A Floorcoverings (which has recycled over 100 million pounds of vinyl backed carpet). The Vinyl Institute recently won an award from WasteCap Wisconsin for support for recycling vinyl siding cutoffs at job sites.

Water savings. 2.2 trillion gallons of treated water are lost every year in the United States because of leaks from aging, corroded metal pipes. Because PVC pipes do not corrode and have among the lowest pipe breaks, they save precious water resources.

Life cycle analysis. PVC's impacts on the environment are comparable to or lower than most alternatives. A 2004 study of environmental life-cycle analyses (LCAs) of PVC and competing building materials by the European Commission (EC) found that PVC offers environmental benefits equal to or better than those of other materials in many applications.[1] The USGBC PVC Task Group reached similar conclusions in its draft report issued December 2004.

What about…

· **Dioxin?** PVC is an extremely small source of dioxin – so small that levels in the environment would be essentially unchanged even if vinyl were not being manufactured and used every day in important products. The proof: dioxin levels in the environment have been declining for decades, according to data from the U.S. Environmental Protection Agency. During this time, production and use of vinyl have soared.

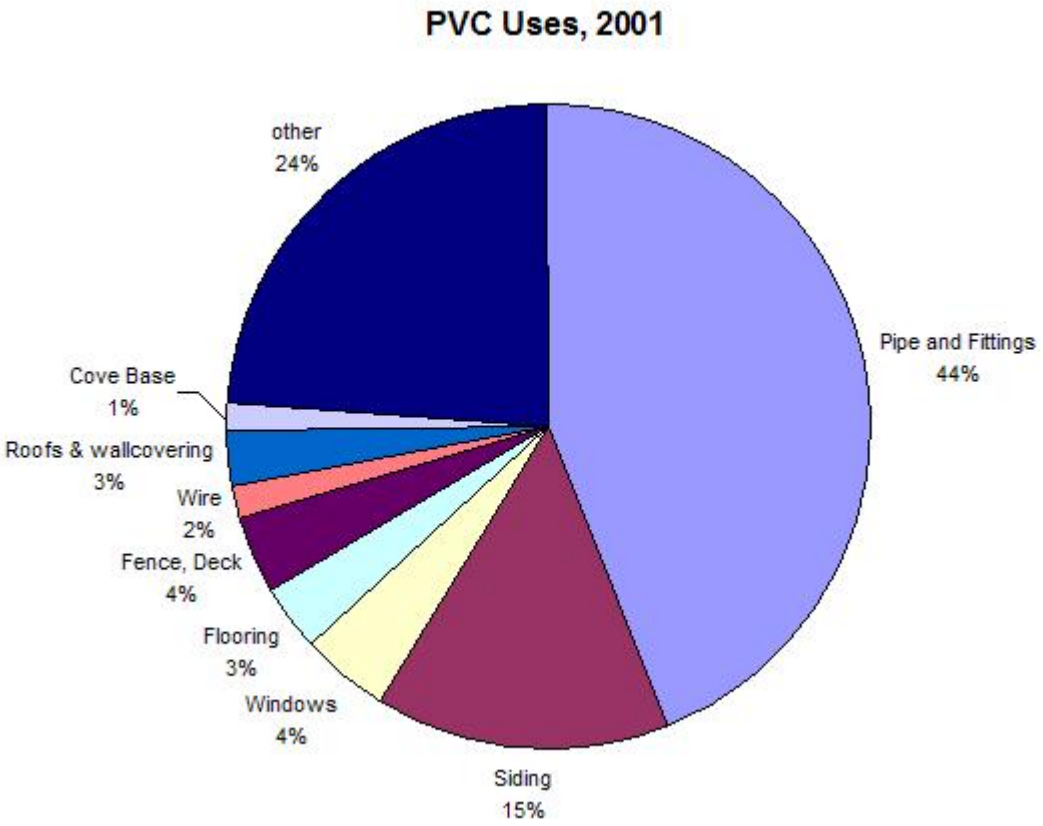
· **Worker safety?** OSHA statistics show that injury and illness rates among PVC workers are significantly less than the manufacturing average. In the 1970s, industry scientists discovered that vinyl chloride, a chemical used to make PVC, could cause angiosarcoma, a rare form of liver cancer, in workers exposed at that time to very high doses. This led to a complete overhaul of the PVC production process, which became essentially a closed loop, recycling wastes back into production and minimizing worker exposure. The U.S. Occupational Safety and Health Administration issued strict regulations in 1975, and there have been no documented cases of angiosarcoma among PVC production workers whose careers in the industry began after the new regulations were promulgated.

· **Indoor air?** Odors and "offgassing" from building products are generally due to dyes, adhesive, and additives. Many building-product manufacturers today are working to reduce use of volatile chemicals and release of their odors. Resilient PVC flooring that qualifies under the Resilient Floor Covering Institute's FloorScore™ program can be certified to help obtain the Green Building Council's indoor air credit under the LEED rating system. PVC-backed carpet can meet the comparable Green Label program of the Carpet & Rug Institute.

PVC in Building and Construction

Approximately 76 percent of PVC is used in building and construction.[2] The following overview of the major types of PVC building products discusses the reasons these building products are used.

PVC's durability is an important environmental benefit, because the longer a product lasts, the less energy and other resources must be expended to make and install replacement products. PVC also conserves energy in manufacture and, more importantly, in use.



PVC building and construction applications are typically divided into rigid and flexible categories. The use of plasticizers differentiates flexible PVC products from rigid. Generally speaking, PVC materials are classified as rigid when plasticizers have not been added to the resin, such as pipe, siding, windows, and fence, deck and rail. PVC flooring, wallcovering and reflective roofing are classified as flexible, and are available in a multitude of styles and colors.

PVC pipe and Fittings

Ø **Overview.** Pipes and fittings comprise the largest portion (44 percent) of PVC usage for building and construction. PVC has become the leading material for large diameter buried pipelines installed by both water and wastewater utilities as well as for smaller diameter drain waste and vent (DWV) piping. CPVC pipes are used for indoor water plumbing pipe. On a lineal basis, PVC has become the leading pipe material in the United States today, accounting for more than 70 percent of all water and sewer pipe now being installed. Alternative metal pipe materials (iron, steel, copper) are vulnerable to corrosion and premature failure. Concrete and clay pipe materials are prone to cracking or fracturing which results in leakage or contamination. PVC is certified for contact with drinking water by NSF International and offers complete immunity to electrochemical corrosion. PVC's flexibility

enables it to resist cracking and leakage.

On January 29, 2007, the state of California gave unrestricted approval to CPVC piping for residential plumbing based on a lengthy and thorough environmental impact review by the state's Department of Housing and Community Development. It had already been approved in 49 other states.

Ø **Energy efficiency and reduced CO_2 emissions.** PVC pipe manufacturing is energy efficient, consuming fewer BTUs than alternative materials for equal lengths of pipe. A Franklin Associates study has indicated that the manufacture of pressure piping used in the building, construction and transportation industries required 56,497 trillion fewer BTUs than iron and concrete/aggregate alternatives would require if they were substituted for all PVC pipe. PVC pipe and fittings also weigh less than alternative piping materials, allowing for significant energy savings in their transportation. Their lighter weight enables them to be installed more easily and efficiently than alternatives.

Ø **Resource conservation.** PVC pipe durability results in resource conservation. When properly designed and installed, PVC pipe has an estimated life span well beyond 100 years, with little or no loss of strength. The National Research Council of Canada found that the "break rate" for vinyl water distribution pipe was 0.5 breaks per 100 km (62 miles) per year as compared with 32.6 breaks per 100 km per year for cast iron and 7.9 breaks per 100 km per year for ductile iron.[3] Lower break rates minimize the risk of contamination and provide major savings in time and resources. Pipe breaks and water loss are major problems for water utilities with corroding metal pipes. According to the American Water Works Association approximately 15 percent of treated water is lost due to line breaks and leaks. That is 2.2 trillion gallons of water every year. A recent Federally funded study estimates that the corrosion of water and sewer pipes costs the US economy $36 billion annually.

Ø **Certification.** All PVC drinking water pipes are certified under NSF International's Standard 61, to assure the preservation of drinking water quality standards established by the US EPA.

Vinyl siding and exterior accessories

Ø **Overview.** Vinyl siding is the second largest use of PVC. It was used on 37 percent of all new residential construction in 2000. Its use has grown because of low maintenance, durability and affordability. It also performs well in life-cycle analysis. A comparison of vinyl siding to alternatives in the National Institute of Standards and Technology, Building for Environmental and Economic Sustainability (BEES 3.0) program shows that PVC vinyl's performance is comparable to that of aluminum siding and much better than brick and mortar, stucco and cedar siding.

Ø **Energy efficiency and reduced CO_2 emissions.** Vinyl siding is significantly lighter in weight than some alternative materials, such as brick or fiber cement, which saves energy and fuel in transportation. New vinyl products such as insulated siding can deliver up to four times the insulating power of ordinary siding, keeping houses warmer in winter and cooler in summer, reducing thermal conductivity, and providing better impact resistance and protection from outside noise and air infiltration.

Ø **Resource conservation.** Vinyl siding and accessories are durable products, which is increasingly being recognized as an advantage not only from an economic perspective but also from an environmental one. The longer a product lasts, the less energy or other resources that must be used to maintain the product or manufacture replacement products and the less scrap that must be disposed of. Vinyl siding manufacturers have improved yield to make more product with less vinyl. The vinyl siding industry has reduced material use, or material intensity, by 23 percent per unit of siding over the last 25 years while improving product performance and styling choices.

Ø **Ease of maintenance.** No paints, stains or harsh chemical cleaners need to be used to clean or maintain vinyl siding, helping to conserve additional resources and time.

Vinyl windows and glass doors

Ø **Overview.** Vinyl windows and doors are the third largest application for PVC. The use of vinyl windows has grown dramatically in recent years, accounting for approximately 56 percent of all residential units installed in 2000. Vinyl use in windows has grown

because of customer demand for improved energy conservation and low maintenance.

Ø **Energy efficiency and reduced CO_2 emissions.**

§ **Manufacturing phase:** Studies show that PVC vinyl windows require two-thirds less energy to manufacture than aluminum windows. The use of vinyl over alternatives in window frames saves the United States nearly 2 trillion BTUs of energy per year – enough to meet the yearly electrical needs of 20,000 single-family homes.

§ **Use phase:** PVC is an efficient insulating material for heat and cold, which means that vinyl windows maintain an even temperature, keeping them comfortable to the touch and decreasing condensation caused by indoor/outdoor temperature and humidity differentials. The design of vinyl window frames further enhances their energy efficiency by creating chambers in the frame that provide additional resistance to heat transfer and insulating air pockets.

Vinyl flooring

Ø **Energy efficiency.** Because of its durability, vinyl flooring does not require replacement as often as many other types of flooring. Durability is a significant benefit for the environment because less energy and other resources are needed to make and install new floors.

Ø **Resource conservation.** Both environmentally and economically, vinyl composition tile (VCT) outperforms two other flooring products – linoleum and recycled-content ceramic tile – based on the criteria developed by the U.S. National Institute of Standards and Technology's Building for Environment and Economic Sustainability (BEES) lifecycle assessment model. These criteria include indoor air quality, solid waste, acid rain, global warming and natural resource depletion. The BEES model for evaluating building products is being used by architects, builders, contractors and other specifiers to select products with reduced environmental impact. For example, a study conducted under the BEES program with funding from the EPA compared "natural" linoleum and VCT flooring and concluded that, when life cycle considerations were "quantified and combined using the EPA importance weights, the net effect is environmental scores slightly favoring vinyl composition tile."[4]

Ø **Indoor air quality.** Vinyl flooring will not adversely impact indoor air quality when installed according to the manufacturers' recommended procedures. Low-level emissions and odors associated with new vinyl flooring typically dissipate within the first 48-72 hours after installation. Low VOC products can be specified if needed.

Ø **Infection control.** Vinyl flooring products provide easy-to-clean surfaces, crucial in controlling pathogens and promoting a clean environment. In addition, sheet applications can be specified to have welded seams and coved corner joints for areas requiring sterile environments, such as operating rooms and bone marrow transplant units. Vinyl interior products are frequently specified in patient care areas as well as the public spaces of healthcare facilities for this specific reason.

Vinyl fencing, decking, railing and other outdoor living products

Ø **Energy efficiency.** Because of vinyl's durability and aesthetics, vinyl outdoor living products do not require replacement as often as many other outdoor building materials. Durability is a significant benefit for the environment because less energy and other resources are needed to make the replacement product.

Ø **Resource conservation.** Vinyl building products like decking and fencing do not require the use of paint, stain or harsh cleansers, and can directly replace other products that do require the use of these maintenance treatments on a continuous basis. In addition composite materials are available with recycled vinyl and wood floor. These composite products handle more like traditional wood but do not rot or require annual sealing.

Vinyl Coated Wire and Cable

Ø **Code Compliance.** All wire and cable products are required to meet a set of application specific performance standards including ultraviolet (UV) resistance, temperature (dry and wet), and flame retardancy. Vinyl jacketing of wire and cable has been used since World War II, when it was adopted by the US Navy following a fatal submarine fire aboard a vessel using natural materials.

Ø **Fire Safety.** As a polymer that resists combustion, vinyl is one of the few materials meeting the stringent National Fire

Protection Association (NFPA) requirements for insulating electrical and data transmission cables, including in plenum applications.

Ø **Resource Conservation.** Vinyl electrical products are extremely durable and can withstand a range of tough conditions, including exposure to the elements, abrasion during installation and use and more. The high abrasion resistance of vinyl wire insulation eliminates the need for a separate jacketing in many cases. Ultraviolet inhibitors give vinyl electrical products excellent weatherability. Vinyl can also be formulated to be resistant to oil, gasoline and most chemicals. Unlike many rubbers, it is inherently resistant to ozone. Vinyl has good dielectric strength, meaning that it can withstand relatively high voltages without breaking down, and high electrical resistivity, which makes it an excellent insulator. These factors have combined to make vinyl the preferred material in wire and cable.

Vinyl roofing

Ø **Energy efficiency and reduced CO_2 emissions.** Many PVC vinyl roofing membranes have been recognized by the ENERGY STAR Roof Products Program of the U.S. EPA and the U.S. DOE for their energy savings performance. Some manufacturers offer roofs reflecting in excess of 80 percent of solar heat. Benefits of using these products include extended roof life, reduced air-conditioning demand and lower surrounding air temperature (reduced "heat island effect"). Asphalt built-up roofs, by comparison, reflect between 6 percent and 26 percent solar heat. All ENERGY STAR-qualifying PVC roofing systems have been tested as having an initial solar reflectivity of at least 0.65 – meaning that 65 percent of the solar heat is reflected, and only 35 percent absorbed (and after three years, a solar reflectivity of 0.50 or greater). In a 2001 federal study, the Lawrence Berkeley National Laboratory (LBNL) measured and calculated the reduction in peak energy demand associated with a PVC roof's surface reflectivity. LBNL found that, compared to the original black rubber roofing membrane on the Texas retail building studied, a retrofitted PVC vinyl roofing membrane delivered an average decrease of 42º F in surface temperature, an 11 percent decrease in aggregate air-conditioning energy consumption, and a corresponding 14 percent drop in peak air-conditioning energy consumption. [5]

Ø **Resource conservation.** Lightweight PVC vinyl roof systems help reduce the dependence on steel and wood that are needed to support heavier roof system options. Vinyl roofing eliminates the need for asphalt, tar and other materials used in built-up roofing and is easily maintained without additional resource expenditures. They are also UV-protected, highly moisture resistant and require no maintenance for decades.

Ø **Outdoor air quality.** The light color of PVC vinyl roofing membranes has also been shown to have a positive impact on air quality. Reinforced thermoplastic vinyl roofing membrane has been recognized for its ability to optimize solar-reflective properties, scoring over 104 on the Solar Reflective Index (SRI). This is particularly significant because the SRI was designed to measure the relative reflective and thermal emissive performance properties of roofing surfaces on a scale of 1-100. In addition, NASA researchers found that summertime urban air temperatures can be greatly reduced by using such light roof surfaces as compared to dark-colored industrial/commercial roofing materials. Decreases in urban air temperature can substantially improve air quality, since smog is the result of photochemical reactions that are triggered by air temperature increases. PVC vinyl roofing membranes – when installed on multiple buildings in an urban setting – can diffuse heat within a city and assist in lowering air-conditioning consumption, thereby helping to lessen smog formation.

The process of removal or replacement of existing vinyl roofing membranes releases little or no airborne contaminants. In addition, during installation of vinyl roofing systems, fumes and odor levels are much lower compared with hot kettles, open flame and asphalt or coal tar used to create built-up roofs. And, because vinyl membranes can be hot-air-welded together, there is less need for high-solvent adhesives to close the seams.

Ø **Planted roofs.** PVC vinyl roofing membranes can be installed over existing roofs and serve as a vital component in planted roof systems. Employing multi-layer soil and drainage systems, vegetation can grow on urban roofs resulting in energy efficiency of buildings, beautiful green urban rooftops and cleaner air.

Vinyl wallcoverings

Ø **Energy efficiency.** According to the Chemical Fabrics and Film Association, the energy required to manufacture vinyl wallcoverings is only half as much as the amount needed to produce the same amount of paper wallcoverings.[6]

Ø **Indoor air quality**. Because vinyl wallcoverings are so easy to clean, they make it easy to remove sources of known allergens, thereby improving indoor air quality. This is also helpful in controlling pathogens and promoting a sterile environment in healthcare settings. Like many interior products, vinyl wallcoverings may have an initial odor when newly installed. This odor results from adhesives, printing inks and additives that give the vinyl its particular performance attributes. Often, complaints from building occupants about irritation and odor are associated with volatile organic compounds (VOCs). These compounds can originate from

many sources, including cleaning solutions and interior materials. To reduce exposure to VOCs, check with the manufacturer for low-emitting and low-odor products. Good ventilation is also critical for good indoor air quality. Ventilating with up to 100 percent outside air can reduce the initial period of emissions. Information on "airing out" times published in the product literature should always be observed. Tests by independent laboratories have shown that, with adequate ventilation, the initial odor in vinyl wallcoverings will dissipate much faster than the odors of most paints.

Ø **Infection control.** Vinyl wallcoverings provide easy-to-clean surfaces, helpful in controlling pathogens and promoting a sterile environment. Vinyl interior products are frequently specified in patient care areas as well as the public spaces of healthcare facilities for this specific reason.

Recyclability and Disposal Issues

PVC's inherent durability allows PVC vinyl products to serve long useful lives, preventing the waste generated when less durable products are used.

As a thermoplastic, it is important to note that all PVC products are recyclable. Recycling facilities across North America accept both post-consumer (i.e., material that has been used for its intended purpose and is being recovered for recycling) and post-industrial (the scrap left over from a product manufacturing process) PVC scrap. A database of PVC vinyl recyclers and companies manufacturing products from recycled vinyl is available on www.vinylindesign.com.

Many manufacturers make products using recycled PVC content – for instance, some vinyl carpet backing systems are made of 100 percent recycled materials, representing many tons of vinyl scrap per year that would otherwise go to a landfill. For PVC pipe, recycling is seldom an issue because the product stays on the job almost indefinitely, providing decades of reliable service. PVC vinyl roofing membranes can be recycled into such second-generation products as speed bumps, parking curbs and asphalt patching material.

If recycling is not economical and PVC scrap must be landfilled, it can be trusted to remain safely inert under normal landfill conditions. PVC is so stable in landfills that vinyl membranes have been used as landfill liners and caps. A recent study conducted by the Vinyl Institute analyzed vinyl scrap under simulated landfill conditions and found that there was little if any degradation of the material.

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[1] http://ec.europa.eu/enterprise/chemicals/sustdev/pvc-final_report_lca.pdf.

[2] The Resin Review: The Annual Statistical Report of the U.S. Plastics Industry, American Plastics Council 2002.

[3] B. Rajani and S. McDonald, "Water Main Break Data on Different Pipe Materials for 1992 and 1993," National Research Council, Ottawa, Ontario, 1995.

[4] B.C. Lippiatt, "Economic and Environmental Performance for Tile/Glass, Linoleum and Vinyl Tile Using the BEES Model," National Institute of Standards and Technology, 1998.

[5] S. Konopacki and H. Akbari, "Measured Energy Savings and Demand Reduction from a Reflective Roof Membrane on a Large Retail Store in Austin," Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, June 2001.

[6] "Facts & Information," a publication of the Chemical Fabrics & Films Association.