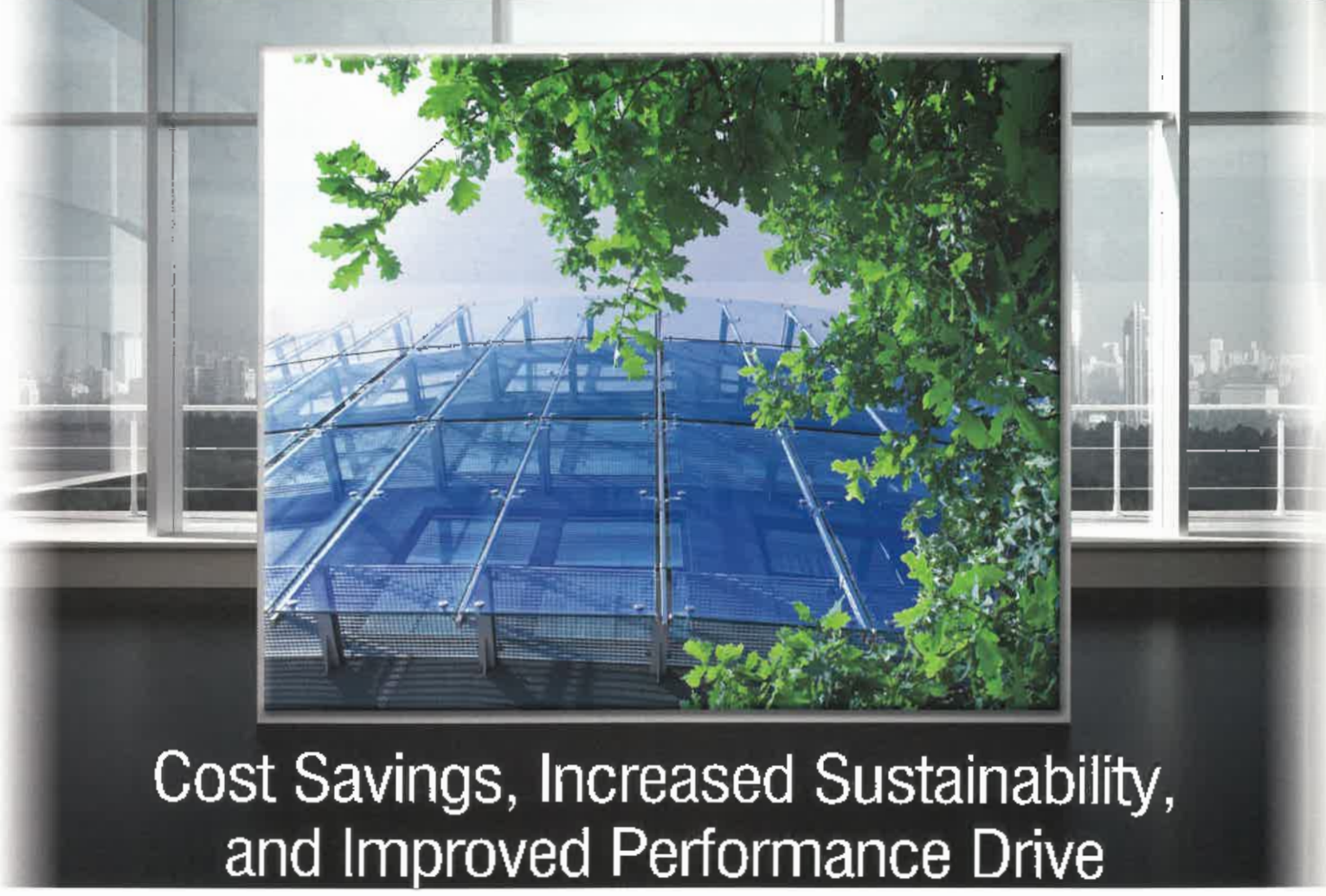

Cost Savings, Increased Sustainability, and Improved Performance Drive

Demand for Energy-Efficient Coatings

by **Cynthia Challener**,
CoatingsTech
Contributing Writer

Home owners, commercial retailers, and managers of industrial plants have several things in common: they want to minimize their costs, reduce their environmental foot print, and increase the performance of their key assets. One way to achieve all three goals at once is to boost energy efficiency. In the past, doing so required installing insulation. Today, however, numerous coating technologies can help reduce undesired heat transfer and significantly lower energy consumption and greenhouse gas (GHG) emissions in a wide range of applications.

ENERGY SAVINGS AT COMMERCIAL AND INSTITUTIONAL FACILITIES

"Many businesses now realize that their future success is dependent upon their ability to meet the major sustainability trends influencing their industries. They know that they need to become much more resource-efficient and will look to many different areas to improve their performance in this respect," says André Veneman, corporate director of sustainability & HSE with AkzoNobel. At the same time, he notes, environmental

regulations and building codes and standards are becoming stricter, and voluntary green building certifications (LEED, BREEAM, GRIHA, DGNB, etc.) are helping to increase the acceptance, use, and development of new technologies designed to help meet these new green standards.

In the commercial and institutional space, reflective roof coatings are the most recognized form of energy efficient coatings. White, cool-roof coatings applied to flat rooftops effectively decrease building heat gain and reduce a building's carbon footprint, according to John Dockery, senior technology associate with Arkema Emulsion Systems. Notably, building energy efficiency standards, including the International Energy Conservation Code (IECC, latest version 2015); the ASHRAE 90.1 (latest version 2013) energy standard of the American Society of Heating, Refrigerating and Air-Conditioning Engineers; ENERGY STAR in the United States; and California's Title 24; as well as the International Green Construction Code, include cool-roof credits or requirements.

In addition, the demand for roof coatings in general has increased because of their overall value proposition. When properly installed and maintained, a roof coating can not only help a building owner to realize energy savings, but also indefinitely extend the life of an aging roof, saving tear-off and re-roofing costs and making roof coatings a truly sustainable solution, according to Vicki Demarest, roofing R&D leader for Dow Construction Chemicals. Cool-roof coatings are also recognized as a tool for reducing the urban heat island effect.

The newest cool roof coatings on the market today can be applied to a much wider range of roofing substrates, including thermoplastic polyolefin (TPO). Although TPO is one of the fastest-growing single ply membranes in the United States, it presents adhesion problems due to its low surface energy, particularly for waterborne coatings. "Newer elastomeric, cool-roof coatings do adhere well to these challenging surfaces and are a cost-effective way to increase the life span and reflectivity of TPO roofing membranes," says Dockery.

Currently there is a demand from applicators and building owners/managers for easy-to-apply, waterborne roof coatings with improved water resistance, according to Demarest. "To address this need, Dow has developed a novel crosslinking technology for roof coating binders and will introduce a new product next year with a step-change reduction in water absorption and significantly improved blistering and water-ponding resistance," she comments.

The company has also entered into a two year Cooperative Research and Development Agreement (CRADA) with the U.S. Department of Energy and Lawrence Berkeley National Laboratory, aimed at speeding the production and marketing of white elastomeric roof coatings with superior performance. "The goal is to expedite the development and commercialization of stay-clean and white elastomeric roof coatings (ERCs) with a three-year aged solar reflectance (SR) of at least 0.75 and a service life of 15 years or more," says Demarest. One of the critical tools in this process is a test method that predicts three years of exterior exposure *in three days*. The proposed test method, "Standard Practice for Laboratory Soiling and Weathering of Roofing Materials to Simulate Effects of Natural Exposure on Solar Reflectance and Thermal Emittance," is expected to receive final approval by ASTM within months and is being evaluated by the Cool Roof Rating Council (CRRC) to supplement its field based rating system.

Arkema has focused on applying its fluoropolymer resins to the formulation of premium, weather-resistant, cool roof formulations in order to extend the length that cool-roof coatings stay clean and thus maintain their solar reflectance

values. "Coatings based on Kynar Aquatec polyvinylidene fluoride (PVDF) emulsions from Arkema pick up very little dirt. In addition, they can withstand extended exposure to water, humidity, temperature extremes, ultraviolet rays, oxygen, and atmospheric pollutants," Dockery says.

"Thermochromic and electrochromic films are alternative technologies for use in windows. They are transparent when applied, but change color in response to a thermal or electrical stimulus, respectively, thus reducing the amount of radiation passing through the glass."

It is important to keep in mind, however, according to Francesca M. Crolley, V.P. of business development with Industrial Nanotech, Inc. (INI), that there can be a heating penalty with reflective coatings used in cold climates, which often has been downplayed. "Cool-roof or white reflective coatings can actually have a negative impact on energy savings under certain conditions," she says.

Dow Construction Chemicals disagrees with this claim, though. "The idea of a cold weather penalty for cool roofs has been in circulation for some time. These claims are based on imperfect models and mathematical equations, however. There has yet to be a real-world study that shows a cold weather penalty or heating penalty for cool roofs installed in northern climates," states

Demarest. "Additionally," she continues, "cool roofing can provide much needed energy savings in peak summer months when cooling loads are at their highest, potentially mitigating blackouts or other stresses on the energy grid."

In addition to cool-roof coatings, there is also growing interest in the use of energy-efficient coatings on walls. In fact, Textured Coatings of America has developed its reflective TEX•COTE® COOLWALL® Coating Systems based on Arkema's Kynar Aquatec PVDF resin. The company reports that a study conducted by the U.S. Department of Energy's Oak Ridge National Laboratory showed that the system can reduce a building's cooling costs from 4.2–21.9% depending on the color, geographical location, climate conditions, and substrate type.

Another alternative is thermal barrier coatings, which reduce heat transfer rather than reflect it. INI offers such coatings. "We have found that architects in particular like our clear coatings because they can be used as a retrofit energy efficiency tool without changing the look of the building or requiring any major construction," Crolley observes. INI's Nansulate® has been recognized by prominent LEED-accredited professionals as being suitable for submission for LEED credits in the categories of Indoor Environmental Quality (IEQ), Energy & Atmosphere (EA), Materials & Resources (MR), and Sustainable Sites (SS), according to the company. Crolley also emphasizes that it is important to realize the difference between reflective coatings and thermal barrier (insulating) coatings. "Each technology works by a different mechanism, and to get the best performance, it is necessary to know whether an application can benefit most from a true insulation or thermal barrier or a reflective coating."

"We have already seen the industrial sector move toward energy-efficient coatings, and I believe the building/construction sector is next." She also maintains that outdated building code standards based on R-values, which require thick insulation to achieve an acceptable number, have prevented thin-film insulation coatings from being adopted. "We do expect, however, that the building sector will ultimately realize that nanotechnology-based insulation coatings provide an improved and updated way to insulate buildings and homes, and thus lower energy costs and use significantly," Crolley asserts.

Dow Construction Chemicals is also very interested in systems for the vertical surfaces of commercial buildings and homes, and believes that they will be the next big application for energy-efficient coatings, particularly given the more stringent energy codes and standards on the horizon, according to Demarest. "We believe that liquid-applied flashing and house wrap-type products (used varyingly as air, vapor, and water barriers) will be very much in demand in the years to come," she states.

The company is currently developing new binders and formulations for liquid-applied flashing and weather-resistive barrier applications, which reduce the air infiltration through holes and gaps in "leaky" buildings that can be responsible for as much as 40% of a building's heating costs, she notes. "Liquid-applied air barrier and flashing systems are attractive because they can provide high air barrier performance levels with a much simpler application process compared to conventional building wraps. In addition, they provide improved water-intrusion resistance, which helps reduce in-wall moisture content and therefore increases the service life and sustainability of new commercial and residential structures," Demarest says. She concludes that liquid-applied flashing and weather resistive barriers can enable buildings to deliver higher energy efficiency, better internal air quality and comfort, and increased service lifetimes.

Crolley also notes that window insulation coatings are in high demand, but it is currently a challenge for the industry to both insulate windows and maintain clarity. INI's products insulate, but give windows and skylights a slightly frosted look, as do window films.

Thermochromic and electrochromic films are alternative technologies for use in windows. They are transparent when applied, but change color in response to a thermal or electrical stimulus, respectively, thus reducing the amount of radiation passing through the glass. Demand for these energy-efficient coatings is being driven by a combination of interest in sustainable design in the architectural community and the advent of the above-mentioned codes and green standards, according to Helen Sanders, VP of technical business development with SAGE Electrochromics. "At the same time," she adds, "many of these green standards also require a minimum amount of daylighting and views to the outside—requirements that can be in conflict with those related to energy-efficiency."

The visible and near-infrared light transmission of an electrochromic coating changes from a high transmission state to a very low transmission state, stopping at points in between by applying a low-voltage direct current (approximately 2,000 square feet can be controlled daily with the same amount of power required by a 60-watt bulb). "By modulating the solar energy flowing into a building, electrochromics can tune the amount of heat and light according to the needs of the building's HVAC system and the occupants. Hence, dynamic solar control can provide significant energy savings over static fenestration," Sanders states.

For buildings, electrochromic glazings are used exclusively with glass substrates and almost

"Window insulation coatings are in high demand, but it is currently a challenge for the industry to both insulate windows and maintain clarity."

entirely on the building envelope, which is the cornerstone of building design and has a significant impact on energy efficiency because it determines the energy flow into and out of the building. Electrochromic coatings make it possible to block solar gains during cooling periods and admit them during heating periods, thus providing additional control over the heat flow, as well as enabling harvesting of daylight at all times of day, providing reduced need for electric lighting. Fenestration with dynamic solar control (such as electrochromics) is on the U.S. Department of Energy's road map to achieving zero-energy buildings, according to Sanders.

Recently, increased demand has led to larger-volume production facilities, which have made it possible to coat larger glass sizes. This, in turn, has given designers more flexibility for incorporating electrochromics into their building designs. Technological advances have included wirelessly controlled and photovoltaic-powered electrochromic fenestration systems that can operate "off grid," according to Sanders. "These developments have increased the accessibility of electronic technology to retrofit applications," she says. It is also now possible to control separate zones within a single pane of glass for optimized glare management, daylight admission, energy performance, and light color quality, which is necessary for floor-to-ceiling glass, according to Sanders.

"Infrared reflective coatings are in demand in a number of areas, particularly warmer climates, because the pigments in these coatings form an infrared reflective barrier in the dried film to help maintain lower surface temperatures on the coated exterior building surfaces."

The current focus is on the development and implementation of appropriate control strategies and integration into other building systems in order to optimize the performance of both the electrochromic systems and the building. SAGE has already developed product features that provide increased design flexibility to architects, such as different color aesthetics, wireless products, and cost reductions to enable wider use. Sanders believes that significant energy savings will come from the design of buildings with better daylighting that use higher-performance fenestration with dynamic solar control for solar gain management and dimmable lighting controls for daylight harvesting. "Such integrated façade systems will allow us to get to net zero or near net-zero buildings," she states.

ENERGY SAVINGS IN THE HOME

There are numerous opportunities for the application of energy-efficient coatings in residential buildings. As with commercial buildings, reflective roof and wall coatings (both colored with infrared reflective pigments), radiant attic barrier coatings, thermal insulation coatings, liquid vertical air barriers, and thermochromic and electrochromic coatings all have applications as energy-efficient coatings in residential construction. "At AkzoNobel, we are aware that paints and coatings make up only a comparably small proportion of all substances and technologies that determine the environmental footprint of a building or new construction project. However, within our scope, we are committed to developing materials and technologies that offer further clear sustainability benefits for our customers through our Planet Possible approach," notes Veneman.

Infrared reflective coatings are in demand in a number of areas, particularly warmer climates, because the pigments in these coatings form an infrared reflective barrier in the dried film to help maintain lower surface temperatures on the coated exterior building surfaces, according to Bob Cregg, industry director—building products in the product finishes division of Sherwin-Williams.

In addition to cool-roof coatings, Sherwin-Williams offers Kem Aqua BP Siding Plus coatings that are infrared-reflective. "Architects can specify such a coating, where possible, to increase the efficiency of their project. In addition, for siding manufacturers, Kem Aqua BP Siding Plus is an innovative solar reflective technology formulated to repel heat in dark colors and resist substrate warping and bowing under solar rays," Cregg comments.

AkzoNobel offers both silicon-modified polyester and PVDF-based cool-roof coatings that contain ceramic infrared reflective pigments in its COOL CHEMISTRY Series. In addition, the company has focused on improving the natural lighting on the interior of homes and other structures to reduce lighting costs, particularly for darker, colder climates. The company's Light & Space product reflects more light than conventional coating systems. Use of this paint can, according to Veneman, significantly reduce the need for artificial lighting and lead to potential energy savings of up to 22%.

Interior radiation control coatings (IRCCs) are highly reflective, low emissivity (thermal emittance) coatings containing aluminum particles. When applied to the underside of roof decking, they prevent the roofing materials from radiating heat, and therefore block a significant amount of the radiant energy that enters a building through the roof. As with exterior cool-roof coatings, they are most effective at lowering internal temperatures in hot climates. ASTM C1313 applies to IRCCs and specifies a maximum thermal emittance level for coatings to be classified as an interior radiation control coating. Very few products meet the standard. The most widely used are produced by BASF, SOLEC Energy Corp, and STS Coatings. The thin coatings are generally spray-applied, are suitable for wood and metal substrates, and often can be an economical way to retrofit a radiant barrier (vs. a foil barrier).

Optical coatings can also play a key role in improving energy efficiency in the home, but indirectly. One example is the hot-mirror coating used to produce energy-efficient halogen lights. Lighting is reported by

the International Energy Agency to account for nearly one fifth of global energy consumption. While compact fluorescent lamps (CFLs) are very efficient, they are perceived to provide less light, are not available in a form compatible with many home lighting fixtures, and often do not last as long as expected due to heat buildup (in multiple-socket fixtures). LEDs are also attractive, but affordable lights that work with existing fixtures are not currently available. A specially designed hot mirror coating on the glass or quartz filament envelopes of halogen bulbs can selectively reflect infrared energy back to the filament, further heating it. As a result, less electricity is required to maintain the filament at the proper temperature. The challenge is depositing the very complex, thin films so that they reflect the infrared radiation correctly for varying bulb envelopes and filaments and so they last for the long lifetimes of the bulbs. Even so, the technology has the potential to provide low-cost, energy-efficient bulbs that are compatible with existing fixtures found in the home.

"When you compare the long-term performance of insulating coatings to fibrous insulations of the past, it's obvious that the technology has evolved, and for energy savings, associated reduction of CO_2 emissions, and equipment protection, thermal barrier coatings are the better and most cost-effective choice."

ENERGY SAVINGS IN THE MANUFACTURING ENVIRONMENT

In the industrial sector, while end users are becoming more interested in sustainability and products that have less impact on the environment, cost savings remains the compelling value proposition, according to Mary Rose Correa, industrial acrylics marketing manager with Dow Coating Materials. "A lot of companies are very focused on cost, and any mechanisms for reducing cost are attractive. Energy is a key area because it is such a large expense," she says. In particular, she points to growing interest in insulation coatings.

Thermal insulation coatings have a lot of advantages over traditional mechanical insulation materials, such as fiberglass or polymeric foam, according to both Correa and Crolley. First, mechanical insulation is very difficult to work with when insulating complex geometries such as valves and levers. Spray-on insulation coating is much easier and can achieve the same results, but more quickly and with less labor. Second, fiberglass and other industrial insulation materials typically require a separate moisture barrier or jacketing to keep out water and prevent corrosion issues; however, water can become trapped between these layers and cause undetected corrosion. Thermal insulation coatings, on the other hand, directly adhere to the substrate, thus minimizing or eliminating the space between the substrate and conventional insulation that can hold moisture. Third, replacing traditional fibrous insulation with an insulation coating makes it much easier to monitor for corrosion under insulation (CUI), which is a very costly process for the industrial sector. Finally, Crolley points out that thermal insulation coatings are much more durable than rock wool or fiberglass insulation materials. "When you compare the long-term performance of insulating coatings to fibrous insulations of the past, it's obvious that the technology has evolved, and for energy savings, associated reduction of CO_2 emissions, and equipment protection, thermal barrier coatings are the better and most cost-effective choice," she states.

Dow initially developed its Maincote™ IC Acrylic Resins for the formulation of coatings with safe-touch properties at elevated temperatures, but testing results indicate that coatings formulated with the resins can also have insulating properties. In a small-scale modeling study, a thermal coating formulated with Maincote IC-1001 Acrylic Resin and silica aerogel required approximately 30% less energy to maintain a target temperature versus no coating insulation, according to Correa. "Because the acrylic backbone offers water barrier protection and elimination of thick insulation and jacketing improves the detection of corrosion under insulation through easier inspection of metal surfaces, paint formulators can offer coatings that meet the need for insulation while reducing the costs associated with energy loss and CUI," she observes.

When looking at insulation coatings, Dow is always considering other chemistries. There are limitations to waterborne acrylic, particularly where temperature is concerned, according to Correa. "Waterborne acrylics are great for any asset or surface under 350°F, but past that, waterborne acrylics will start to break down, char, and lose properties," she says. The oil

and gas industry, for example, has temperatures that reach 500–600°F. "Having a technology that can reach those high temperatures is what Dow is looking for as a next-generation product," Correa notes. Dow is also exploring the use of its thermal insulation coatings in avenues where insulation coatings may be beneficial beyond the industrial market, such as in architectural applications where they might be used in combination with other insulation materials, and in dishwashers, washing machines, and other appliances that have insulation. "We're looking into how we might leverage our insulation coating technologies outside of the stereotypical industrial space," says Correa.

According to Crolley, INI has experienced strong demand for its Nansulate thermal insulation coatings both overseas and in the United States, largely due to the need for an insulation material that can withstand both the harsh manufacturing environment and exposure to all types of weather (for exterior storage tanks). "Manufacturing facilities have a lot of equipment that needs to be insulated for energy efficiency, and thermal barrier (insulation) coatings give them the best option with respect to performance, longevity, spray application onto any shape/size surface, and the ability to stand up to weathering without the need for exterior cladding," she says. Crolley also notes that the food industry has special insulation needs, because the issue of food contamination must be addressed. Thermal insulation coatings in these applications must be registered as safe for incidental food contact surfaces.

"Manufacturing facilities have a lot of equipment that needs to be insulated for energy efficiency, and thermal barrier (insulation) coatings give them the best option with respect to performance, longevity, spray application onto any shape/size surface, and the ability to stand up to weathering without the need for exterior cladding."

"Next-generation products will be water-based versions that provide the same process energy savings while reducing VOCs."

Nansulate translucent coatings contain a nanocomposite (Hydro-NM-Oxide) that possesses a nanoscale internal architecture and surface chemistry. Because the nanocomposite has a very low thermal conductivity, the coating acts as a barrier to heat transfer. Nansulate acrylic waterborne coatings have also been shown to provide good corrosion, as well as mold, UV, and moisture resistance. Crolley emphasizes that the durability of thermal insulation coatings cannot be stressed enough. "Thin film insulation coatings don't get infiltrated by moisture, dirt, dust, and other contaminants like fiberglass and rock wool, and thus maintain a consistent insulating performance throughout their lifespan," she says.

While its Nansulate coatings address many of the limitations of older insulation technologies, INI continues to develop additional products in response to requests from customers. The company is currently developing a thermal barrier coating that can be used in underwater conditions and is focused on identifying a thermal insulation coating system that can perform in extreme heat (up to 1000°F). INI has also received requests for flexible insulation coatings that can be applied to fabrics. The water-based acrylic latex systems the company offers today are not suitable as textile coatings, so Crolley sees that interest as an opportunity to develop further coating products.

Beyond the obvious use of energy-efficient coatings for cool-roof and thermal insulation applications, there are also opportunities to improve the energy efficiency of their production processes. With respect to coatings for use on pumps and engines, for example, energy reduction is achieved by reducing the energy required to coat the parts and minimize the "process footprint," according to David V. Calabra, global market director for general finishing in the product finishes division of Sherwin-Williams. He sees the demand for these "reduced process energy" coatings as greatest outside of the United States, where fuel is much more expensive. "Our efforts are focused on the development of air-dry or low-cure coatings with reduced energy consumption (baking/gas/electricity) that maintain process throughput and coating performance," he says. Examples include two-component polyurethanes and non-isocyanate or polyaspartic coatings that cure rapidly without heat, which are alternatives to baking enamels. Next-generation products will be water-based versions that provide the same process energy savings while reducing

VOCs. Calabra also notes that significant efforts are being made to eliminate the need for primers in liquid systems to enhance productivity.

For powder coatings, lower-temperature curing products and dry on-dry powder systems that eliminate the baking of the primer and consequently reduce the process energy demand are also being developed. AkzoNobel, for example, offers its Interpon Align, a two-coat, one-bake system that uses dry-on-dry technology, eliminating one full cure cycle. "The simultaneous curing of the two coating layers results in significantly improved productivity, as well as energy and cost savings," says Veneman. He adds that the new technology can be tailored to meet exact color and performance requirements, resulting in a wide range of end-use products, including thick and heavy mass metal parts that meet the most demanding specifications for protection and appearance.

"By 2050 the world population will be 9 billion, 95% of new building stock will use zero net energy, there will be universal access to low carbon transport, and landfilling for industrial processes will be significantly reduced."

FUTURE OUTLOOK

According to the World Business Council for Sustainable Development's (WBCSD) "Vision 2050" report, by 2050 the world population will be 9 billion, 95% of new building stock will use zero net energy, there will be universal access to low carbon transport, and landfilling for industrial processes will be significantly reduced.

"At AkzoNobel the 'Vision 2050' report is used to inform our long-term innovation strategy and to help us identify changes in the market. In our buildings and infrastructure customer segment, the growing demand for buildings with lower energy costs forms a driver for us to develop more sustainable products, be that in their manufacture, their application, their capabilities, or their life-cycle," comments Veneman. The company's efforts include powder coatings that can be cured at lower temperatures and liquid paints that release fewer solvents, as well as coatings that need little or no maintenance or can reflect heat. In the transportation segment, AkzoNobel is shifting its focus to new, lighter materials, while in the consumer goods and industrial segments, resource scarcity is driving the company's innovation activities toward eco-efficiency, using waste as a resource rather than simply as a disposal problem and improving resource efficiency in the value chain (with customers, consumers, and in the end-of-life phase), according to Veneman.

Sherwin-Williams continues to invest in the development of energy efficient coatings technologies, with one focus on improvement of cure response, which can lead to energy savings for the manufacturer by reducing energy costs for bake ovens and/or increasing product throughput. A second focus is on reducing or eliminating VOCs in a number of its formulations, according to Cregg. "The demand for energy-efficient coatings will only continue to escalate," adds Calabra. He also notes that environmental regulations are becoming more stringent globally, particularly in Eastern Europe, the Asia Pacific region, and China. "To meet these regulations, the development of new coating systems, curing mechanisms, such as LED, and application techniques will be necessary," he says. While the focus on sustainability and reducing environmental impacts will continue, reducing cost will also remain a major focus, according to Correa. "Energy-efficient coatings are going to grow exponentially in the long term. It's the best of both worlds—cost savings and sustainability for our customers and our customers' customers," she states.

In the end, it will be a coordinated effort between raw material suppliers, coatings producers, and application equipment companies to optimize the systems of the future, according to Calabra. INI's CEO also believes that the future of any energy-efficient coating technology will come from the "brain trust" of scientists in the nanotechnology sector. To that end, the company has fostered relationships with experts who can help develop cutting-edge technologies for use across a wide spectrum of applications that will lower energy use and thus reduce both energy dependence and associated CO_2 emissions, according to Crolley.