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MANUFACTURING

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WEATHERING THE STORM: HOW MANUFACTURERS ARE COPING WITH VOLATILE ENERGY COSTS

CAN DECENTRALIZED ENERGY GET GOOD ENOUGH, FAST ENOUGH?

A NANOCERAMIC APPROACH TO THE CLIMATE CRISIS AND CARBON REDUCTION

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INDUSTRY NEWS

KYOCERA PLANS 'SMART' FACTORY FOR SEMICONDUCTOR APPLICATIONS

Kyocera Corp. reached an agreement to acquire 37 acres of land for a "smart" factory at the Minami Isahaya Industrial Park in Isahaya City, Nagasaki Prefecture, Japan. The agreement includes a developed site of about 14 acres, where construction will begin in October 2023, and another 23-acre, pre-developed site that Kyocera plans to acquire in 2024. The factory will produce fine ceramic components used in semiconductor-related applications, as well as semiconductor packages, with production expected to begin in 2026.



A rendering of the new plant.

IFGL has manufacturing facilities in India, China, Germany, U.K., and U.S.



IFGL REFRACTORIES ACQUIRES U.K. REFRACTORIES BUSINESS

Kolkata, India-based IFGL Refractories Ltd. said its subsidiary in the U.K., Monocon International Refractories, completed the acquisition of Sheffield Refractories, a manufacturer and installer of monolithic refractory products, shotcreting materials, and other specialty monolithic products for the iron and steel, cement, incineration, and waste-to-energy industries. Sheffield's revenue from operations during the 12 months ending Sept. 30, 2022, was more than GBP 17.5 million.

PILKINGTON REBUILDS LINES, EXPANDS IN N.C.

Glass manufacturer Pilkington North America, Inc. plans to invest \$86.8 million in its operations in North Carolina. The project includes the rebuild of one of its two float glass lines, expansion of existing coating capabilities, and other building and equipment improvements at the company's float glass facility in Laurinburg, N.C. The project will create 20 jobs. PNA is part of Tokyo-based NSG Group, a supplier of glass and glazing systems for the automotive, architectural, solar, and creative technology sectors. The Laurinburg plant produces float glass for the architectural market.



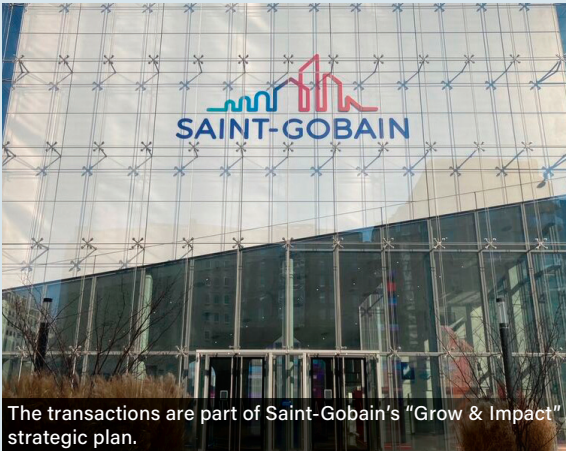
Pilkington in the U.K. invented the float manufacturing process for glass in 1952.



U.S. Rep. Matt Cartwright (D-Pa.) is shown a launch tube window.

DEFENSE CONTRACT FOR INFRARED GLASS AWARDED TO SCHOTT

Schott was awarded a multimillion-dollar contract from a defense contractor for infrared glass. The order supplies glass for launch tube windows, a component of air defense systems provided to the U.S. Army. Schott is already producing launch tube window parts for an existing order, and will now be able to extend production and further support employment of more than 150 people at its site in Duryea, Pa.



The transactions are part of Saint-Gobain's "Grow & Impact" strategic plan.

SAINT-GOBAIN SELLS TWO BUSINESS UNITS

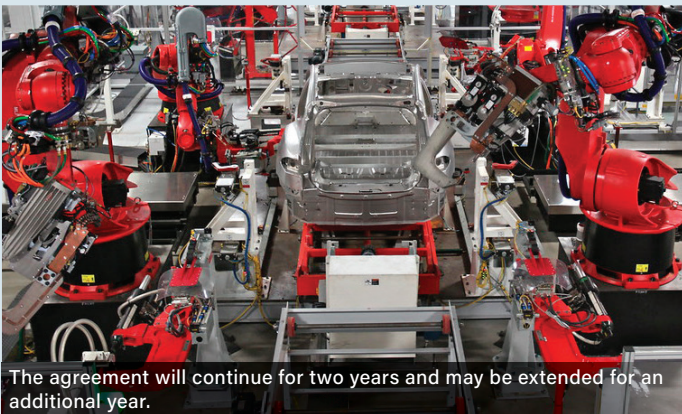
Saint-Gobain signed an agreement to sell its glass processing business Glassolutions in Switzerland to the privately-owned German group Aequita. The business generated sales of around 25 million euro in 2022, and employs approximately 70 people at its production site in Kreuzlingen. This transaction is part of Saint-Gobain's business profile optimization strategy. Saint-Gobain also completed the sale of its scintillation and photonic crystals business to SK Capital Partners and Edgewater Capital Partners, two U.S.-based private investment firms.

DOE SUPPORTS STUDIES ON RARE EARTHS FROM MINE WASTES

The U.S. Department of Energy announced \$16 million from the Bipartisan Infrastructure Law to support projects in West Virginia and North Dakota that are developing rare earth element and critical minerals extraction and separation refineries. The University of North Dakota will complete a study to recover and refine minerals from North Dakota lignite mine wastes. West Virginia University will complete a study of producing minerals using acid mine drainage and mineral tailings feedstocks. Both projects were awarded \$8 million.



The studies will identify risks and costs of producing rare earth elements from mining wastes.



The agreement will continue for two years and may be extended for an additional year.

HAYDALE INKS AGREEMENT ON BORON NITRIDE WITH SAINT-GOBAIN

Haydale signed an agreement with Saint-Gobain to further develop Saint-Gobain's boron nitride powder solutions. Saint-Gobain Boron Nitride, a business unit within Saint-Gobain Ceramics, develops advanced hexagonal boron nitride, an advanced synthetic ceramic used in electronics, automotive, and metal forming industries, among others. Haydale is a technology and advanced materials group based in the United Kingdom.

RAK CERAMICS UPGRADES KILN TECHNOLOGY

RAK Ceramics announced a \$14 million investment in its sanitary ware production line in the United Arab Emirates to upgrade the facility with new kiln technology. The investment will allow an upgrade of the heat exchanger system with the capability for future conversion to hydrogen fuel and waste heat recycling. RAK, based in Ras Al Khaimah, UAE, specializes in ceramic porcelain wall and floor tiles, tableware, sanitary ware, and faucets.



RAK aims to go online with the new machinery in the first half of 2024.

WEATHERING THE STORM: HOW MANUFACTURERS ARE COPING WITH VOLATILE ENERGY COSTS

By David Holthaus

As a cost of doing business, energy has been relatively cheap for many years. That changed in 2022, when a variety of factors—notably a war started by one of the world’s leading natural gas suppliers—caused energy prices to spike.

In Europe, wholesale gas prices hit an all-time high in August 2022. Shortages and blackouts were feared as Russia cut its gas exports to the continent when the European Union initiated sanctions over the war in Ukraine.

In the U.S. in 2022, the natural gas spot price hit its highest annual average since 2008, according to the Energy Information Administration. A decline in U.S. production, combined with increased demand from Europe and weather-driven demand in the States, all contributed to the price surge.

Fortunately, 2023 has been a different story. In Europe, natural gas prices normalized back to pre-war lows, according to SEB Research, a division of the Swedish investment bank. Reduced industrial consumption, increased exports from the U.S. and other alternative suppliers, and a relatively mild winter combined to bring prices back in line, the firm says.

In the U.S., reduced consumption (thanks to a mild winter) and increased natural gas production resulted in natural gas prices dropping 40% from December 2022 to January 2023. The Energy Information Administration forecast that prices would, on average, drop 50% in 2023 from last year’s spikes.

RISING ENERGY COSTS STILL A THREAT, EXECS SAY

Despite the reprieve from price increases, energy costs remain a top concern for business leaders. That can be seen in a study of 2,300 executives around the world commissioned by ABB Electrification, a division of Zurich-based conglomerate ABB Ltd. Published in March 2023, the findings show that energy costs and stability challenges are impacting businesses across the board, with 74% of survey respondents saying rising costs are a “major” or “moderate” threat to their companies’ competitiveness.

Over the last year, higher energy costs caused businesses to reduce spending in other areas (34% cited this impact) and reduced profit margins (also 34% of respondents). Executives say dealing with energy challenges may outweigh spending normally considered necessary to remain competitive, including employee recruitment; retaining or developing talent, salaries, overtime, and bonuses; and investing in new technology for greater productivity.

Apart from reductions in investment in the workforce, businesses also reduced spending in other key areas as a result of energy challenges, including technology (38%), infrastructure (33%), marketing (31%), manufacturing (27%), and research and development (18%).

Looking out over the longer term (3–5 years), if energy costs and uncertainty persist, businesses anticipate further spending and investment reductions in similar areas to the last year, with the main impacts being employee-related, including staff recruitment (42%), compensation (38%), and training and development (37%).

Respondents say other affected areas would include spending on technology (37%), infrastructure (34%), and marketing (33%).

Much of the concern can be attributed to the inherently volatile nature of energy costs and the knowledge that the factors that contributed to the spikes in 2022 are still with us. The war in Ukraine is still raging, and an unpredictable climate means a harsh winter could push consumption to the point that prices surge again.

On top of that is global economic uncertainty, particularly concern-



The energy-intensive glass and ceramic industries are especially vulnerable to energy costs.
Credit: Schott

Hydrogen fuel projects will test a developing technology

By David Holthaus

In the energy-intensive glass and ceramic manufacturing industries, decarbonizing the heating and firing processes is a major challenge. Hydrogen is one technology that holds promise for replacing natural gas. However, the technology is still under development and is years away from being commercially available on a broad basis, says Erik Muijsenberg, vice president of Glass Service, Inc. a Vsetin, Czechia-based consulting firm that works with glass and ceramic makers to optimize their furnace technologies.

"I see a very big future for hydrogen, but not in the next 10 or 15 years," Muijsenberg says.

The hydrogen fuel technologies available now are more expensive than natural gas, and they are not necessarily very efficient or green, as much of the hydrogen produced now is based on fossil fuels, Muijsenberg explains. But there are many projects under way that will provide data and help the technology to be developed for wider use.

Ardagh Glass Packaging in Limmared, Sweden, a subsidiary of Ardagh Group, signed an agreement with Absolut Vodka to use a partly hydrogen-fired glass furnace for large-scale production of the vodka maker's glass bottles. Ardagh's Limmared facility currently uses a combination of natural gas and electricity to power its furnaces. In the second half of 2023, Ardagh will launch a pilot replacing 20% of its natural gas with green hydrogen to manufacture all of Absolut's bottles. The hydrogen will be produced onsite at Ardagh by using renewably sourced electricity.

"There are challenges with such innovation, but we are committed to being an early mover in future-proofing our glass manufacturing operations worldwide," says Bo Nilsson, managing director of Ardagh Glass Limmared AB.

In December 2022, glass manufacturer Encirc and spirits giant Diageo announced a partnership to build a new furnace at Encirc's Elton plant in Cheshire, U.K., which will reduce carbon emissions by 90%, with an

energy mix of green electricity and low carbon hydrogen. The process will produce up to 200 million Smirnoff, Captain Morgan, Gordon's, and Tanqueray bottles annually by 2030, the companies say.

The U.K. has been a leader in developing the infrastructure for hydrogen technology. Its HyNet project aims to produce, store, and distribute hydrogen, as well as capture and store carbon, throughout the north-west of England and North Wales.

Saint-Gobain in March 2023 carried out a test production of flat glass using more than 30% hydrogen at its Herzogenrath site in Germany. With the test, the company says it "has proven the technical feasibility of manufacturing flat glass with a significant proportion of hydrogen."

Ceramics manufacturer NGK says it has been conducting hydrogen flame evaluation tests in a test furnace installed near its headquarters in Nagoya, Japan, since January 2022. The company says it will install a new firing furnace at a hydrogen combustion test field in Tokai, Japan.

These and many other projects could provide the investment and information needed to scale up the use of low-carbon hydrogen as an alternative fuel for industries. ▽



Ardagh Glass will manufacture Absolut Vodka bottles in a hydrogen fuel pilot project. Credit: Absolut Vodka

ing China. The country ended its strict zero-COVID policy in December 2022, reopening its borders and moving away from the testing and quarantine orders that slowed its economy over the last three years. China's economic growth of 3% in 2022 was its slowest in decades. The International Monetary Fund now predicts growth of 5.2% in that country, the world's second-largest economy, this year. Stronger growth in China could mean steeper global demand for gas, possibly exerting upward pressure on prices.

"Energy cost inflation, volatility, and supply insecurity are a problematic combination that need monitoring closely," says Morten Wierod, president of ABB Electrification.

COPING WITH COST VOLATILITY

With the memory of last year's energy spikes still fresh, manufacturing leaders can take steps to improve their energy resiliency. Among the cheapest steps are basic efficiency measures, says Michael Lyda, a technical supervisor with

Advanced Energy, a North Carolina-based nonprofit energy consulting firm.

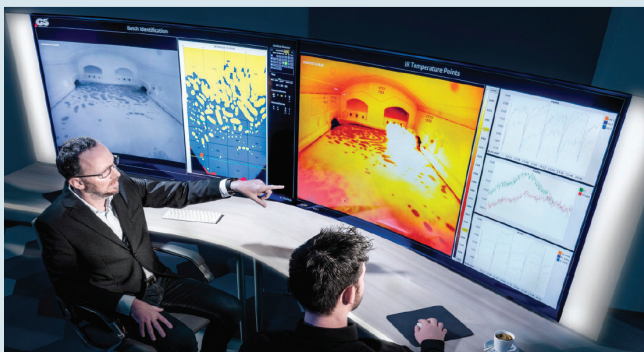
"Energy efficiency is the low-hanging fruit," he says.

Old lighting technology can be replaced to create near-immediate savings, Lyda says. Simply turning the lights off at times and in places where they are not needed will add up, and dropping the use of old, inefficient technologies will yield savings.

"Only use energy when it needs to be used," he says.

Business leaders are becoming conscious of their companies' energy usage, and more to the point, of the energy waste in their companies' processes, the ABB survey found. Thirty-four percent say they have increased investment focused on improving energy efficiency, while 22% say they are switching off lights and equipment when not in use. Twenty-two percent report using less heating or air conditioning in their operations.

For example, Saint-Gobain, the Paris-based materials manufacturing giant, recently received an award from the U.S. Department of Energy for implementing a smart energy management system at its gypsum plant in Buchanan, N.Y.



Glass Service Inc. experts use artificial intelligence software to measure batch and temperatures in a furnace analysis. Credit: Glass Service Inc.

The system was designed in-house and consists of more than 180 energy meters that allow employees to track and contextualize energy data, forecast future energy use, and tackle actual losses once they are identified. Within the first three months of installation, the system helped identify several opportunities to reduce energy use and enabled the plant's team to identify process changes and projects to address them, the company says. The company plans to deploy similar technology at some of its 145 manufacturing sites throughout the U.S.

Lyda says his company can work to help industries meet the ISO 50001 energy standard. The standard provides a framework of requirements for organizations to develop an energy management system by creating policies for more efficient use of energy, fixing targets and objectives, using data to better understand and make decisions about energy use, and measuring the results for continuous improvement. It is a standard that is more often practiced in Europe than in the U.S. due to European Union directives, Lyda says.

Energy efficiency becomes especially critical in the glass and ceramic manufacturing industries, as the processes are so energy intensive, with furnaces reaching temperatures of more than 1,500°C for the melting and refinement of raw materials.

Glass Service Inc., a company based in Vsetin, Czechia, has been in business for 33 years and has developed technologies to help optimize furnace efficiency. The company offers experience in furnace engineer-

The CoorsTek facility in Rayong, Thailand, where a rooftop and carport solar photovoltaic system will be installed. Credit: CoorsTek



ing, data analysis and auditing, and furnace monitoring, and it can provide mathematical simulation studies to model the combustion and discover methods to improve efficiency, says Erik Muijsenberg, vice president.

Glass Service has conducted simulation studies of more than 800 furnaces around the world, Muijsenberg says.

"Energy has become more expensive and decarbonization is important," he says. "We want to find a solution using less or no fossil fuels."

The company is working to develop technologies that are greener and more efficient, including developing a hydrogen burner, as well as melters that are all electric or use hybrid sources of energy.

"There's more need than ever before to make these changes available," Muijsenberg says.

MOVING FORWARD WITH ALTERNATIVE ENERGY SOURCES

But high energy costs may, paradoxically, result in diverting or delaying investments meant to help achieve decarbonization commitments, the ABB survey found. More than half (58%) of the respondents say the cost of energy could delay achieving their sustainability and carbon reduction targets by anywhere from one to five years.

At the same time, 40% say they were "very concerned" about the security and reliability of their businesses' energy supply, and many are moving forward with plans to take action over the next 12 months, including installing onsite, renewable energy sources (40%), such as solar or wind, or procuring renewable power under long-term power purchase agreements (36%).

CoorsTek, the Golden, Colo.-based manufacturer of technical ceramics, is one company proceeding with plans to reduce its carbon footprint. In March 2023, the company signed a long-term agreement with TotalEnergies ENEOS for a 1.5 megawatt-peak rooftop and carport solar photovoltaic system at its 110,000-square-foot manufacturing facility in Rayong, Thailand. The system is expected to generate about 2,000 megawatt-hours of renewable electricity annually, realize significant cost savings, and reduce the company's carbon footprint by about 840 metric tons of CO₂ emissions per year.

"It's our first foray into onsite renewables," says Dara Ward, CoorsTek's corporate sustainability manager. "It's something that our leadership is very committed to seeing played out globally."

CoorsTek broke ground on its Rayong facility in January 2021 and began operations in January 2022. The facility is a production hub for Southeast Asia.

"It's a really perfect opportunity for us to evaluate solar because we would have a brand new roof and a lot of space," Ward says.

Under the agreement, TotalEnergies ENEOS will finance, install, and operate the system. The company is a 50/50 joint venture between TotalEnergies and ENEOS to develop onsite, business-to-business solar

Advanced nuclear reactors hold promise for clean, efficient energy

By David Holthaus

Nuclear energy has acquired a poor image over the years. As a result, the development of a promising technology that could help further the decarbonization of the planet has been slowed.

Major nuclear reactor incidents at Three Mile Island in the United States, Chernobyl in Ukraine, and, most recently, Fukushima in Japan have demonstrated how serious problems can be at such sites. Some older nuclear plants were decommissioned and closed, and nuclear now accounts for only 10% of the world's energy production, according to the World Nuclear Association.

But nuclear technology has advanced to the point where small, modular nuclear reactors—and even microreactors—may soon be providing low-carbon, efficient energy for manufacturers and power suppliers. Several companies are developing advanced reactors using different technologies that promise to be safer and easier to deploy than conventional nuclear technology.

"All of them have the potential to compete globally once deployed, and they will offer consumers more access to a reliable, clean power source that can be depended on in the near future to flexibly generate electricity and drive industrial processes," says the U.S. Department of Energy.

The DOE's Advanced Reactor Demonstration Program (ARDP) is supporting several projects.

TerraPower is a Bellevue-Wash.-based company founded by Bill Gates that is working on a demonstration project for a sodium fast reactor in Kemmerer, Wyo., in collaboration with PacifiCorp, a utility that is retiring a coal-fired plant in that community. In fall 2022, the two companies announced they would study the feasibility of deploying up to five additional small modular reactors and integrated energy storage systems in the PacifiCorp service territory by 2035.

X-Energy Reactor Company, based in Rockville, Md., is developing the first grid-scale advanced nuclear reactor for an industrial site in North America. The company is working with materials science company Dow and intends to install a high-temperature, gas-cooled reactor plant at one of Dow's U.S. Gulf Coast sites. The companies say the site will be selected sometime this year.

"From the beginning to the end of the supply chain, our technology can supply both power and heat to businesses in most sectors of the economy to help limit their carbon footprint," says J. Clay Sell, X-energy CEO. X-energy was selected by DOE in 2020 to receive up to \$1.2 billion under the ARDP in federal cost-shared funding to develop, license, build, and demonstrate an operational advanced reactor and fuel fabrication facility by the end of the decade.



A rendering of a Westinghouse eVinci microreactor plant. Credit: Westinghouse

Westinghouse, based in Pittsburgh, Pa., is in the process of licensing its eVinci microreactor that is designed to provide five megawatts of electricity for more than eight years without refueling. The eVinci is factory built and assembled before it is shipped in a container to its location. Westinghouse says it can be used for electricity and heating for remote communities, universities, mining operations, industrial centers, data centers, and defense facilities. Westinghouse says the passive safety features of its design allow the reactor to operate and achieve safe shut-down without the need for additional controls, external power sources, or operator intervention, enabling highly autonomous operation.

BWX Technologies, Inc., based in Lynchburg, Va., is building an advanced, transportable, nuclear microreactor under a contract awarded by the U.S. Department of Defense. The company says the transportable microreactor will "deliver clean, zero-carbon energy where and when it is needed in a variety of austere conditions for not only the DoD but also potential commercial applications for disaster response and recovery, power generation at remote locations, and deep decarbonization initiatives." The company expects it to be completed and delivered to the Idaho National Laboratory in 2024 for testing.

The DOE is using its National Reactor Innovation Center at the Idaho National Laboratory to test these innovations. It has awarded grants to help support their development and demonstration over the next several years, it says.

"These aggressive timelines are needed to ensure the United States takes advantage of the advanced reactor market that's expected to be worth billions of dollars," the agency says. "That's why we plan to invest more than \$600 million in these projects over the next seven years, pending the availability of future appropriations by Congress."

distributed generation across Asia. It is headquartered in Singapore and plans to develop 2 GW of decentralized solar capacity over the next five years. CoorsTek will purchase the solar electricity generated for the duration of the contract. CoorsTek plans to take the learnings from the project and apply them at other plants, Ward says.

CoorsTek also works with utilities at some of its sites to implement strategic energy management programs to identify opportunities for efficiencies and savings, Ward says.

On the natural gas side of things, "We see a lot of volatility," Ward says. "So we're always looking at ways to hedge and reduce our consumption because that's the best way to become more resilient against these rising prices."

Specialty glass maker Schott is another company moving forward in the face of global economic challenges. Schott is based in Mainz, Germany, and operates in more than 30 countries. The company is switching to 100% green electricity and has made a 60% reduction

CAN DECENTRALIZED ENERGY GET GOOD ENOUGH, FAST ENOUGH?

This article was originally published on EY.com and is authored by Arnaud de Giovanni, EY global renewables leader, and Ben Warren, EY global power and utilities corporate finance leader, using research from the EY Renewable Energy Country Attractiveness Index. Republished with permission.

The need for energy resilience has never been more urgent. Ramping up renewable generation, accelerating energy diversification, and increasing energy storage are global priorities amid heightened geopolitical tensions, supply chain shortages, an increase in extreme weather events, and soaring natural gas prices.

These issues were some of the topics on the agenda for thousands of government and business delegates from around the world at the 2022 United Nations Climate Change Conference (COP27) as they sought to collaborate in solving the myriad challenges presented by the climate emergency.

Decentralization has been talked about for decades, but, as markets seek to rapidly integrate more renewables and improve grid flexibility, it is encouraging that now, with stronger regulatory support, we are beginning to see real progress.

For countries to reach net zero, the integration of renewables must improve significantly. Distributed energy resources (DERs) have a vital role to play in allowing a range of green energy sources to be integrated into the grid, but delivering new and more efficient approaches to permitting, connecting, and managing energy flows is particularly urgent.

Responding to waves of demand or localized power challenges has long been a weakness of centralized grids. However, smart grids are now moving into focus, offering bidirectional flows of electricity and data using two-way communication and control capabilities to optimize the flow of energy along a network and enable real-time responses to change in demand.

With a more energy-resilient future on the horizon, now is the time to seize the power of a more flexible energy system.

The global transition from centralized grid networks to decentralized distributed energy systems is accelerating. From microgrids,

small-scale renewables, and combined heat and power facilities, to distributed energy storage and controllable loads, a plethora of options is emerging.

The primary drivers of this transition are increasing pressure on markets to reach their decarbonization goals and a desire to strengthen energy security, particularly in the wake of the war in Ukraine. A favorable climate for DERs has also emerged, with the cost of technologies falling and regulatory support increasing, notably the tax benefits in the U.S. Inflation Reduction Act and the European Commission's REPowerEU plan.

DERs offer the potential for increased grid flexibility and have a key role to play in boosting energy resilience, allowing markets to adapt to changing conditions and to recover rapidly from disruptions. Excess electricity generated by self-sustaining distributed systems can be stored and used when centralized grids are hit by outages. This ability means DERs will be vital in helping counter the high number of grid failures caused by extreme weather in recent years.

Markets around the world are adopting a variety of measures to integrate more DERs, such as metering policies to support distributed solar power and favorable legislation for installing rooftop photovoltaics.

There are challenges to be overcome, however. For example, weather-proofing energy infrastructure to protect it against extreme hot and cold weather, and ensuring there is enough capacity to accommodate the accelerating rollout of electric vehicles.

The intermittent nature of renewables will need to be balanced by more sophisticated energy storage or conventional power-generation capacity, and smart grids are likely to be at the heart of this changing energy landscape. Equipped with robust data flows, they offer improved reliability, efficiency, and flexibility—from smart meters that

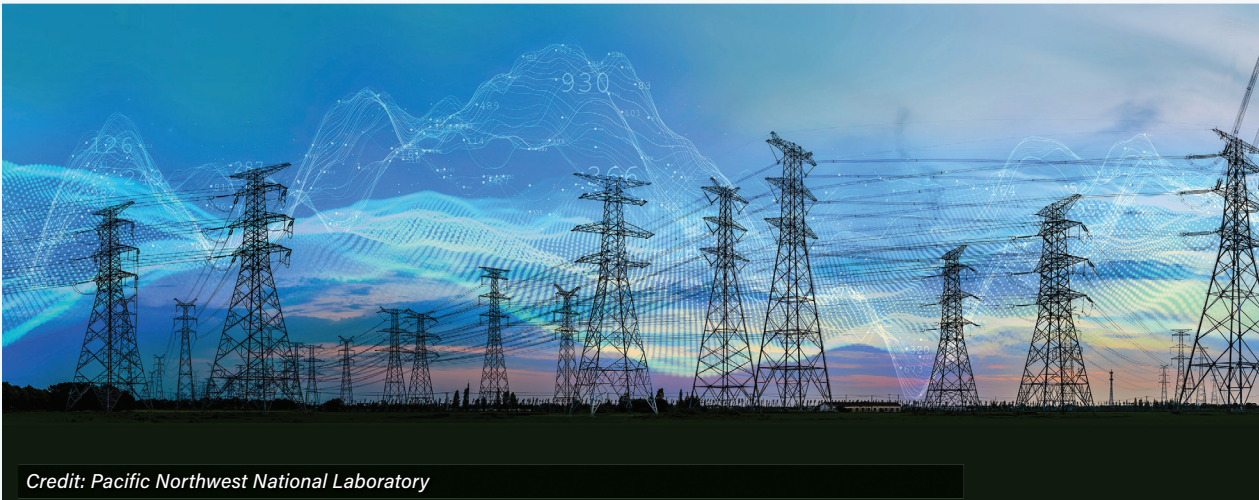
in its carbon emissions. Schott uses natural gas to fire its furnaces, but electricity is its next largest energy source. Schott is relying on renewable, independently verified, green sources of electricity. Since last year, the company also relies on power purchase agreements, or contracts with operators of renewable energy plants such as wind farms.

"Globally, we are experiencing a lot of economic uncertainties," says Jens Schulte, a board member and head of Schott's zero carbon program. "However, we don't want these to negatively impact our progress in the fight against climate change."

NGK Group, the Nagoya, Japan-based maker of high-performance ceramics, set an incremental goal of cutting emissions by 25% by

2025 compared to 2013 levels. As one of its strategies for meeting its target, the company is installing solar at its manufacturing plants in Poland and Thailand. In Poland, it is installing a large-scale photovoltaic system with a total capacity of 15.1 MW on the roofs of two factories and on neighboring land at one of them. In Thailand, it is installing a system with a total capacity of 4.25 MW on the rooftops of its buildings there.

These and many other projects are promising developments, but large-scale, industrywide conversion away from natural gas to renewable sources is a long-term and expensive prospect. For green energy sources to be made available on an industrial scale,



Credit: Pacific Northwest National Laboratory

allow consumers to monitor their electricity usage, to automation that can isolate local faults so they do not shut down an entire network.

Indeed, smart grid technology is creating a new energy distribution model in markets without established national grids, whereby the overall grid is composed of microgrids that can switch to operating independently. This technology provides greater resilience for isolated rural areas, as well as for highly concentrated urban areas where brownouts or blackouts can result from surges in demand.

While their benefits are many, smart grids present several challenges, particularly in making them intelligent enough to manage the integration of DERs, bringing together a wide range of power sources, and controlling the flow of electricity so that it meets demand.

In addition, cybersecurity will be an issue, given the interconnectedness of DER ecosystems, with the increased potential attack surface area making such systems more vulnerable to cyber attacks.

Storage and supply management can also be problematic. As electric vehicles scale up, for example, they will be both a strain on the grid and a support, able to absorb excess generation from renewable energy resources, as well as acting as real-time, demand-response assets. But work still needs to be done on optimizing them as DERs.

Accelerating the use of renewable resources will require annual electric network investments to nearly triple by the late 2020s, to almost

it will require infrastructure investments by energy suppliers and grid operators.

“The electricity network, the electric infrastructure, needs to be increased,” Muijsenberg says. “That will be a challenge for industry.”

He sees the energy supply transition taking 10 to 15 years, as furnaces cannot be replaced at any time because they have defined lifetimes and are planned in investment cycles.

Until then, forward-thinking manufacturers will continue to invest in efficiency measures and renewable energy sources so they can weather the volatility of energy markets. ▽

\$800 billion, according to the International Energy Agency. This investment will need to be matched by an eightfold increase in investment in digital assets.

Continued regulatory support for DERs will be required, therefore, if markets are to realize the potential of such technology to bolster energy resilience through increased grid flexibility and help achieve the world’s decarbonization goals. ▽

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A NANOCERAMIC APPROACH TO THE CLIMATE CRISIS AND CARBON REDUCTION

By Jan Thoren

Over the past decade, mounting evidence indicates that natural disasters, including wildfires, floods, earthquakes, and hurricanes, are becoming increasingly more common and more intense throughout the world.¹ As the rate at which never-before-seen events take place continues to rise, the need to adopt greater resilience against such events is universally recognized as requiring a global response.

Nations around the world are setting climate-related goals to slow the rising intensity of catastrophic events. For example, the United Nations established a Net Zero Coalition to meet the Paris Accord target of 45% emissions reduction by 2030, followed by net zero by 2050.² The two most important issues are to “Build Back Better,”³ as per the UN, and to lower carbon emissions as soon as possible.

Reducing emissions and developing materials with greater resistance to extreme events were the goals of the late architectural physicist John Orava. In 2001, following 9/11, Orava was tasked by two United States entities (the Federal Emergency Management Agency and Department of Housing and Urban Development) to

develop high-performance, low-carbon solutions. Over the next decade, Orava developed and patented several solutions involving closed loop building systems and advanced nanomaterials based on unfired ceramics.

After Orava’s death in 2010, his trustee, innovation partner, and companion Jan Thoren worked to establish a new company to commercialize the patents as per his wishes. Thoren and architect Ron Suverkrop founded NanoArchitech in San Francisco, Calif., in 2015. In 2018, Jeff Selph became chief technology officer of NanoArchitech, bringing his own patents and expertise to the company.

The mission of NanoArchitech is to encourage the shift to mainstream sustainability and prepare communities to survive increasing climate-related threats. To do so, inventors at NanoArchitech have pioneered, researched, tested, and built new technologies for various types of infrastructure, including for water storage, bridge and building renovation, and prefabricated housing. However, the company’s main approach to “Build Back Better” involves cementitious nanoceramic composites.



Figure 1. Zaha Hadid, a London-based architect, is known for innovative designs with creative curves. The Beijing Daxing International Airport terminal in China (left) and the One Thousand Museum high-rise residential condominium in Miami, Fla. (right) are examples of her iconic style. Credit: (left) QuantFoto, Flickr (CC BY-NC-ND 2.0); (right) ucumari photography, Flickr (CC BY-NC-ND 2.0)

NanoArchitech’s work on nanocomposites was inspired by affordable precast and 3D-printing methods that aim to move modern (square) design toward resilient curvature. NanoArchitech engineers have developed several proprietary nanoceramic formulations that are price competitive due to their unfired manufacturing process, which offers huge cost and carbon savings.

Today’s focus is on affordable and resilient building envelopes, which are described in more detail below. But NanoArchitech plans to someday use its nanocomposites for elaborate structures, such as the marvelous designs of Zaha Hadid (Figure 1).

CEMENTITIOUS NANOSCALE BUILDING MATERIALS

A nanocomposite is a multiphase solid material where either a) one of the phases has one, two, or three dimensions of less than 100 nanometers or b) the atomic structure features nanoscale repeating distances between the different phases that comprise the material. In the broadest sense, this definition can include porous media, colloids, gels, and copolymers, but it is usually taken to mean the solid combination of a bulk matrix with a reinforcing second phase.

Nanocomposites offer the ability to design and create new materials with unprecedented flexibility and improvement in their physical properties. At NanoArchitech, cementitious nanoceramic coatings and composites are formulated and manufactured to be lighter, stronger, and faster setting than the standard Portland cement, plus they are highly resistant to fire, water, mold, and toxins.

Sold under the brand name Neuskyns™, the NanoArchitech composites are made from commonly available minerals and recycled materials, bringing the carbon footprint to nearly zero depending on the chemical engineering. Specifically, the Neuskyns proprietary, patented formulations feature a variety of powder components consisting of oxides and acidic materials that are phosphate bonded in conjunction with other raw and recycled materials.

Neuskyns is sold as a powder in 50-pound buckets or one-ton super sacks. When water is added to the powders, the components react exothermically within minutes at room

NanoArchitech: Steering the legacy of climate tech for a resilient planet

NanoArchitech evolved from 18 years of research and development led by architectural physicist John Orava. The company was formally established in 2015 by architects Jan Thoren and Ron Suverkrop to further develop his technology.

Based on this strong foundational history and years of testing and building, Thoren, CEO, expects that Nanoarchitech’s multifunctional and long-lived products will help propel the green economy, the Environmental Protection Agency’s “Healthy Buildings, Healthy People” initiative, and support net-zero goals.

NanoArchitech has won several awards and acknowledgements in Europe and the United States for its products since 2013, when the company placed as a semifinalist in the Cleantech Open national competition in San Jose, Calif. Since then, other awards include the “Best new materials for a building envelope” in Architectural Record in 2019, the “Most Innovative Architectural technology in 2020” in Builtworlds magazine, and the “Top Ten Material Solution Providers” in Manufacturing Technology Insights in 2021. A full list of awards can be viewed at <https://nanoarchitech.com/honors>.

NanoArchitech is currently involved in the Impel Accelerator program at Lawrence Berkeley Labs in Berkeley, Calif. The interdisciplinary NanoArchitech team is excited to hear of other innovations in nanoceramic materials, and they look forward to continuing the incorporation of ceramics, glass, and photovoltaics in global green building projects.

TABLE 1. COMPARISON OF ENGINEERING PROPERTIES OF NEUSKYNS WITH COMMON BUILDING MATERIALS.

Material attribute	Neuskyns	Portland cement	Stucco	Asphalt
Typical strength (psi)	2,200–12,000	2,000–4,000	1,200–1,500	2,000–5,000
Fire-proof	Yes	No burns <1,000°F	No	No
Heat resistance	Tolerates >2,700°F	Low	Low	Low
Water-proof	Yes	No	No	No
Conductivity of hydrocarbons	Negligible	High	N/A	N/A
pH 3–11 tolerance	Yes	No	No	No
Hardening time	5–40 mins	2–4 hrs	<1 hr	>5 hrs
Functional cure time	15–60 minutes	1–3 days	1 day	1–3 days
Can apply below 32°F	Yes	No	No	No
Expansion or contraction	Minimal	Yes	Yes	Yes
Temperature related cracking	No	Yes	Yes	Yes
Self-leveling	Yes	No	No	No
Bonds to itself	Yes	No	No	No
“Green” material	Yes	No	No	No
Tolerant of salt water	Yes	No	No	No
Underwater setting	Yes	No	No	No
Combustible due to fire	No	Yes	N/A	N/A
Flame spread index	No flame and no smoke for Neuskyns			
Smoke test				



Figure 2. (left) Pigmented Neuskyns. (right) Neuskyns slab embossed with redwood bark pattern. Credit: NanoArchitech.



Figure 3. The first Neuskyns nanoceramic housing designed for hurricane resilience in the Caribbean. Credit: NanoArchitech.



Figure 4. Bridge walls cured in less than two hours in subzero temperatures in Ontario, Canada. Credit: NanoArchitech.

temperature and create a high density, strong covalent bond with the surface on which it is being applied. (It does not bond with rubber or plastic, however, which makes them useful for molding Neuskyns.)

The exothermic chemical reaction can cause the temperature of the mixture to reach up to 170°F. When the exothermic reaction commences, the mixture is pasty and can self-level on a substrate or in a container. The overall performance attributes are the result of the reaction and the use of precise specifications of raw materials and mixture methodologies. Table 1 compares engineering properties of the Neuskyns nanoceramic formulation to other common building materials, namely, Portland cement, stucco, and asphalt.

DIVERSE FORM FACTORS AND USE CASES

The Neuskyns nanoceramics can be colored to blend in with surrounding materials, and decorative patterns can be applied, as shown in Figure 2. Figures 3 and 4 (described below) show two successful use cases for the material in the Caribbean and Canada, demonstrating the breadth of its usefulness.

Between 2014–2017, more than 200 prefabricated ceramic structural insulated panel (C-SIP) homes were built in the Caribbean (Figure 3). The homes were simple two- or three-bedroom houses with a 3/8-in. finish of nanoceramic over a Styrofoam core attached to a steel frame. The homes were prefabricated in Florida and moved by truck and ferry to the island sites. Selph designed the C-SIPs in accordance with Miami-Dade high hurricane resistant building codes. The successful installations have now withstood two category 5 hurricanes without damage, and they set a precedent for higher standards of building in the Caribbean hurricane corridor.

At the other weather extreme, Neuskyns nanoceramics were used to repair a set of bridge walls in a frigid Canadian environment (Figure 4).

CONCLUSION

The United Nations' plea to "Build Back Better" needs immediate answers and a robust response with new materials. Current legacy materials do not hold up to the extreme weather patterns that the world is now experiencing.

The NanoArchitech team is confident that nanoceramic composites hold the key to withstanding the challenges that are threatening the built environment. And after more than 10 years of investigations and trials, NanoArchitech's products have proven their worth in extreme temperatures and hurricane corridors.

NanoArchitech's unique "green chemistry" process has led to the continued development of new nanocomposites with low- to zero-carbon footprints. Plus, by eliminating the traditional heat-intensive manufacturing process for ceramics, production cost could be reduced by at least 50% as these products become mainstream.

Of course, there are ceramic materials that will continue to require kiln processing. Exploration is underway to neutralize the footprint, while recognizing that for buildings, price must be affordable.

We invite you to partner with us in this worldwide race to net zero.

ABOUT THE AUTHOR

Jan Thoren is cofounder and CEO of NanoArchitech following a 25-year career as an architect. Contact Thoren at jan@nanoarchitech.com.

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