SiC & MORE

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DIFFICULT TIMES IN EU & THE GLOBAL PRICE OF SiC



When SiC pricing, along with hundreds of other commodities, began to climb during Q4 2021, virtually everyone in the SiC industry understood the trials and tribulations that would follow. Prices on SiC continued to increase to the point by the end of summer 2022 many SiC products had reached their historical peak and angst amongst many of the SiC producers was also reaching its zenith.

The driving forces behind the increases were easily identified by ***SiC & More*** but more importantly, we focused on what could be an industry structure upheaval. As this newsletter has reiterated over and over again, first and foremost, is the price of kWh. In issue #94, "The energy issue is essentially a worldwide crisis. To put just the unstable kWh pricing into perspective, consider SiC furnace operations that were accustomed to paying 5-8 cents per kWh have been paying a firm 10-15 cents with spot purchases of 25-30 cents with some prices even higher than 30 cents. It takes approximately 7000 kWh to produce a ton of SiC crude. In other words, depending on the region energy alone has contributed from $350 to over $2,000 per ton to production cost."

The issue at hand is that pricing for kWh and petroleum coke remain at high levels while the market price for most SiC products is eroding. That is especially the case in EU where energy costs and environmental constraints continue to suffocate manufacturing while SiC producers in countries like China, Vietnam, and Brazil enjoy lower kWh costs and relaxed environmental restrictions. A trader said, "China, Brazil and especially Vietnam seem to be filling the gap left by EU silicon carbide producers whose customers will no longer pay a premium for European energy."
Whereas the EU seemed to be somewhat insulated from less expensive Chinese SiC during 2022, that is not the case in 2023 with freight rates having dropped exponentially and Chinese kWh pricing having returned to normal levels.

With what most would call sluggish demand for SiC, the current situation does not bode well for those afflicted with high kWh and pet coke pricing and hamstrung with environmental woes. The EU producers seem most vulnerable, however, anyone furnacing SiC outside of specific regions find themselves in a precarious situation as end-use market prices continue to drop at a faster pace than kWh pricing.

In the case of metallurgical SiC, with global FeSi prices imploding, there is added pressure on pricing as we move further into 2023. Since metallurgical SiC is a "necessary evil" in the words of one producer, more and more emphasis must be put on recovering #1 grade SiC and processing higher value-added products.

What can the world's SiC aficionados expect as we look deeper into 2023 and take a peek at 2024? According to one trader, "Depending on SiC product, since the first of the year, we have seen about a 5% drop in pricing for material destined for North America and 5-10% for SiC shipped to EU. Most of this is SiC originating from China or Vietnam." A producer said, "My macro approach is that prices will soften a bit between now and the end of Q3 but actually strengthen as we enter 2024. I also believe that if China's economy surges, there will be a global shortage and prices will increase."

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LITHIUM'S WILD RIDE CONTINUES

By Paul Harris



Pictured above is the Patriot Battery Metals' Corvette project.

The lithium space continues to confound investors with wild commodity price swings, aggressive M&A and a plague of new lithium exploration companies adding noise which muffles the signal.

US specialty chemical company Albemarle has made several unsolicited offers for Australian lithium developer Liontown Resources and its pre-production Kathleen Valley project, all of which have been rejected, even with a premium of more than 60%, the company determining it "substantially" undervalued the company. Kathleen Valley is expected to produce more than 500,000tpy of spodumene concentrate.

Albemarle's bid was based on the recent price action of Liontown, which fell to A$1.40 on lithium market weakness. Liontown management seems to still have its head at the A$2.20 all-time high in November 2022 as a valuation reference. The market agreed and propelled Liontown up to the A$2.60 level when the Albemarle bid surfaced. Meanwhile, Albemarle is accumulating Liontown shares in the open market.

Lithium pricing continues to be volatile. The spot price has retrenched from highs of US$85,000/t at the end of 2022 to around US$50,000/t. That is a large fall but pricing is still five times higher than in 2019-2021, and well above the production costs of producers.

The price slide is variously attributed to news that Chinese subsidies for electric vehicles (EV) are expiring and are concerned that the lithium market will be in oversupply with new mine builds coming online.

EV demand concerns are likely to only be temporary as automotive producers are increasingly all-in on them. "One thing that is very different between now and seven years ago is Ford, Chrysler, General Motors, Volkswagen, and BMW. They are all producing EVs (electric vehicles) on multiple platforms so they cannot turn back now. They need batteries, and right now those batteries are all coming from China," Patriot Battery Metals president and CEO Blair Way told SiC & More.

Albemarle clearly saw opportunity in developers whose market capitalisations became more palatable as stock prices fell in response to the lithium price slide, which wiped almost A$20 billion off the stock market value of Australian lithium mining companies in recent months.

Canadian investors, still sore from disasters like Nemaska Lithium, a few years back, are even more gun shy than their Australian counterparts, despite the lithium market having evolved and matured considerably.

"If you compare the scale of what Lionstown has compared to what we have, we believe we have more than that. ... Our investor base is probably 60%, even 70% Australian. They understand it, but you look at the trading on the TSX and ASX and you see sometimes the TSX gets a bit nervy and draws us down, and then the ASX brings us back up," said Way.

The Western world, looking to reduce a strategic vulnerability to China is enacting an increasing series of budget initiatives to stimulate domestic lithium-ion battery production and the extraction of the minerals they require, including lithium, nickel, graphite and cobalt. The Canadian budget in March included battery supply chain incentives and added to those also put in place by the European Union and in the US.

At the start of the year, Albemarle said the 2022 US Inflation Reduction Act (IRA) is expected to spur a five-fold increase in lithium demand by the end of the decade as EV production and its need for lithium-based batteries would surge. The company recently announced plans to locate a US$1.3 billion lithium hydroxide Mega-Flex facility in South Carolina to help meet surging demand for EV batteries. "This facility will help increase the production of US-based lithium resources to fuel the clean energy revolution while

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bringing us closer to our customers as the supply chain is built out in North America," said Albemarle CEO Kent Masters.

While appearing to be good news for the North American economy, some observers, such as Rick Rule of Rule Investment Media, commenting that the cost of the subsidies and grants will heap other great sums on national debt levels and will ultimately be borne by taxpayers. “Those budgets are a disaster for the economy, a disaster for the taxpayer,” said Rule.

The money sloshing around has triggered an outbreak of new lithium explorers. It seems anyone who has dropped their cell phone in their backyard claims they have a lithium property and formed a junior. In the March quarter of 2023, at least 250 lithium-related news releases were published via the Junior Mining Network service—which republishes news releases by Toronto Stock Exchange Venture Exchange and main board companies—by more than 125 individual companies. Of these, only four can be considered development-stage companies: Lithium Americas, Piedmont Lithium, Sigma Lithium and Standard Lithium. About one third of all the releases refer to the acquisition of lithium properties.

"$50,000/t is bringing everyone out as people think that after a few false starts in 2012-2013 and 2017-2018, the market is here to stay this time, that it is a more sustainable story this time, based on demand rather than a shortage of supply," Matt Fernley, editor of *Battery Materials Review* told SiC & More.

Fernley recently published a primer on investment opportunities in hard rock lithium called How to invest in hard rock lithium, which is available from www.BatteryMaterialsReview.com. Fernley was driven to produce this guide to better equip investors to face the veritable assault of lithium juniors coming at them. "It is quite a difficult industry to get one's head around, and there is a lot of disinformation out there, so a lot of money is going to be lost for the unwary. People need normal mining common sense, but in hot markets, there is less common sense around than there should be," he said.

Additionally, the increasing participation from companies further down the value chain, such as battery producers and automotive companies, signifies new potential funding sources and strategic partners for the tricky yet crucial development of a lithium chemical project which the market will receive, as well as an increased potential to eventually be bought out rather than having to bring a deposit into production.

"At some companies, there is a view that someone will buy them and all they have to do is explore as many pegmatites as possible, and it will be up to the person who buys them to do the product qualification. This is shortsighted as an OEM or battery cell manufacturer is not going to buy a project that needs to be qualified. An OEM will not start from the beginning," said Fernley.

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Overall, as ***SiC & More*** has stated in recent issues, 2022 was what we consider a watershed moment for global SiC production. Prices will not return to pre-COVID levels and new benchmark pricing is likely to be a minimum of $200-300 ton higher than it was in mid-2020. A processor of refractory and abrasive grain stated, “The .30-.40 per pound increases won’t stick around but you should expect .20# higher than you paid during most of 2020.”

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NEWS FROM UKRAINE'S KYRYL SHAPOVALOV AND ZAPORIZHABRAZYV



A section of the ZAK silicon carbide furnace yard is pictured above.

In three previous issues of ***SiC & More*** we provided brief updates regarding the stark reality of doing business in Ukraine while in the middle of a war zone.

For example, in issue #95, Kyryl Shapovalov (Head of Foreign Trade Department) reported, "I can say that today we have enough electricity to produce both SiC and BFA though the price of kWh also increased a lot." Trying to do business under the conditions that currently exist in Ukraine are reflected in the following comments from Shapovalov, "We protect our energy system from terrorist attacks. Some parts of the power system were fired upon five or six and even seven times on different days. In general, shelling tool place in almost all regions with few exceptions. The aggressor is trying to stop our power system. However, we remain optimistic and continue to work. ZAC keeps producing both BFA and SiC for our customers."

Shapovalov continued, "Thanks to ENTSO-E, the energy system in Ukraine can receive emergency assistance of up to 500 MW. The problem with energy imports is that European electricity prices are higher than Ukrainian indicators. During January through September of current year, the average price of electricity in the day-ahead market segment was 34% higher than in the same period las year."

Despite the menacing situation that employees at ZAC face each day, the company's commitment to their employees and customers has not wavered. Nevertheless, the threat is real. As told to ***SiC & More***, "Unfortunately civilians and personel of power system facilities die from the shellings."

SiC & More recently made contact with Kyryl Shapovalov, Head of Foreign Trade Department, to discuss working and living conditions as we enter Q2 2023.

According to Shapovalov, "Ukrainian Zaporizhabrazyv (ZAC) has not stopped the production of BFA & SiC despite the blackout and the war. Despite blackouts and shelling, ZAC did not stop for a single day of their work. The company fulfilled all its contracts and delivered products to different parts of the world."

In addition, Shapovalov said, "ZAC has successfully passed the toughest heating season and continues to produce BFA and SiC for their foreign partners. The company is currently provided with raw materials and electricity for all production processes.

Logistics is working also, so we can fulfill all contracts." It's not only an effort to conduct business as usual at ZAC, but to continue to move the company forward. For example, Shapovalov also mentioned, "The company is currently working on introducing a new convenient service for its customers - the brand new electronic catalog of plant's products. That would be an open resource tool designed to help our common and new partners from any country of the world. After visiting the site, will be able to choose products, specify the quantity, click on the "Order" button -and that the order immediately arrives at the sales department. It will allow the customers to place orders much faster, and for us to be more efficient and focused on customer needs."

SiC & More will remain in contact with ZAC management to provide readers with information regarding the Ukrainian struggle and ZAC's commitment to remaining a viable business supplying valued added products to its customers while sitting in the middle of a war zone.

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VIETNAM'S NHQ KEEPS HUMMING ALONG



Pictured above is an NHQ silicon carbide furnace under power.

SiC & More's last report from Vietnam came in March of 2022. Since the ownership and management of New He Qiao Shareholding Company (NHQ) are committed to making continuous progress, ***SiC & More*** was eager to conduct an interview to hear more about Vietnam's only SiC-producing entity.

One year ago, NHQ was operating at about 75% theoretical capacity utilization but had absorbed several kWh price hikes. Although the energy cost increases represented a substantial boost, they were, for the most part, on par with other regions of the world.

As we enter Q2 2023, NHQ is operating at just shy of 75% capacity utilization. Although overall global market demand is a bit sluggish, supply of SiC is also running short of expectations due to environmental and energy-related issues. The macro view of the market leads management to believe that 75% capacity utilization will be the minimum objective as we move deeper into 2023.

Operating cost budgeting for 2023 is similar to 2022 with kWh and raw materials still running at 2022 levels. The good news is that high quality raw materials are readily available. Regarding freight costs, management told ***SiC & More*** that rates started softening during late 2022.

In previous issues of ***SiC & More*** we reported that NHQ had committed cap ex money to upgrading transformer group #2, however, due to a combination of obstacles the project was postponed. Current plans are to finish the upgrade to the smelting operation during 2023, which will also increase annual capacity.

NHQ is primed to produce in excess of 40,000 tons of high quality SiC during 2023 with the vast majority of the material dedicated to Japan, Korea, India, Southeast Asia, and EU.

Looking forward, assuming that energy is available at competitive levels, Vietnam is in the driver's seat when it comes to being one of the world's leading producers of SiC. Environmental, energy, and political issues in other countries make the landscape all that much more attractive for Vietnam and NHQ. This will be fun to watch unfold over the next 2-3 years.

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DENGFENG WUDO ABRASIVE, CO. LTD.



Processing line at Dengfeng Abrasive.

Several years ago, ***SiC & More*** visited with what we called a noteworthy brown fused aluminum oxide producer in China, namely Dengfeng Abrasive located in Dengfeng City, Henan province. We called it noteworthy for several reasons.

Dengfeng has annual furnace capacity of 90,000 metric tons per year but due to environmental restrictions, is smelting at about 50-60% capacity utilization. In other words, Dengfeng remains economically viable despite losing 40-50% of its output. The Dengfeng processing line was built many years ago, and doesn't meet new and improved Chinese environmental limitations.

In a country that can theoretically produce in excess of 2,000,000 metric tons per year of aluminum oxide, and has experienced overall utilization of as low as 20% on several occasions over the past decade, Dengfeng has not only survived but thrived.

Dengfeng's BFA output remains dedicated to both the abrasive and refractory markets with about 70% of the tons being exported. The key export markets for Dengfeng remain Japan, Korea, EU, and U.S.

Dengfeng remains a world-class producer with a kWh rate 3.5-4 cents. Over the past two years, however, bauxite has increased from about $250-275 to $295-300 metric ton. Fe chips have also increased as have the cost of graphite electrodes.

Ownership and management at Dengfeng still see growth in electrolytic aluminum and high level abrasive products with emphasis on microgrits (powders).

The primary obstacle facing Dengfeng, like many others across China and the globe, remains environmental controls. However, recent production line improvements at Dengfeng have helped pave a better environmental path to the future.

India Energy Technology Forum Conference & Exhibition 13th -14th June 2023 in New Delhi

www.indiaenergytechforum.co.in

Greetings From **IETF,**

We are organizing the **India Energy Technology Forum (Conference & Exhibition) to be held on 13th -14th JUNE 2023 in New Delhi India.**

India's energy presenting the sectors of Hydrogen Energy & Fuel Cells Technology, discussing hydrogen process, production & application, Clean energy, sustainability energy, Renewable Energy, coal and oil, gas, pipeline ,refinery, petrochemical, chemical solar, wind, gas and biomass, new technologies e-mobility, floating solar, offshore wind and Hydrogen .

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NEWS FROM BRAZIL VIA FRANCISCO BATISTA

a) Energy: As Brazil approaches the end of the rainy season (April 30th), we can now state for sure that energy supply is secured for the next four (4) years. Every major hydro plant reservoir in the country has at least 85% of water level and many of them are spilling over significant amounts of water. There is clearly an oversupply of energy both in terms of installed capacity and of raw material (water and natural gas). Energy forward prices are on a record-low: 2023 at R$ 70/MWh (US$ 14/MWh); 2024 at R$ 78/MWh (US$ 16/MWh); 2025 at R$ 84/MWh (US$ 17/MWh), and; 2026 at R$ 98 ($20/MWh). El Niño was recently confirmed by NOAA (www.noaa.gov) to be strong and to peak between August and November of 2023. The historical effects of El Niño in Brazil are: drought in the North and Northeast regions, excess rain in the South region and unclear in the Southeast region. In terms of potential impact for energy prices it will depend on how it affects the next rainy season (Oct/23 - Apr/24) in the Southeast region where 75% of the hydro reservoirs are located. We don't foresee El Niño having a major impact in energy prices for 2024+ as reservoirs are already filled up and wind generation ramps up during winter/spring time in Brazil (June - November) which always helps preserve water in hydro reservoirs.

b) Macroeconomics: although the official 2022 GDP was +2.9% it is becoming clear that Brazilian economy is losing traction and will probably touch negative terrain by mid-2023. Inflation is still high which refrains Central Bank from lowering interest rate. Brazil has currently the highest real interest rate in the world and Central Bank is being targeted by new administration to lower it even though this administration is in full speed increasing expenses and the fiscal deficit. A new fiscal policy was recently announced by the secretary of treasury but many economists are skeptical about its capacity to reduce deficit and federal debt especially in the recession scenario ahead. Current FX rate (R$5.1/$1) is reflecting this situation and could go as low as R$4/$1 in the unlikely scenario of deficit and spending being fought by a tight fiscal policy.

c) Commodities: There has been virtually no change from the last report. Increases in capacity utilization are underway across the industry and the energy cost prospects add reason for additional optimism.

d) Politics: The new President of Brazil (Lula) seems more worried about scrutinizing and demonizing the last administration's acts than proposing real solutions to the problems the country is facing. As Lula made very few promises during his campaign one cannot complain about what he is delivering but his rating is worsening every week which makes him very vulnerable and weak to implement his typical leftist agenda. Political experts are predicting Lula will deliver very little in terms of real reforms (tax, administrative and others) and the economy will struggle for the next couple of years as a consequence of that.



John Gross added to speaker lineup

The Battery and Critical Metals Recycling Conference (June 12-13, 2023, Atlanta, Georgia), is the only industry event serving the ballooning market for environmentally responsible management of end-of-life batteries from electric vehicles, consumer electronics and the rapidly developing stored power sector.

John Gross, president of John E. Gross Consulting Inc., a metals management consulting firm, and publisher of The Copper Journal, a widely read industry report established in 1987, will be joining our panel of industry experts and speaking at this can't miss session:

Tuesday, June 13th, at 9:45 AM – 11:00 AM

Market Outlook: Battery Demand, Raw Materials and Recycling

Benchmark Mineral Intelligence provides an exclusive look into demand growth for lithium-ion batteries, its impact on raw materials demand and how battery recycling fits into the picture. John Gross of The Copper Journal will provide unique insights into the factors shaping supply and demand for this critical metal.

Be sure to register today to take advantage of our early bird registration pricing, as pricing will increase.
Save **more than $250** by registering today and experience this unique event that focuses solely on issues surrounding battery recovery and recycling!

Details are being added to the website frequently. Visit BatteryRecyclingConference.com for more information and to register.

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DIGGING THROUGH THE ARCHIVES: (SiC & Semi-Conductors)

No doubt, it's an adventure locating old documents in your library and the process can often be enlightening. This is the sixteenth segment from the dusty but irreplaceable ***SiC & More*** archives. Most of the previous segments have been related to abrasive and refractory topics. The literature that has been pulled from the archives makes it apparent that the evolution of the business often goes unnoticed. These segments are also great reminders of the many years of tedious research done by those that came before us in this astonishing industry. The following excerpt does not bear the name of the author.

Continued from issue #95:
Electrical Resistance: Silicon carbide belongs to the class of materials known as semi-conductors. For a discussion of what this implies according to modern theories the reader is referred to work done by G. Busch. Busch, wishing to study the electrical resistance of silicon carbide itself apart from the variations introduced by special considerations, used current densities in the range of 10(-5) to 1 ampere per square centimeter. Busch found that for these very low currents the resistance varied with temperature but not with voltage, or in other words, obeyed Ohms' Law, and followed Wilson's theory of semi-conductors.

According to F.P. Henninger, when a voltage is applied to a silicon carbide crystal, the resistance is relatively high initially. If a surge higher voltage current is passed through the crystal and the voltage is then reduced to the original amount, the resistance will be found to be lower than when measured initially. The resistance will remain about constant for that voltage thereafter unless the crystal receives another surge of current of voltage still higher than that of the first high voltage impulse. This effect has been explained as due to the presence in the crystal of poorly conducting barrier layers which are penetrated by the high voltage current.

Silica forming as an oxidized surface film on the crystal will also have an effect on the res9stance. The resistance is seen to be affected by variations in the temperature and in voltage, by grain type including such factors as degree of purity, and by the prior history of the crystal. Thus its electrical resistance is not a property that can conveniently be pinned down to a few data. An article by D. Lundquist discusses the effect of some of these impurities on the semi-conductor properties of silicon carbide, and Sear and Becker determined the specific resistance of black silicon carbide crystals as 2.13 ohms/cm and of green crystals as 0.41 ohms/cm.

Silicon carbide crystals were also found by G.W. Pierce and R.D. Evans to have the property of electrical capacity which they explained as being due to stratification in the crystal. The concept that a single crystal is comprised of alternate conducting and insulating strata further indicates that the electrical properties of the crystal are anisotropic and makes the assignment of a specific volume or bulk resistivity for a single crystal impossible.

From a practical standpoint, the electrical resistance of single crystals has little meaning. It is the manufactured shapes of industry with which we deal in practical application. These theories and single crystal measurements are of interest primarily in understanding the kinds of variations to be expected and in the development of manufacturing techniques to take advantage of them.

The behavior of the electrical resistance of silicon carbide shapes bonded with two different types of bond, one with greater electrical resistance than the other, can be taken from the data determined by M.L. Hartman, A.P. Sullivan, and D.E. Allen.

Data by H.E. White for determinations on bonded silicon carbide shapes show that electrical resistance increases with increasing porosity and decreases with increasing silicon carbide content.

The electrical resistance of such products thus depends on the composition of the bond between the grains, the size and type of grain, the amount of oxide film on the grains, etc., and thus is subject to control withing certain limits by the selection of the raw materials and manufacturing process so as to adapt the product to the application for which it is intended.

The resistance-temperature curve for silicon carbide electric furnace heating elements depicts the resistivity at room temperature is 0.116 ohms/cm(3) which decreases to a minimum of about 0.075 ohms/cm(3) at about 400 degrees C and then increases to 0.13 ohms/cm(3) at 1500 degrees C. This has the effect of reducing the total power input used in getting the furnace up to temperature while keeping the furnace from running away when it has reached operating temperature.

The negative voltage coefficient of resistance is made use of in low watt capacity resistors for electronic applications. Further discussion of the applications and properties of these products is given in the section on Resistors.

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COSTS TO PRODUCE SIC



SiC & More **decided to reprint the last page of issue #96 to continue to illustrate the changing global landscape for furnacing SiC. In issue 98, we will provide further details depicting the differences between production costs in China vs. other parts of the world.**

The following numbers are somewhat generic and simply meant to illustrate not just the trials and tribulations of operating a high-energy consuming facility but help explain the recent price fluctuations for SiC products. The following are in U.S. dollars to produce one ton of crude SiC. It's necessary for readers to understand the following numbers are not only generic but represent only crude and not value-added SiC.

	2020/2021	2021/2022
Energy Consumption	350.00	1,050.00
Raw Material Mix	100.00	175.00
Labor	150.00	150.00
All Other Operating Costs	190.00	190.00
Environmental & SGA	90.00	90.00
Estimated Total Cost to Produce a ton of SiC	**880.00**	**1,655.00**

The difference between the two columns illustrates almost a 100% increase, however, that still doesn't capture the difficulties that faced SiC producers in some parts of the world the past 12 months. For example, some producers don't know there energy costs from one day to the next. Quite literally, in just a few days, kWh prices can fluctuate from 5 cents per kWh to 25 cents and even more.

Assuming 7,000 kWh necessary to produce a net ton of SiC, the second column energy consumption price of $1,050 (15 cents per kWh) was often times 25 cents or $1,750 ton just for energy. In some parts of the world, prices went to nearly 40 cents per kWh forcing SiC furnace plants to temporarily cease production.
As we entered 2023, the situation had improved in regard to the average cost of electricity in most areas of the world. However, some producers still don't know the price of kWh until the day before production begins, i.e., "Day-Ahead Pricing". This makes planning and organizing production nearly impossible not to mention the challenges of providing a customer with a price per ton for any reasonable duration.

Although this is not the situation in all parts of the world, the globe has shrunk enough over the past 30 years to know that there is a trickle-down effect of the aforementioned energy dilemma that impacts every SiC end-use market in all areas of the world.

Silicon Carbide & More

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