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RENEWABLE ENERGY, BATTERY SPACE & SILICON CARBIDE

As Told to Paul Harris



Pictured above is a photo depicting a mining "Microgrid"

US technology development firm 247 is about to pilot solar generation and battery-storage technology which has the promise of providing baseload power for remote mining operations.

Using high-efficiency heat technologies developed by MIT professor-emeritus Dr David Gordon Wilson, 247Solar founder and MIT alumnus Bruce Anderson conceived a truly 24/7, cost-effective approach to round-the-clock clean power.

The ultra-high-temperature solar technology platform comprises a concentrated solar power plant, or CSP, a modular system with a breakthrough solar receiver design, proprietary thermal storage system and a unique turbine, combined with other proven technologies and off-the-shelf components, which it says will be able to produce the world's lowest-cost 24/7 solar electricity.

247's CSP differs from conventional CSP, such as systems that use molten salts, in two ways. Firstly, it is modular with each module having 400kW capacity and occupying about two hectares of land, whereas CSP plants are typically very large and have to be custom engineered. "It is much smaller than conventional CSP and therefore can be deployed in places where you don't have large areas of flat land," director of marketing communications, Mark von Keszycki told ***SiC&More.***

The other key attribute is that it operates at a much higher temperature than conventional CSP and operates at about 970°C compared to about 600°C for other systems. The system uses atmospheric pressure air as the heat transfer fluid as opposed to molten salts and uses inexpensive media such as sand or ceramic pellets as the storage medium, which allows it to be a much more efficient system. The primary important material is a proprietary outlet absorber made of a silicon carbide matrix that converts sunlight to heat >1,000°C and then transfers the heat to air.

"Our heat transfer fluid is atmospheric pressure air. Like any power tower CSP, mirrors concentrate sunlight onto a receiver at the top of a tower and we blow atmospheric pressure air through that receiver and it gets heated to 970°C. It is then ducted using off-the-shelf blowers to either thermal storage, where it heats an inexpensive medium like sand to store heat, or directly to the turbine, which uses the hot air to produce electricity without either burning fuel or generating steam. While you need water to clean the heliostats, you don't need a constant high-volume source of water to produce steam," said von Keszycki.

The technology is paired with a long-duration thermal storage battery called HeatStorE which, while not looking like a battery, it can both be charged and discharged on demand to produce electricity with long duration of from eight to 20 hours. It is a thermal storage system as opposed to an electrochemical system which would be particularly suitable in a hybrid microgrid, which may already exist in a mining setting, which has PV, wind or short-duration batteries. "We have the ability to take electricity surplus during the time where supply exceeds demand, convert that to heat by simple, high efficiency electric resistance heating and store the energy as heat for later use at peak times or at night. We fill the gap between the availability of

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RENEWABLE ENERGY, BATTERY SPACE & SILICON CARBIDE

Continued from page 1

clean electricity and demand. Even where the CSP system might not make sense, the battery has an important role to play."

247 believes it has a low-cost power generation solution because many of the core components such as the heliostats can be bought off the shelf. "The receiver, the turbine and the storage are proprietary but everything else, the ducting, the tower and the blowers are all factory produced components, which not only accommodates quick deployment, but also means there are significant economies of scale," said von Keszycki.

The CSP needs intense direct sunlight to function and so is most suited to arid environments in equatorial and tropical latitudes, with relatively high levels of direct normal radiation (DNI). DNI is the amount of solar radiation received per unit area by a surface always held perpendicular to the rays that come in a straight line from the direction of the sun at its current position in the sky.

"We require a minimum 1,600 DNI and ideally 2,000 p," said von Keszycki. DNI hotspots include Australia, Africa, much of South America, Mexico, the southwestern US and the Middle East.

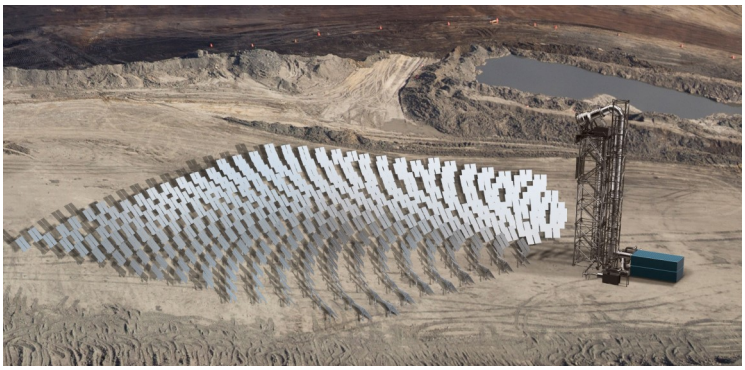
247 is developing a commercial demonstration plant in Arizona, USA which it aims to have operational by the end of the year to start generating performance data. Initially, it is looking to be competitive with unsubsidised electricity at around 12c/kWh, although its sales focus is on off-grid applications at installations which typically use diesel generation and have higher energy costs.

In addition to potentially reducing power costs at remote installations, the 247Solar Plant will provide environmental benefits including the reduction of carbon dioxide emissions from both the diesel generation and transportation of diesel fuel to site, as well as reducing the social disruption that truck transportation through communities can cause.

"We talk about providing a pathway to 100% renewables for off-grid mines, which even if they have solar or wind power, are supplemented by diesel. We provide baseload power up to 80% or higher of power needs. With renewable-based technology, there will be times when the sun hasn't shone for two weeks or the wind doesn't blow, but our system provides its own backup so you don't need diesel, as our turbines can also burn a variety of fuels, including green hydrogen, when that becomes available," said von Keszycki.

The modular system means that mine builders can phase in the development of their energy provision 400kW at a time in line with production expansion, reducing upfront capital costs.

"If you don't reach full production right away, you don't need to put the entire power installation in all at once so you can scale it as demand requires," said von Keszycki.



Pictured above is a double stack grid configuration

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A Message from Zaporozhabrasiv Ukraine



Pictured above is finished product being shipped out of one of ZAK's warehouses

The Ukrainian producer of brown fused alumina and silicon carbide, which at the beginning of hostilities suspended production, and then got involved in work and gradually increased the load, reached the pre-war level of production.

Today Zaporozhabrasive Plant continues its work, using its production capacities to the maximum.

Despite the fact that Zaporozhabrasive Plant suspended its work on February 24 due to the outbreak of hostilities in Ukraine, already in March the company began a gradual resumption of production, having decided to increase the utilization of its production capacities as much as possible.

And if in April the volume of output of finished products of the enterprise was approximately 50% of the pre-war level, then by now Zaporozhabrasive Plant has increased the production of both brown fused alumina and silicon carbide to 100% of its capacity.

Shipment of goods for the partners of the plant did not stop even during the suspension of production. Products, although in smaller volumes than usual, were constantly shipped from warehouses, although logistics issues were very acute.

To date, we have solved all the complex logistics issues that arose due to the disruption of traditional supply routes during military operations. This applies to both finished products and raw materials.

New routes have been developed that provide the enterprise with the delivery of raw materials. The work of the enterprise has returned to normal, and we can provide a service for the regular delivery of finished products to any region.

Francisco Batista Speaks Out on Brazil

Energy: The scenario of water reservoirs is now settled and although dry season is just starting, the spot prices will be very low throughout the remaining of this year. However, 2023 is a different story as prices are almost entirely dependent on every year's rainy season. Energy system tariffs, charges, and taxes are a different story as they accumulate every sector's mismanagement and bad political decisions of the past. The federal government is now forcing federal and state taxes down to reduce the overall burden of electricity for energy consumers once final tariffs have created upward pressure on inflation indexes up for the last two years. The country's track record shows that every time populist administrations interfere in the energy sector's regulation and taxes, a new and bigger cost arises from it and is passed-through tariffs in the future. It's deja vu all over again.....

Macroeconomics: Inflation is still high but a few signs of relief have shown up on the horizon. Should this trend be confirmed then Brazilian Central Bank may start thinking of reducing the hiking in interest rates and maybe stabilizing it by 4Q22. The sooner it happens the better are the chances of Brazil avoiding an economic recession in 2022 and 2023.

Commodities: Not much has changed from issue #92 of ***SiC & More*** when we reported that prices were high, and some were at record levels. The overall scenario is still very favorable even considering the general increase in raw materials and production costs.

Major Elections 2022: Between the far-left (Lula) and the far-right (Bolsonaro), the center (also called in Brazil as "the third way") has been struggling to consolidate over a single name since early 2022. However, after the latest political moves, it seems like the third way will be represented by Senator Simone Tebet (MDB party). Despite all the excitement about Mrs. Tebet running for office, her chances to be a real contender is still very unknown and unlikely. Brazil, just like everywhere else, is still living in the extremes of the Left vs. Right battle. Should current polls be confirmed then President Bolsonaro will be in real trouble to beat former President Lula in the runoff.

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DIGGING THROUGH THE ARCHIVES



Refractory block. Stock photo

This is the thirteenth segment from the dusty but irreplaceable ***SiC & More*** archives. The initial segments were dedicated to abrasive-related topics and, due to popular demand, we continued to move forward with sections related to refractories. All thirteen of the segments have been taken from a paper that was discovered in a file several years ago but does not bear the name of the author. Continued from issue #92 and representing the final segment on refractory.

Silicon carbide cements are recommended for laying silicon carbide bricks or other shapes, for rammed linings or patches, and for furnaces wall washes in various types of furnaces. These cements are shipped to the customer as dry mixtures of silicon carbide grain, powdered bond, usually fireclay, and a percentage of temporary binder. To prepare it for use the dry cement is mixed with sufficient water to make the cement of proper working consistency for the task at hand.

When used for monolithic furnace linings, the cement is rammed into place usually behind retaining forms. After the cement is dried, the furnace is fired. During this first firing operation the bond vitrifies sufficiently to form the monolithic lining, while the temporary binder is burned out as in other fired bonded articles. Patching is also done by ramming into a carefully cleaned and undercut area. Rammed linings are used in brass melting furnaces, forge furnaces, boiler furnaces, etc.

Several different types of cement are prepared. One type is especially intended for monolithic linings, another for brick laying, and a third for shallow patching or for a wash on furnace walls to form a protective coat over the original refractory lining. The major difference between these types is in the grain size used, lining cement being made of a coarser grain and wall wash of a finer grain than the cement intended for brick laying.

This ends the series on refractory. Beginning in issue #94, ***SiC & More*** will present a short series called *Facts About Silicon Carbide.*

METALS INDUSTRY UPDATE

U.S. Vehicle Sales

New light-vehicle sales dropped in May 2022 to a seasonally adjusted rate of 12.8 million units. This is a drop of 24.9% from May 2021 and is lower than the forecast 13.4 million.

Iron Ore

Spot prices for iron ore ranged from $131 to $137 metric ton in recent weeks. During late March when issue #92 was released, spot prices ranged from $146 to $158 m/t.

Ford Motor Co

Ford announced on June 2 that the company would make large plant renovations in Ohio, Michigan, and Missouri, which are all meant to bring more commercial electric vehicles to market. Ford will invest $3.7 billion in plant expansions and create 6,200 jobs in the three above states.

CUMMINS

Cummins recently introduced its 15-liter hydrogen engine built on Cummins' new fuel-agnostic platform. The engine will be a zero-carbon fueled solution for multiple markets and is expected to be in full production in 2027.

TESLA

The Company recently released an Impact Report that indicated nickel would represent the biggest problem in its supply chain for batteries when it comes to emissions.

SCRAP

Scrap prices in the U.S. took another significant drop in June. Depending on the quality, pricing on both prime and obsolete scrap products dropped 10% in May followed by another 10% in June.

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CURIMBABA'S SUBLIME SiC UPDATE



Pictured above is a large SiC furnace being cracked after being taken off-power and cooled at the Curimbaba Group's Sublime SiC plant in South Africa.

In issue #91 of ***SiC & More*** we reported on the status of Curimbaba's Sublime SiC plant in South Africa. At that time, conversations were taking place regarding the re-start of Sublime's #1 transformer group. According to Leonardo Curimbaba at that time, "We are discussing this matter with the local electricity supplier, once we need their allowance to purchase more energy."

Then in March 2022, with issue #92, Leonardo informed ***SiC & More***, "Yes. Our intention is to have it running in three months. We are finishing some repairs and awaiting some critical parts from abroad."

Leonardo also told ***SiC & More*** that Sublime would have enough energy allocated from ESKOM to enable #1 transformer group to run at 60% capacity while running #3 at capacity.

After recently checking in with Leonardo regarding the start-up for #1 transformer group, ***SiC & More*** has encouraging news to report. When asked about the status of the restart, Leonardo said, "Furnace #1 will resume by the end of June, beginning of July. The idea is to start it right away." Quite frankly, although most SiC experts assumed that technology was in good supply within the Curimbaba group, many thought critical replacement parts would pose a stumbling block to restart.

SiC & More asked Leonardo about the 60% capacity limit and he responded, "Yes. This is related with the quantity of electricity we have available from ESKOM."

The new SiC production will be well received by the metallurgical, refractory, and abrasives industries. In issue #94, ***SiC & More*** will report on SiC tonnage out of Sublime.

> Continued from previous page

CHINA NEW VEHICLE MARKET

China's new vehicle market dropped again in May 2022. After selling 2,128,000 units in May 2021, the most recent result reflected a 13% drop to 1,862,000 units. China's zero-COVID policy and lockdowns contributed to the drop in sales.

Raw Steel Production 2021

Global raw steel production reached 1.95 billion metric tons is 2021 with China representing 53% of that total. The global output grew by 3.8% over 2020. China remained the world's #`1 producer with 1.03 billion metric tons, India next with 118.2 million, Japan with 96.3, and the U.S. number four with 85.8 million metric tons.

NUCOR

CHARLOTTE, N.C., June 9, 2022 /PRNewswire/ – The board of directors of **Nucor Corporation** (NYSE: NUE) declared the regular quarterly cash dividend of **$0.50** per share on **Nucor's** common stock. This cash dividend is payable on **August 11, 2022** to stockholders of record on **June 30, 2022** and is **Nucor's** 197th consecutive quarterly cash dividend.

U.S. Raw Steel Production

U.S. raw steel production increased for seven of the last eight weeks with mills producing 1,798k tons with a capacity utilization rate of 82.4%.

John Deere

Moline, IL (May 20, 2022) Deere & Company reported net income of $2.098 billion for the second quarter ended May 1, 2022, or $6.81 per share. The John Deere Foundation announced a $1 million donation to World Food Program USA to combat global food insecurity and address the staggering rise of acute hunger exacerbated by the crisis in Ukraine.

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CHATTING WITH MANAGING DIRECTOR ANANTHASESHAN



Pictured above are the CUMI and Rhodius Abrasives teams with the Mayor of Burgbrohl

SiC & More last did an extensive article on Carborundum Universal Limited (CUMI) in August 2020. At that time, Managing Director Ananthaseshan Narayanan (Ananth) openly shared with ***SiC & More*** how CUMI was addressing business conditions during what turned out to be the most difficult and troubling days of the COVID19 pandemic.

There is arguably no company better served to provide a true global snapshot of business conditions than CUMI, a part of the Murugappa Group headquartered in India. CUMI produces an incredibly wide range of products that add value to a long list of diverse markets including aerospace, foundry, stone, wood working, automotive, etc. CUMI also operates production facilities, sales offices, and warehouses all over the world.

SiC & More recently asked Director Ananthaseshan for a status report on Volzhsky Abrasives Works (VAW), the large SiC producer owned by CUMI and located in Volgograd, Russia.

According to Director Ananthaseshan, *There are six packages of sanctions released to date by Western countries targeting Russian economy, businesses, banks, state-owned enterprises, and wealthy individuals. Just to reiterate, the products produced by VAW aren't under any sanction or considered a restricted material. Neither VAW, as an entity, nor its Directors or employees are under any sanctions.*

There are, of course, logistics challenges in terms of dispatching materials from VAW to markets in Europe and Asia. This has an impact on costs and additional time to deliver. The focus is currently on addressing the demand in the domestic market and working on newer applications. This is helping with the capacity utilization of the facility. We do hope that things would get better for everyone involved and quickly.

Since CUMI is much more than just a SiC company, Director Ananthaseshan added, *On other business at CUMI, we have been pursuing our growth ambitions through acquisitions in abrasives and materials for thermal energy storage. Last quarter, CUMI acquired the assets of CUMI-Awuko, a reputable coated abrasives manufacturer in Germany. CUMI also successfully bid and acquired the well respected cutting and grinding wheel manufacturer, Rhodius Abrasives, again in Germany. This gives CUMI a footprint in Europe for expanding into newer geographies and leveraging the strengths of our raw materials, production processes, and distribution in many parts of the world. The other acquisition was PLUSS Advanced Technologies, a company that formulates and designs thermal energy storage solutions using Phase Change Materials (PCM's) in India.*

In the recently completed financial year Apr 21-Mar 22, on a consolidated basis, CUMI's turnover grew to USD 435 million from USD 345 million, a growth of 26%.

CUMI was founded in 1954 as a tripartite collaboration between the Murugappa Group, The Carborundum Co., USA, and the Universal Grinding Wheel Co. Ltd U.K. CUMI produces thousands of different product codes and sells them in over 40 countries. CUMI, like its mother-ship Murugappa Group, has a rich history of business and product development during both boom cycles and downturns. CUMI continues to be a leader in virtually all its market segments and endeavors to add value to its shareholders, employees, and customers.

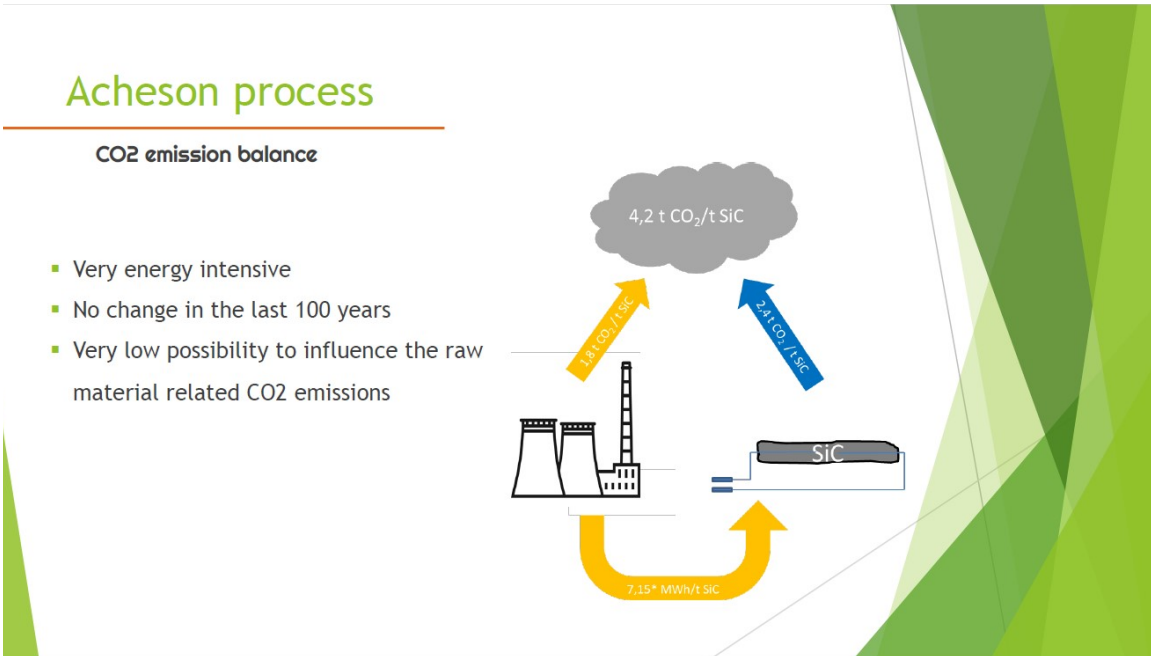
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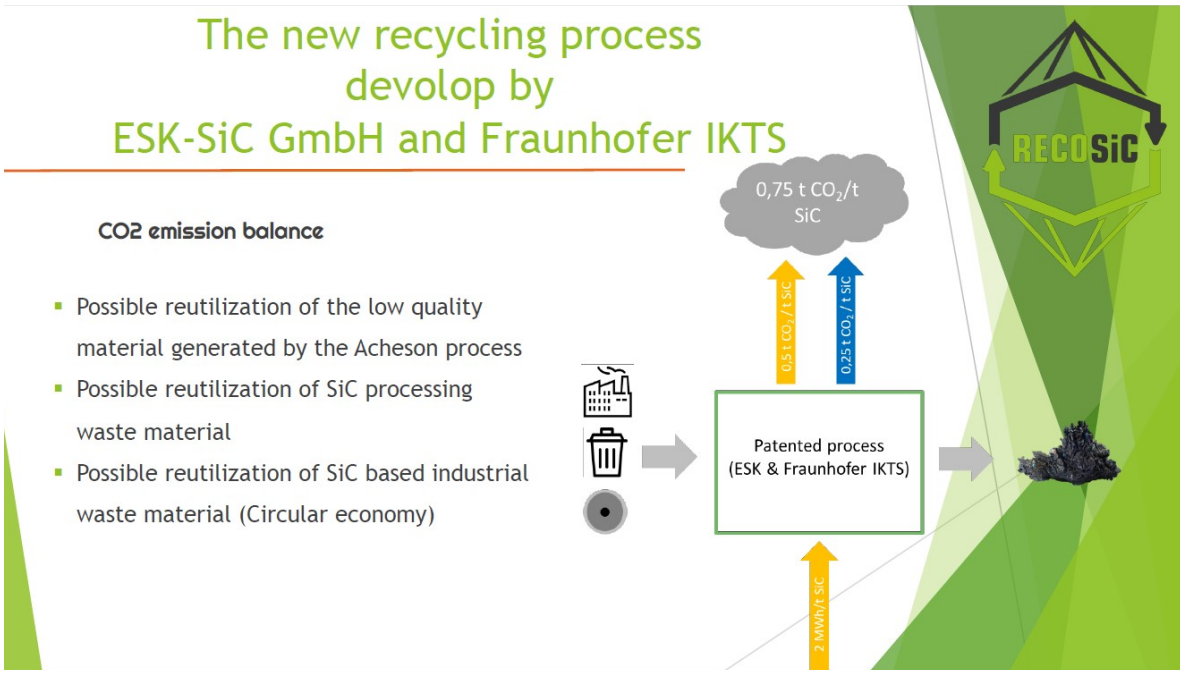
What is Afoot at ESK-SiC?

SiC & More **recently reached out to Guido Mueller of ESK-SiC to learn more about the SiC recycling process developed by ESK-SiC GmbH and Fraunhofer IKTS.**

Regarding the patented recycling process, Mueller has stated, "This process will change the game in SiC!" In addition, "We see an environmental friendly process, which gives Silicon Carbide the chance to step in the future, where a low carbon footprint and the saving of resources is key to be successful."

Rather than making effort to explain the RECOSIC technology, the following charts provided by Mueller give the reader a rudimentary description of the Acheson process and how it compares to the new recycling process developed by ESK-SiC and Fraunhofer.





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What is Afoot at ESK-SiC?

continued

The Acheson process dates to 1891 with the discovery of SiC by George Acheson while attempting to produce synthetic diamonds. It's true that the original furnacing technology has fundamentally remained the same and that it takes large amounts of electrical power (7 MWh) to produce just one ton of SiC. Besides the energy, there are gas emissions associated with the production process.

Silicon carbide is produced through the following reaction: SiO2 + 3C ®SiC + 2CO (+ O2 ®2CO2)
To read more about emissions, the Office of Air and Radiation U.S. Environmental Protection Agency published *Technical Support Document for the Silicon Carbide Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases* January 22, 2009.

Nevertheless, there have also been significant strides in SiC by-product gas collection over the years spearheaded by both ESK in the 1970's and Exolon-ESK in 1997, however, that is for another issue.

The subject of re-introducing lower quality SiC into the furnace process, to reduce emissions and "steal" kWh, is not necessarily a new technology. Discussions with Carborundum employees of yore often touched on this "ancient" practice that had proven to be successful but also less cost effective to the overall furnace operation. There are SiC advocates that believe this "ancient" practice is being refined, documented, and re-introduced in the form of RECOSIC.

Let's not lose focus on the long-range goal of Mueller and ESK-SiC. If SiC is to continue to be a strategic and value-added product, made available for technologies such as enhancing EV battery and semiconductor efficiencies, there must be a long-term solution to the carbon footprint. That starts with SiC furnace technology as proposed by RECOSIC.

According to some sources, global SiC producers are expected to furnace 1,217,000 tons of SiC during 2022 with most of those tons coming from China. Obviously, furnace technology improvements are most likely to occur where the war on the carbon footprint is the most heated and that falls on SiC producers located in the U.S. and EU. The irony is that the world's economic leaders want to be less dependent on China yet the most progressive SiC furnace plants in the world, located in the U.S. and EU, are the ones that are less likely to be cost efficient producers due to the cost inputs associated with strict environmental compliance.

In summary, RECOSIC is a step in the right direction, however, it should be implemented, in one form or another, by all the world's producers not just by those under strict environmental compliance.

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What's Up – Or Down – With SiC Pricing

In issue #92 of ***SiC & More***, when asked about future SiC pricing, a trader commented, "Generally, what goes up must come down. Many producers of commodities are suffering from bizarre costs and finding it almost impossible to operate their factories. When kWh prices are this high, operating at off-peak hours is the only avenue for survival. I cannot fathom this continuing into 2023 but I would have never imagined this is where we would be in 2022." When asked about SiC pricing during May and June, this same trader said, "There has been about a $30 ton softening but I attribute that to currency exchange rates."

A SiC processor said, "Traditionally, we see commodity prices soften in July and August, however, the usual global measuring sticks are out of whack. I suspect a bit of softening in the third quarter, but the Chinese suppliers have drawn a line in the sand on pricing. In addition, although the global price of energy seemingly decreased in May, the summer months are upon us, and kWh pricing is likely to jump again."

In issue #92, we estimated the costs associated with producing a ton of SiC crude. Those estimates led us to believe that SiC pricing was at historical highs. When you review those numbers today, not much has changed. The spot purchase price of kWh has improved, however, the base price for kWh is still the highest in history for SiC furnace plants. In addition, the price of pet coke and anthracite remain at, or near, record highs.

China still drives the market. Whether it's supply/price or overall demand, China drives the locomotive. A trader recently told ***SiC & More***, "Most of the SiC plants in China have little or no finished goods inventory. Petroleum coke continues to increase in price and energy prices are still higher than normal. Although demand for SiC in China dropped during the first half of 2022, the SiC furnace plants have scaled back production due to working capital constraints. Fundamentally, I believe supply and demand of SiC in China are in balance."

Fastmarkets (May 17, 2022 by Sofia Okun) reported, "Worries about the war in Ukraine and logistics from China continue to support silicon carbide prices in Europe, but further price increases are likely. In late April, prices remained stable at a high level with recent shocks putting the market on pause."

On May 31, 2022, *Asian Metals* reports on black SiC abrasive grain, "Despite the weak demand, most processing plants still hold their prices firm based on the firm prices of lumps."

In other words, the SiC industry does not expect a panic-like drop in pricing any time soon. A processor told ***SiC & More***, "I believe we have seen the top of the crude market pricing, but the question remains how long it will stay at these levels. Crude prices have seemingly stabilized but end-use markets such as refractory, abrasives, and metallurgy will see upward price pressure through year-end."

In the EU, during the month of May, petroleum coke for SiC production increased by 65%. Although kWh pricing across the EU dropped in April and May, the average is still four times more than the traditional price. In the wake of this sort of cost input pricing, exacerbated by the limited tonnage available from Russia or Ukraine, how can anyone expect a decrease in crude or end-use market pricing?

The summer months are a question mark from many perspectives. A producer said it all, "We have all calm these days. In the past you fixed a price for the product at the start of the year and that was it. Now, everyday you have new inputs, things are not as usual and you have to cope with every new."

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BROWN FUSED ALUMINUM OXIDE

While canvassing producers, processors, and traders for the state of the BFA market for issue #93, we could print the same information as found on page 7 of issue #92. In other words, as one trader said, "When it comes to brown fused, it's the status quo."

The same trader did say, "The price pressure felt for the last eight or nine months has lifted a bit. I wouldn't say prices, across the board, are going down but we did close a deal that reflected about a $30 ton decrease."

During January 2022 a processor might have paid $880-905 ton delivered to NOLA. By the end of March that price range was closer to $930-950. As we enter mid-June, the price has softened to $895-925 ton. Considering a processor might have purchased the same crude during late 2020 or early 2021 for $600-615 ton delivered to NOLA, that is quite a bump. Keep in mind, although a processor might have contracted for a parcel in early June 2022 at a price $30 ton lower than in March 2022, that material probably won't be on a vessel until July 2022 and arrive at destination until early September 2022. That means, unless something peculiar would occur in the marketplace, the end-use markets won't see that material until Q1 2023.

As mentioned in issue #92, it is believed that China supplies about 85% of the world's BFA markets. There are a few other options for BFA consumers including The Curimbaba Group, which is a major player out of Brazil. When interviewed for issue #91, Leonardo Curimbaba said, "Regarding Al2O3, I'd like to say that ELFUSA is operating at full capacity. The main problem faced right now is related to logistics to export ELFUSA's products overseas. Freight is extremely high and it's really difficult to get room in the vessels."

The same issues continue to haunt China's BFA industry; the cost of bauxite, environmental issues that stifle production, cost of energy, COVID, capacity utilization, and logistics issues and hurdles that affect product movement from the moment BFA leaves the Chinese furnace plant all the way to Rotterdam or NOLA.

Finally, a trader said, "I expect to see some softening in Chinese FOB pricing as we progress through summer and into autumn. Beyond that, however, I will be keeping an eye on China's steel industry. I believe China's steel capacity utilization will have a profound effect on BFA supply and demand and pricing as we enter Q4 and another New Year."

Silicon Carbide & More

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