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SILICON CARBIDE PRICING APPROACHING 10-YEAR HIGH

During a recent discussion with an international metals and minerals trader, this gent commented, "What is occurring with the price of commodities from China is equivalent to a perfect storm and I don't see the weather clearing up anytime soon."



Pictured above is the striking Navarro Cuenca SiC plant located in a beautiful hillside setting about 100 km from Madrid.

Global pricing for virtually all SiC products has been increasing since November 2020. Some of the price adjustments were due to increased demand for SiC due to the world's recovering economies, however, let's take a closer look and explain why our trading colleague referred to this as a "perfect storm".

To review, the Chinese environmental police have been curtailing or shutting down polluters over the past few months and that is expected to accelerate as the 2022 Winter Olympics draw nearer. Silicon carbide (SiC) is one of the commodities feeling the sting of the curtailments as the Chinese implement the "Olympic Blue" policy. In other words, although many industries across China have been under pressure in recent years to control emissions, the pressure is increased when there is massive media exposure, i.e., Beijing Winter Olympics. Although SiC is not as adversely affected by the *Olympic Blue* policy as MgO or BFA, there is still some residual affect.

During most of 2020, practically everyone in the global supply chain had significantly reduced their inventory of raw materials and finished products because of COVID19. With business down as much as 25-50%, depending on the market, many companies were running as lean as possible. As business improved during Q3 and especially Q4, just when traders and processors needed material the most, the curtailments and shutdowns had greatly reduced SiC inventory at furnace plants and at port.

Besides the effects of production curtailments and demand suddenly exceeding supply, to make a difficult situation even worse, the cost of energy increased across the entire SiC landscape. China began rationing power in many provinces while Brazil suffered from a devastating drought. In some Chinese provinces the price of energy increased by as much as one to two cents per kWh, which is devastating to SiC producers.

To exacerbate an already tenuous situation, both anthracite and petroleum coke – key raw materials to produce SiC – began to increase in price with each tender. In China, by late August 2021, the price of anthracite reached $270 net ton while pet coke hit $230 net ton. According to one source, the cost of anthracite and pet coke will continue to increase across China in the coming months.

Two key components to produce SiC had increased substantially in a matter of months. To put the increases in perspective, depending on the producer, kWh and a raw material carbon source will combine to represent as much as 70% of the operating costs to produce a ton of SiC. This is not an exact science, considering the number of producers and the diverse production regions, however, this is meant to further illustrate what has happened to SiC pricing in China.

This isn't a "Perfect Storm", however, without mentioning the most difficult logistics issues in recent memory caused by COVID19. Suffice it to say, anyone importing products from offshore has felt the impact of increased shipping costs, not to mention the abysmal service. In some cases, container freight has increased tenfold. The entire supply

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PETERSEN'S STATE OF THE SiC NATION

Interview by Paul Harris

As we approach the next annual UN climate change conference in Glasgow on 31 October–12 November, COP26, there has been a momentous shift within the natural resources sector on the path towards decarbonisation. With increased scrutiny from investors, banks, governments and NGOs, climate change has become a crucial and unavoidable issue for all companies and in the European Union (EU) in particular, this is bringing an increasing regulatory burden. ***SiC & More*** spoke with Heiko Petersen, CEO of Germany's ESK-SiC to find out what the changing zeitgeist means for the silicon carbide industry.

SiC: Decarbonisation has been a growing theme over the past 18 months. As an EU-based SiC producer, is this starting to have an impact on you?

HP: From the production, at the start of the year the EU launched an increased CO2 price (under the emissions trading system) which energy intensive industries receive partial compensation, but it is a cost-driving factor. We have our own power plant and so have some possibilities regarding carbon credits and because our energy costs less than we would normally have to pay if we did not have a power plant [ESK-SiC generates power from the off-gases at its ESD furnace operation in the Netherlands] which we have had in place for many years. We are improving all our processes such as changing equipment, moving to electric engines etc, to reduce energy usage wherever we can.

One positive is that ESK-SiC obtained a patent for silicon carbide recycling which will improve our CO2 footprint. Recycled SiC uses far less energy than it takes to produce it. We get waste back from customers and recycle it and we have received a lot of positive feedback from the industry since we announced this several weeks ago as everyone is looking to reduce their carbon footprint.

SIC: How recyclable is silicon carbide?

HP: All silicon carbide products can be recycled, even dusts. We can break up the SiC content into a coarser grain size that is really lovely and end up with a 98%+ SiC product.

SiC: Increasing EU regulations also extend to the carbon footprint of products being brought into the EU. Will this provide ESK-SiC with an advantage compared with producers in jurisdictions with less stringent environmental regulation?

HP: It should be more difficult for other producers to bring SiC into the EU in future but increasing regulations mean a huge work demand for the EU as each product coming from outside needs to have its CO2 footprint evaluated. In theory, it should mean it is more difficult to export SiC into the EU but let's see what happens in the implementation. We have seen this before, that the regulations say one thing but the implementation results in the adjustment of a lot of things.

SiC: 2020 was a difficult year due to COVID-19. How has the SiC industry recovered in Europe?
HP: In general, the industry has really caught up in the EU and ESK-SiC is fully sold out. There is far less material coming in which perhaps contributes to us being sold out. Other sources seem to be less available than they were in the past. Looking at the import stats, there is far less SiC coming in from other countries. Nothing is coming in from Paraguay or Venezuela and the container freight rates from China have gone up to US$12,000 per container [from about $2,000 per container a year ago]. Dividing that for a 25-tonne shipment of SiC means it doesn't make much sense to buy SiC products from China if you have to add that freight rate.

SiC: With energy issues and carbon taxes, how are energy prices in the EU?

HP: Prices in the EU have increased considerably since the new CO2 regulations went online at the beginning of year and prices have nearly tripled since January. Our own power supply is a good contribution but we still need to buy a lot of our power.

SiC: Energy is becoming an increasing focus in the EU. Is that also the case in China?

HP: Energy is a key point in China as well. China is buying coal to put into its power plants as their own quantities of coal are not enough anymore. When you consider that silicon carbide is not much more than condensed energy I cannot imagine that there is a lot of interest in buying very expensive coal to use for SiC and to then export SiC for a cheap price. Energy is the factor that is a worldwide issue.

SiC: What about pet coke, the other key ingredient for silicon carbide. The oil market has been quite volatile so how is that impacting prices?

HP: There has been an impact for pet coke as well and it has gone up by 50% during the course of the year. However, it is not as big a factor as the price increase for energy as in general you need 7MW of power to produce a tonne of silicon carbide.
SiC: With energy costs increasing does this increase the need to migrate towards higher margin products and away from metallurgical grades?

HP: That would be nice in theory but the yield from a large furnace is 55% of crystalline SiC and 45% metallurgical SiC so cannot shift it. There is only a little space to change this ratio and so the cost increases must be passed directly through to the end customer. There is no alternative.

SiC: Inflation is becoming a growing macro theme around the world following all the economic stimulus in the EU, USA and other parts of the world. It appears this is impacting SiC too.

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HP: Inflation was 3.9% in Germany last month and this was the first time we have had this level of inflation since 1993 and it is mainly from energy.

SiC: What impact has this had in SiC pricing?

HP: Prices for certain grades have seen around 40% price increases. Metallurgical grades have perhaps doubled.

SiC: A key end market for silicon carbide is the automotive industry and that is one facing major changes through the migration from internal combustion engines (ICE) to electric vehicles (EVs). EVs have fewer parts than an ICE vehicle which means fewer castings, fewer abrasives and so on. How do you see the SiC market changing because of this?

HP: Governments are following the green movement and want to put us all in EVS. Their vision is that in 10-12 years to preferably have no more ICE,. Germany would like to close all its coal fired and nuclear power plants and have just green energy. There are 43 million cars in Germany and right now we don't have enough energy to power them. If there is a 10% switch to EVs we don't have enough power for them and we are far away from having the grid for that. Have fun if you are looking for a charging point in Germany. In reality, there is a limitation for achieving EV penetration. There is not enough lithium available for all the EV batteries; Ford closed its Cologne plant for a week recently as it was missing parts from China as supply chains are difficult at the moment. I do not see the fleet of German cars changing to all EV. EV is not the only solution either. Hydrogen would still need an engine.

SIC: A couple of SiC markets are directly tied to decarbonisation: diesel particulate filters (DPF) and solar photovoltaic. How are they fairing?

HP: As long as we use gasoline we will have diesel as we get this product in petroleum cracking as well. A diesel engine is far more efficient than a gasoline engine and technologies have been implemented so that the discussion of pollution is solved as they no longer generate and DPFs remove the fine particles. A study in Germany found that in industrial areas, the exhaust gas coming from a diesel engine fitted with a DPF contained fewer particles than the air the engines sucked in from the outside. My feeling however, is that the automotive market is flat and weakening because no one knows what kind of car to buy and so people are keeping their old cars rather than buying new. The average holding time of a car is about eight yrs.

There has been a certain stagnation for the classical SiC products which have been in use for decades like macro and micro abrasives, refractory and metallurgical products, but ceramic powders and specialties like 5N where ESK-SiC is fairly advanced, are future markets, especially for the production of computer chips that are able to withstand high temperatures. Autonomous driving needs chips with high potential and that can withstand high temperatures, so there is still a lot of potential ahead. The solar photovoltaic market boomed some years and is now at a lower level. There are not too many new developments in SiC so we follow the new ideas and invest in R&D in what may be the products of the future.

SiC: What are the biggest threats to the SiC business at the moment?

HP: The biggest threat is the green environmental movement for products that are energy intensive such as aluminium, steel and SiC. Industries which consume huge amounts of energy and emit lots of CO2 are a target of the green movement, which prefers to close them down. It makes no sense to stop this production in Europe and to produce in other countries which have less environmental regulation as CO2 does not stop at the border. It is better to produce with the best technology and lowest impact on the environment.

SiC: How do you see the industry in the next two- to five years? With it getting harder to produce SiC, will the number of participants in the industry continue to shrink?

HP: It is getting to be a huge challenge to produce SiC. There will always be more regulation and challenges to reduce energy consumption and carbon emissions. This primarily applies to the producers of SiC crude. ESK-SiC is a processor and we are fairly optimised with state-of-the-art equipment. Furnace production always has challenges and is getting more difficult. Our advantage is that Germany is the biggest market in Europe for SiC and we are in the middle of the country so we have short supply routes. We speak the language of the people in Europe, we are close to the customers and we have the technical support that other producers do not have. Their only advantage is price normally, while we can add value with customer support.



Pictured above is the ESD furnace operation in the Netherlands

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Electric Vehicles, Batteries, & Nickel

3 of 4 in a series by Mr. Paul Harris



Pictured above is the Nouveau Monde Graphite Pilot Plant

*Due to the length of issues #88 and #89, **SiC & More** has converted Paul Harris' three-part feature into a four-part with issue #89 focusing on graphite and issue #90 on lithium.*

With electric vehicles (EVs) continuing their low-hummed drive towards price parity with their internal combustion engine counterparts, their demand is set to soar in the coming years, raising question marks about the supply of key metals for the batteries which will power them such as lithium, cobalt, nickel, and graphite. Paul Harris continuously researches the activities of the mining industry and has key observations and news regarding the key metals needed for EV batteries.

Paul has more than 20 years of experience in the mining sector in investor relations, communications, research, and news reporting roles. Paul has thirteen years of experience in the Columbia gold sector including investor relations roles with Continental Gold, Gran Columbia Gold and Mineros. Paul founded the successful Colombia Gold Symposium in 2016 and has written for industry leading publication Mining Journal since 2015. Previously, Paul spent five years in Chile reporting and analyzing the copper sector for CRU and Metal Bulletin. Paul has also worked as Editor and as a featured reporter for *SiC & More* since its inception in 2003. Paul received a BA in Business Administration from the University of The West of England, UK and a MA in International Business from the University of Chile, Santiago, Chile. Paul is fluent in English and Spanish.

Graphite:

Ironically, decarbonisation of transportation requires a carbon product in the form of graphite. While cobalt often grabs the headlines for its supply chain issues, a looming shortage of graphite is considered a more acute problem for the battery sector.

With EV batteries containing 40-60kg of graphite, they account for 200,000tpy of demand in a market of 700-800,000tpy. Benchmark forecasts EV demand will soar to nearly 3Mtpy in 2030 as the overall market grows to 4Mtpy, which in short means graphite requires the largest production increase of any battery mineral. Will an expected price rise trigger a supply side response and will budding producers be able to meet the battery sector's need for fine grade, sub 100 mesh material?

Like lithium, graphite is in the composition of all lithium-ion battery formulations where it forms the anode. Graphite is the least like a speciality chemical which means the processing challenges are not as great as form budding lithium or nickel producers. However, it is an industrial mineral which means its production will produce a range of grades, each of which will have to find a market for a mining operation to be economic. The larger the flake and the higher the purity, the greater the value. A key challenge though is that the grade demanded by the battery sector is the basic and lowest value -100 mesh commodity grade rather than the higher value large flakes, which is why many developers talk of developing facilities to produce value-added spherical graphite and with a purification process to take the graphite to +99% purity. "Battery companies want a small spherical particle as that helps conductivity as it allows the ions to flow in an out. However, if a flake is too small the fear is it won't have the structural integrity to stay as a sphere and if the flake is too big, it will have to be broken down," said Miller.

Companies with graphite projects are also looking at adding additional processing to produce higher value-added products such as spherical coated graphite, a necessary value-added step if they are to compete with supply from China.

"Multiple new graphite mines will ultimately be required to satisfy the projected growth in lithium-ion battery/EV markets and to provide secure, transparent, ethical sources of supply that are not dominated by the Chinese. Increasing demand is expected to lead to the higher prices required to stimulate such development," said Northern Graphite CEO Greg Bowes.

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The majority of graphite action in North America is in Quebec, Canada. Nouveau Monde Graphite has obtained a ministerial environmental decree authorising its Matawinie graphite mining operation in Quebec, which will produce 100,000tpy of high-purity graphite concentrate for more than 25 years. Matawinie hosts a reserve of 59.8Mt grading 4.35% Cg (graphitic carbon) and a measured and indicated resource of 120.3Mt grading 4.27% Cg. The company plans to start early works for the $211 million development in the second quarter with full construction expected to be launched in the third once permits and authorisations are finalised. The project timeline sees commissioning and start-up of commercial production in 2023. "After a decade of meticulous planning, we can now commence the mine construction of our world-class Matawinie graphite project. … The creation of the Western world's largest anode-quality graphite mine will assist positioning Quebec as the prime location for the North American battery materials hub," said Nouveau Monde chair Arne Frandsen. The ultimate aim of the company is to become a vertically-integrated producer of graphite anodes with a second stage project contemplating the development of an anode plant at Betancour, Quebec to produce 41,600tpy from 2024.

Mason Graphite says its Lac Gueret project in northeastern Quebec is one of the highest grades in the world with an average ore grade of 27.8% Cg over the first 25 years of operations, which it says should translate into low costs. With 11Mt of graphite resources the deposit could has more than 200 years' of production at a rate of 50,000tpy. A December 2018 feasibility study update put a capital cost of C$258.2 million with 1.3Mt of reserves and 9.5Mt of in-pit resources. The project is permitted and the main process equipment has been delivered on site but financing is on hold pending better market conditions. "Demand for flake graphite from the anode value chain is set to surge this year, forecasting a 49% growth rate in demand from the battery sector in 2021 as consumers, institutions and nations alike strive for a green recovery from COVID-19," said Mason Graphite chair Fahad Al-Tamimi.

Focus Graphite has the Lac Knife project in Cote Nord region of Quebec which has a 2014 feasibility for a project to produce 44,300tpy of concentrate with a capex of C$166 million. The company expects the permitting process to complete in 2021. Lac Knife has a reserve of 7.9Mt grading 15% Cg including proven reserves of 429,000t grading 23.61% Cg and 7.4Mt grading 14.64% Cg of probable reserves. A PFS is underway for a value-added products plant planned for Sept-Iles in southern Quebec.

Northern Graphite is advancing the Bissett Creek project in Ontario, which has a feasibility with an $85 million capital cost for a 20-year mine life. The company aims to complete permitting and start construction this year with the goal of reaching commercial production in 2022. Metallurgical testing shows Bissett Creek can produce a high percentage of valuable, large flake concentrates with February metallurgical test results of 22% +32 mesh (XXL) flake and 46% +48 mesh (XL) flake, with 95% of concentrates expected to be greater than 80 mesh which is the cut-off for large flake. Few deposits contain any appreciable amounts of XXL flake material. The feasibility study covers phase 1 of the project with an initial plan of producing 25,000tpy of graphite concentrate. A PEA contemplates a subsequent phase 2 expansion to about 45,000tpy, with the deposit believed to have an ultimate potential of 80-100,000tpy.

On the other side of the continent in Alaska, USA, Graphite One Resources aims to complete a PFS for its Graphite Creek project mid-2021. The company is looking to mine about 1Mtpy and produce 60,000-70,000tpy of processed graphite from its large-flake deposit in the Kigluaik Mountains about 60km north of Nome. The project has a March 2019 measured and indicated resource of 10.95Mt grading 7.8% Cg and an inferred resource of 91.89Mt grading 8% Cg. Graphite One aims to produce high-grade coated spherical graphite (CSG) concentrate via a vertically integrated project. A January 2017 PEA outlined annual production of 41,850tpy of CSG and 13,500tpy of purified graphite powder , when full production is reached in year six, with a 40-year mine life and initial capital cost of $363 million. Some 60,000tpy of concentrate grading 95% Cg would be sent via Port of Nome to a manufacturing plant in Washington State. The concentrate would be pelletised and fed into high temperature, electric furnaces for purification under an inert atmosphere to at least 99.95% Cg. The opportunity for the company is that the USA has no flake graphite mining or anode production and currently imports about 70,000tpy.

Graphite Creek has been designated a High-Priority Infrastructure Project (HPIP) in by the US Government's Federal Permitting Improvement Steering Committee (FPISC), following its nomination for HPIP designation by Alaska Governor Mike Dunleavy in October 2019. This allows Graphite One to list on the government's Federal Permitting Dashboard, which ensures federal agencies coordinate their project review authorities, resulting in a more efficient and transparent process.

With projections for graphite future demand for lithium-ion batteries for electric vehicles seeming to increase each month, a challenge for the company is determining what its market will be.

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"We have one of the largest graphite deposits in the world and if the demand is there we will focus more on creating a project that can meet that demand, but it is a moving target and we don't want to be too high or low. Much of the PFS will be standard but the feasibility will change because demand projections are going to change over the next 18 months," said president and CEO Anthony Huston.

Huston maintains regular contact with automotive companies and analysts to get a feel for future demand but admits the battery sector is in a situation it has never been in before. "What does it mean for Tesla to go from producing 500,000 cars a year to thee million? What will do to the demand for critical minerals? And then you have to multiply that by every other EV company. We need to be focused on what our end users will need and want over the next five to ten years. They will need a one-stop-shop, where we produce something that is specific to them and that fits seamlessly into their technology," said Huston.

As the project advances the company may have different development options and partners available to fund a portion of capex to ensure offtake. "Graphite is being used in all the things that define our life in 2021 and going forward: EVs, laptops and even nuclear reactors. It is an essential material for the electrification of everything and many more applications. The energy storage side is going to be incredible and that market has not even gotten started yet. Natural graphite going to dominate in energy storage as it has higher capacity than synthetic graphite and potentially a lower cost," said Huston.

Earlier stage players in the graphite space include Lomiko Metals with the La Loutre project in southern Quebec 53km from the Timcal mine of French specialty minerals giant Imerys, which produces 7.42% Cg from an open pit operation. Lomiko has a 2016 resource estimate of 4.1Mt grading 6.5% Cg, similar to Timcal. The company completed the acquisition of La Loutre in February and intends to complete a PEA on the project. Canada Carbon Graphite has the Miller graphite-marble project in Grenville-sur-la-Rouge in Quebec although the company says it will target the nuclear market rather than the battery market. The company puts initial capital costs at C$44.38 million with planned production of about 1,500tpy of high-purity thermally treated graphite (99.99+Cg) for 19 years from a resource of 952,000t grading 2% Cg containing 19,000t of graphite.

*Issue #90 of **SiC & More** will include the fourth and final segment of Paul Harris' Electric Vehicles & Batteries feature.*

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chain, from inland freight costs in China to the offloading at ports in the U.S. or EU, has seen costs associated with logistics increase substantially. A trader told ***SiC & More***, "Freight is going to increase with shipments in December and it will increase again in January. I suspect SiC will see a $60-100 net ton bump, depending on quality, with December vessels leaving China."

Lastly, the global price of FeSi has reached record levels. Although only metallurgical grade SiC is directly impacted by FeSi reaching as high as $1.90# contained, this sort of pricing puts pressure on all SiC units. A processor told *SiC & More*, "You can make metallurgical SiC out of #1 grade but you can't make metallurgical into #1." Due to the exorbitant pricing for FeSi, high carbon steel mills across the world are getting their Si units from SiC instead of FeSi. This same processor said, "In recent months, many steel producers in China have switched allegiance to SiC as opposed to FeSi saving hundreds of thousands of dollars."

What to expect as we move forward continues to be the key question when it comes to pricing. In ***SiC & More*** issue #88 we summarized with a colleague's comment, "Depending on the product, prices on SiC are likely to increase by another $75-125 per net ton over the next month. Some of that material, however, will not be on a vessel until September or December 2021. Considering the panic by some processors to get on these vessels, I believe prices will suffer even more as we move forward. That means that the end-use markets can expect price increases throughout 2021 and well into 2022."

Our colleague's forecasting has proven to be right on target except it took two-plus months to feel the price increases instead of one. Depending on the quality and quantity of SiC, global prices have increased by $75-125 per ton since issue #88. As we look toward the end of 2021 and the 1H2022, most experts feel that pricing will continue to increase. If SiC being loaded onto December and/or January vessels in China prove to increase by another $60-100 ton, the end-use markets across the globe can expect higher prices throughout 2022.

SiC prices have now exceeded a global price spike that hit during Q1 2019 and will soon exceed the market prices experienced during Q1 2012. More than likely, Q1 2022 will represent a 10-year high mark that will trickle down to all SiC end-use markets throughout the 2022 calendar year. According to one processor, "Yes, it's a perfect storm and I suspect the question will not be price but whether there is supply."

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DIGGING THROUGH THE ARCHIVES



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This is the ninth segment from the incredibly dusty but irreplaceable ***SiC & M***ore archives. The previous eight segments were focused on abrasives-related topics and, due to popular demand, the next few issues of SiC & More will emphasize the nuances of silicon carbide (SiC) in the production of refractories. All nine segments are from a paper that we uncovered that does not bear the name of the author.

Refractories

Manufacture: For the manufacture of refractories the grain, after it has been graded to size to obtain the desired density, is mixed with a bond, usually a refractory clay or similar powered mineral, a small proportion of temporary binder, and just enough water to help the temporary binder to take hold. After a thorough mixing, a weighted amount of mix is evenly distributed in a mold and formed on a hydraulic press. The shape is removed from the mold, oven dried, loaded on cars, and fired in a kiln at a high temperature. As with bonded abrasives, the more complicated shapes may be formed by other methods such as jolting or tamping.

Since the bond is much lower in such properties as heat resistivity and thermal conductivity than the silicon carbide grain, it follows that the brick for heavy duty service will contain a minimum of bond, but it is sometimes feasible to use a higher bond content for moderate duty requirements. Silicon carbide refractories are therefore made in several grades, the most refractory type containing 85 to 92% of silicon carbide, a medium grade containing about 78% and a semi-silicon carbide with a still lower percentage.

Since the grain is not plastic, workability of the mix is imparted by the bonds, and product with a low percentage of bond cannot be formed by extrusion or any of the other methods usually employed for plastic clay structural products.

Properties of Silicon Carbide Refractories: As noted in the section on “Thermal Properties”, data on single crystals, even if it were available, would be of little value since it is with reference to the manufactured shapes that such information is desired. In these bonded refractories the properties are affected by the kind and mount of material used as the bond. For the present discussion, only the products containing a high percent of silicon carbide will be considered but even here variations will cause the data to be given generally as a range rather than a specific figure.

Emissivity: Silicon carbide has high thermal emissivity. This property was studied by S.C. Linbarger and later by R.H. Heilman, who obtained the value 0.9 compared to 1.0 for black body. W. Brugal obtained values between 0.8 and 0.9 through a wave length of 0.6 to 15. F.H. Norton of Massachusetts Institute of Technology has compiled a set of curves comparing the total emission of a number of refractories. The curve for silicon carbide has a maximum of 0.95 at 580 degrees C, a minimum of 0.88 at 800 degrees C, a secondary maximum of 0.91 at 1100 degrees C after which the curve continues to descend to 0.8 at 1500 degrees C; these figures are approximate.

Thermal Conductivity: Thermal conductivity of silicon carbide is quite high and does not vary greatly with temperature. It does vary, however, with the percent of bond and the amount of porosity in the refractory. A discussion of thermal conductivity of silicon carbide will be found in the article by H.N. Baumann, Jr. and J.P. Swentzel who assemble the data from earlier investigators, give comparative curves and evaluate them critically. The value generally used for furnace calculations is 90 Btu/hr./sq./ft/in. degree F.

Thermal Expansion: Various methods have been used to measure thermal expansion of bonded silicon carbide refractories. R.A. Heindl and W. Bussam and his co-workers describe their methods and their data is compared in a set of curves prepared by H.N. Baumann, Jr., and J.P. Swentzel. The curves show a steady increase in the percent of expansion with rising temperature to a maximum of about 0.75 at 1700 degrees C after which the curve falls off sharply. This sharp drop above 1700 degrees C is due to failure of the bond employed. The mean linear coefficient of thermal expansion as determined by O.A. Hougen for the temperature interval 100 degrees – 900 degrees was 4.7 x 10(-6) per degree C. The figure given in the latest Carborundum Company pamphlet for use in calculating expansion for furnace installations is 4.4 x 10(-6) per degree C, for the range 25 degrees -1400 degree C.

In issue #90 SiC & More will continue with the refractory segment with emphasis on Hot Strength, Resistance to Thermal Shock, Resistance to Oxidation, and Applications.

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A WORD OR TWO FROM BRAZIL

If readers are involved or interested in the metals and minerals business, which includes a long list of products such as silicon carbide, aluminum oxide, bauxite, copper, manganese, tin, nickel, uranium, gold, iron, etc., then what occurs in Brazil should be more than moderately interesting.

In SiC & More issues #84 and #85 we took the opportunity to visit with a colleague that sells energy in Brazil and got caught up on some of the "on the ground" news. We revisited with our esteemed colleague over the past few weeks and continue the efforts to keep readers informed of business conditions in Brazil.

The Brazilian economy has been rebounding and forecasts point to a promising recovery. The Brazilian Report recent adjusted their median growth forecast for 2021 from 3.96% to 5.05%. In late June, Brazil's central bank altered its economic growth outlook for 2021 from 3.6% to 4.6%.

The World Bank reported Brazil's 2020 growth at -4.1%, which sounds incredibly disappointing until you compare it to other large global economies in 2020. For example, France -8.1%; Germany -4.9%; India -8.0%; Italy -8.9%; Mexico -8.2%; Netherlands -3.7%; United States -3.5%.

Brazil's GDP for 2020 was $1.44 trillion surpassing the estimate of $1.36 trillion retaining Brazil's position as one of the world's largest economies.

Regarding energy, however, the situation has been bleak of late. Brazil has long been one of the world leaders in the production of electricity from hydroelectric power. We reported in issue #85 that Brazil boasted of 217 hydro power plants in 2019. Although Brazil continues to develop other sources of energy such as thermoelectric, photovoltaic, wind power, and other alternative sources to compliment the grid, the country remains heavily dependent on hydroelectric.

Brazil is suffering from one of its worst droughts in a century. The lack of rainfall has relegated reservoirs to dangerously low levels, which imposes the dispatch of thermal plants with much higher fuel costs thus contributing to inflation and damaging the agriculture business.

SiC & More visited with our colleague in Brazil that sells alternative energy and is in the trenches when it comes to monitoring Brazil's power grid. "As I anticipated, the energy supply in Brazil is now under severe threat. The excess offer of energy in 2020 was turned into a nightmare due to the worst drought ever in the last rainy season, which is December 2020 through April 2021."

"Brazil's government announced the morning of August 26th several measure to reduce energy consumption and to increase energy output from existing power plants. The measure will be further regulated in the upcoming days/week. What we officially know regarding consumption reduction is as follows:

Heavy consumers are being encouraged but not mandated to return energy back to the grid by reducing consumption during peak hours. This process will follow a reverse auction system where consumers will offer an energy price to give up their energy contracts. This is restricted to peak-hours and it is expected to have very low interest by commodity producers because all of them are struggling to keep up with product demand.

Public institutions have an immediate mandated 10% energy consumption reduction.

Residential consumers have a financial stimulus of R$0.5/kWh to reduce energy consumption when compared to the same month of 2020."

Planalto Palace advisers estimate that the adoption of rationing energy at this time would further damage embattled President Jair Bolsonaro's campaign for re-election. According to another source, to cover energy generation costs due to the water crisis, the government needs to activate thermal plants, which produce more expensive energy. Regardless of the strategy, Brazil's industrial and residential base need more energy.

In summary, Brazil is faced with high interest rates, fiscal disarray, rising inflation of 10%-plus in 2021, historic drought, as well as an energy shortage and it's how the country's leadership leads into the future as to whether or not Brazil remains one of the world's most dynamic economies. After all, this is a country with an estimated $20 trillion worth of natural resources, which according to some sources, is significantly undervalued.

SiC & More's energy colleague in Brazil continued, "Some think tankers of the electric sector in Brazil have been loud about how short, late, and inefficient the government's measures are and that the risk of blackout during peak hours for the remaining of 2021 has jumped from 5% to more than 20%.

2022 also remains very unclear as La Nina has 80%-plus likelihood to be in place during next rainy season and if its effect is the same of last rainy season, it means rain will come way shorter than average. Anything lower than 75% will force the country to adopt a much harder and mandatory energy rationing program after April 2022."

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Metals Industry Update

GM BATTERY PLANTS

General Motors announced it would increase planned investments in electric and autonomous vehicles between 2020 and 2025 to $25 billion. GM's CEO Mary Barra said, "There is a strong and growing conviction among our employees, customers, dealers, suppliers, union, and investors, as well as policymakers, that electric vehicles and self-driving technology are the keys to a cleaner, safer world for all."

JOHN DEERE

John Deere and Hitachi announced that they would dissolve their long-term joint venture for manufacturing excavators in North and South America. Deere recently reported Q3 earnings of $1.667 billion compared with net income of $811 million for Q3 2020.

MACHINE TOOL

U.S. machine shops and other manufacturers used $172.1 million worth of cutting tools during June, which represents a 7.1% increase over May 2021. The $172 million is also 20.5% higher than June of 2020. Cutting tool consumption is considered a leading indicator of manufacturing activity.

U.S. GDP

The U.S. Commerce Department recently reported that the economy grew a bit faster for Q2 2021 than was originally reported. The most recent Q2 2021 estimate is that growth was 6.6%.

ELECTRIC VEHICLES

Nearly 2.6 million electric cars were sold during the first half of 2021, which represents a 160% increase over the 1H 2020. Fastmarkets recently reported that electric vehicle market penetration will reach 15% in 2025.

EVRAZ

EVRAZ – North America recently broke ground in Pueblo, CO for a $500 million long rail steel mill. The facility is expected to employ 300 people when the project is complete. The mill will have the capability of producing ¼-mile long sections of rail.

LITHIUM

Lithium carbonate prices reached over $16,000 tonne during mid-August 2021 compared to just a bit over $6,000 tonne during December 2020. A U.S. Federal judge recently ruled that Lithium Americas Corp can proceed with excavation work at the Thacker Pass lithium mine in Nevada. The court must still consider whether or not President Trump's administration erred when it approved the project in January and that ruling is expected during early 2022. No digging can take place until the U.S. Bureau of Land Management issues an Archeological Resources Protection Act Permit.

GLOBAL RAW STEEL PRODUCTION

Raw steel production on a tons per day basis, declined in July for what represents three months in a row with China reporting a 10.5% month-over-month decline in July. The July production rate in China represents the lowest number since April of 2020.

NUCOR

On July 22, 2021, Nucor Corporation announced record quarterly net earnings of $1.51 billion for Q2 2021. In the first six months of 2021, Nucor reported consolidated net earnings of $2.45 billion compared to net earnings of $129.2 million in 1H 2020. According to Leon Topalian, Nucor's President and Chief Executive Officer, "We expect to set a new record for quarterly earnings in the third quarter of 2021 as demand remains robust and virtually all the steel end use markets that we monitor are growing."

TOYOTA

Toyota announced that the Company will invest $13.6 billion into batteries for electric and hybrid vehicles by 2030. The Japanese company also revealed that it plans to develop and supply batteries for electric vehicles and is aiming to cut battery costs by 50% per car by 2030.

CLEVELAND CLIFFS

Cleveland Cliffs announced on August 26, 2021 that the company intends to enter the steel scrap business and modernize its EAF mills in Pennsylvania.

NOUVEAU MONDE GRAPHITE

Nouveau Monde began civil construction for its Matawinie graphite project in Quebec, Canada. They company plans to complete the Matawinie graphite project by the end of 2023. The graphite mine is located 120km north of Montreal and is targeted to produce 100,000 tones per year of high-purity graphite concentrate and has a life of 25.5 years. The all-electric open pit graphite mine has an initial capital expenditure projection of about $220 million.



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BFA BEING HIT HARD



Brown Fused Aluminum Oxide Pigs in Cooling Stage

When it came to flat pricing for brown fused aluminum oxide (BFA) in March and April, a trader told ***SiC & More*** during an interview for issue #87, "This could be the lull before the storm. I suspect that is one reason that many processors in North America, Korea, and Japan have been ordering extra parcels. Prices could either spike or even take a significant drop as we draw closer to winter. The price direction depends on a number of variables including the environmental shutdown, currency devaluation, and worldwide economic recovery."

Apparently, March and April 2021 did represent a lull before the storm. BFA prices increased during May and June and have been hit with another $60-100 m/t during July and August. The price increases or the last two month were across the board for typical BFA crude used for most refractory and abrasive applications with a few exceptions based on either lower or higher than typical quality.

BFA is currently in short supply in China and due to some operational issues at several large smelters in Henan along with a shortage of bauxite, prices are expected to increase again during Q4 2021. Bauxite has become increasingly more expensive as inflated calcining costs are passed on to the BFA furnace plants. BFA, like so many other commodities that consume large amounts of energy and emit offgases and dust, is under scrutiny from the respective province's environmental authorities creating additional angst for smelters. BFA production was also hampered when key provinces received record rainfall that led to flooding and plant closings.

Essentially, the same issues that have affected the supply and price of SiC, ferroalloys, and many other commodities, have also impacted the supply and price of BFA; environmental, weather, kWh pricing, raw material availability and price, COVID19, demand exceeding supply; logistics, etc.

A BFA processor told ***SiC & More***, "Prices are going to increase during the fourth quarter of 2021 and I even expect supply issues. We are buying as far ahead as we can to ensure supply. I anticipate that our customers will see price increases during the balance of 2021 and throughout 2022."

Silicon Carbide & More

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