How Refractory and Insulating Solutions Contribute to a Sustainable World: An Internal and External Perspective

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58Th Annual St. Louis Section/ Refractory Ceramics Division Symposium on Refractories

March 29, 2023

Morgan Advanced Materials ("Morgan") is an advanced materials manufacturing company whose purpose is to help make more efficient use of the world's resources and to improve the quality of life. Thermal Ceramics, a division of Morgan Advanced Materials, delivers on this purpose through the products we design and manufacture, supporting our customers to solve complex problems, such as heat management and enabling greener technologies.

Sustainability's three pillars of environment, economy, and society overlap with the broader environmental, social and governance (ESG) goals. For this paper, we will focus on examining a high-temperature insulation and refractory company's impact on the environment and how Morgan collects data and prioritises its environmental objectives. Fundamentally, the refractory industry's main objective is to enable a wide range of demanding, high-temperature industrial processes. Innovative designs allow for improved insulation, reducing heat loss, improving efficiency, and reducing energy costs and greenhouse gas emissions for downstream industries. By taking a closer look at some of Morgan Advanced Materials - Thermal Ceramics Division process improvements, we hope to share best practices for improving the refractory industry.

2022 silver EcoVadis medal winner

As of 2021, Morgan received an MSCI ESG Rating of AAA.

As of 2022, we had a climate change score of B.

Figure 1. Morgan Advanced Materials ESG Disclosure Ratings

Introduction to Morgan Advanced Materials - Thermal Ceramics Division

Thermal Ceramics manufactures a comprehensive range of fibre, refractory and microporous high-temperature insulation products used to reduce energy consumption in demanding industrial processes. We have extensive experience working with customers all over the world to engineer, design and install high-performance insulation in operating environments from 500°C to 1871°C (932°F to 3400°F). We have a proven track record for helping customers to improve operational efficiency and respond to changing environmental pressures.

Background – Sustainability definitions

As stakeholders' opinions shift towards a more vital environmental consciousness, it becomes critical for companies to prioritise sustainability against the three pillars of: the environment, economy, and society. Therefore, a company cannot solely focus on one pillar (i.e., focusing on economic goals solely while disregarding environmental impact). Doing so may be profitable in the short term but detrimental to the company's long-term viability as regulatory penalties, investor or other stakeholder interests, and public opinion can negatively impact the company. By contrast, every company will have an environmental footprint, and there is a limit to reducing the impact of that footprint before the price becomes so large that it impacts the economic pillar.

Making Commitments

Balancing the level of investment against the level of environmental improvement can take time for most companies. A good place to start is to choose the areas of focus and then benchmark the current impact. While meeting environmental regulation requirements has always been necessary, there are unregulated or voluntary regulatory areas that have been gaining more public attention. Creating a materiality matrix allows a company to quickly identify what is important to stakeholders and leadership.

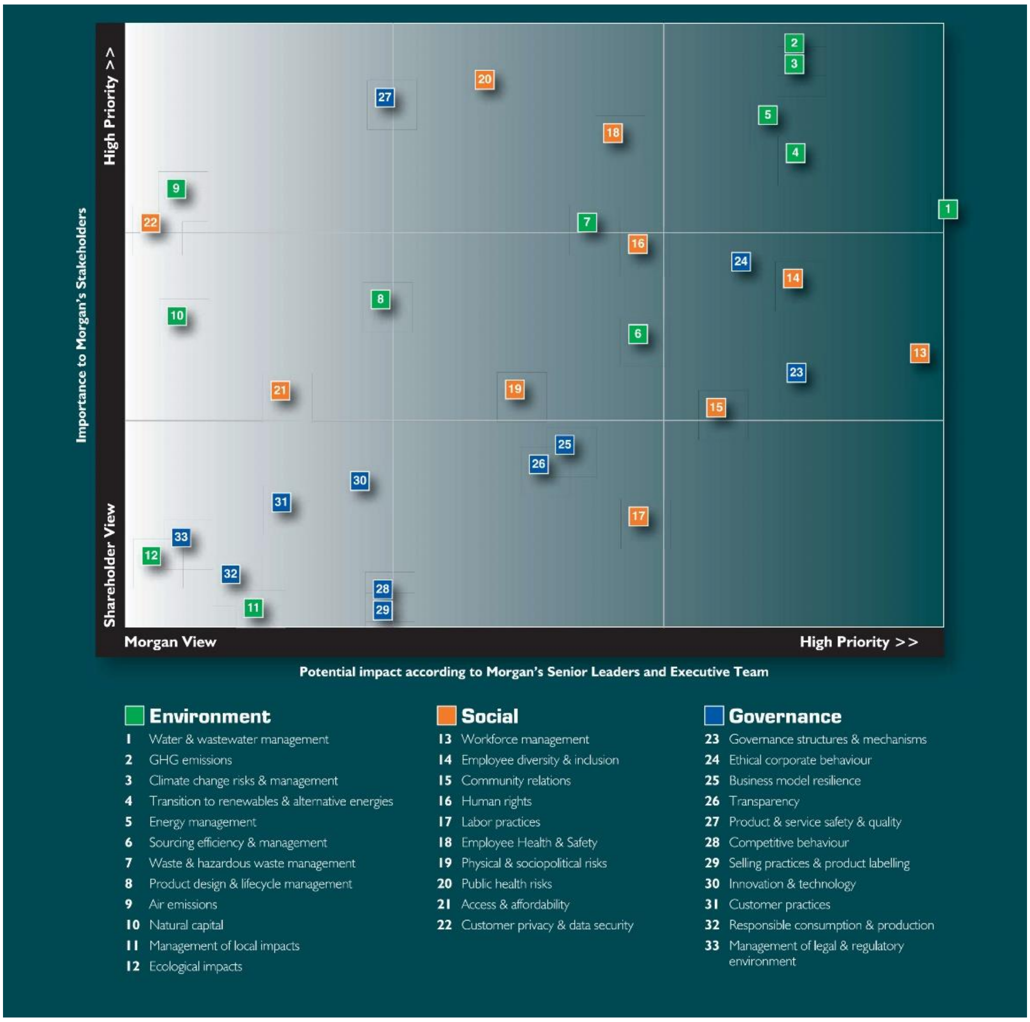


Figure 2: Morgan Advanced Materials Materiality Matrix

As an organisation committed to environmental sustainability, Morgan Advanced Materials prioritised our top 5 environmental areas of focus, which are outlined below [in no particular order]:

1. Water and wastewater management
2. GHG emissions (CO_2e)
3. Climate change risks and management
4. Transition to renewables & alternative energies
5. Energy management

Morgan Advanced Materials has made public commitments for water usage and CO_2 equivalence (CO_2e) for 2030 and 2050. Choosing ambitious but reasonable commitments is key: by 2030, to strive for a 30% reduction in water use compared to the 2015 baseline, with the ambition to use water sustainably across the business. A target of 50% reduction in Scope 1 and 2 CO_2e has been set against a 2015 baseline, aiming to reach net zero CO_2 equivalence by 2050.

Morgan Advanced Materials - Actions So Far

Morgan Advanced Materials' leadership identified water and wastewater management as a top priority. Using water sustainably involves re-using the same water in a closed loop or multiple times. Across Thermal Ceramics, there is substantial opportunity for water savings due to the age of many sites and especially manufacturing plants in water-stressed areas. For example, one of our plants in a water-stressed area replaced old piping and radiators for water cooling, installed water recovery tanks, and repaired several water leakages. This work resulted in an estimated savings of over 1.5 million gallons for the year. The company is on track to achieve the 2030 target and more. 2021 water use was 26% below the 2015 annual levels. Morgan is making good progress; however, an increase in 2021 levels is due to business ramp-up after a decline during the COVID-19 pandemic.

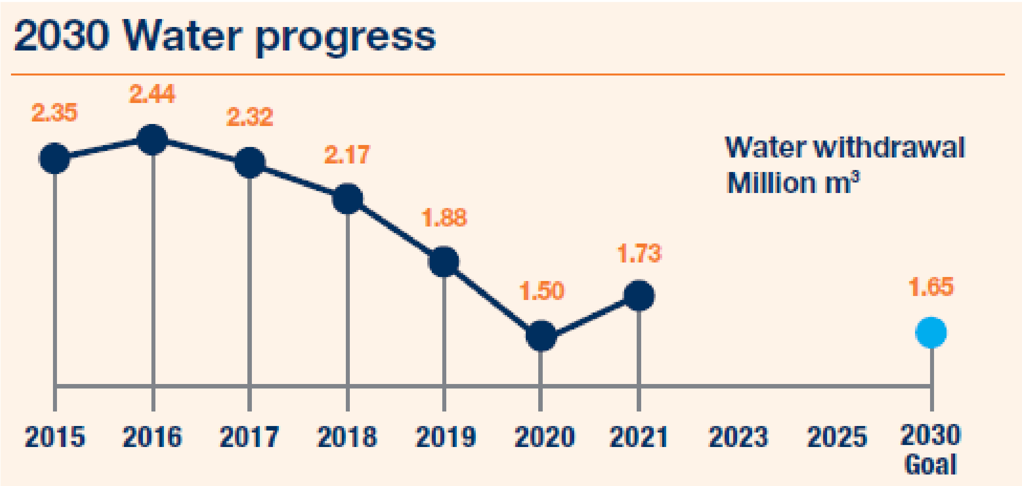


Figure 3: Morgan Advanced Materials Water Progress towards 2030 goal

Many of the above areas found in the materiality matrix overlap with one another. An easy way to tackle greenhouse gas (GHG) emissions and energy management is through a transition to renewables and alternative energies. Renewables are called "green energy" and have a reduced carbon footprint compared to non-renewables. This reduced carbon footprint usually comes at a higher cost. Morgan Advanced Materials has chosen to make green energy a priority over the next few years and one of the primary ways to tackle the company's carbon footprint. Our internal target is to achieve 100% green electricity by 2030. The next actions show estimated savings (data assurance in progress by third-party disclosure agencies), in 2022:

- one site increased its procurement of wind power and is projected to produce 1.8 MWh (1,800,000 kWh), saving 1280 MT of CO_2e in 2023.
- another secured an agreement for 15 years of green power at 16,000 kWh/day. This will significantly reduce costs and CO_2e savings of 4135 MT/yr.
- a third site will save 329 MT CO_2e/yr by commissioning a second stage of solar panels on the existing rooftop.

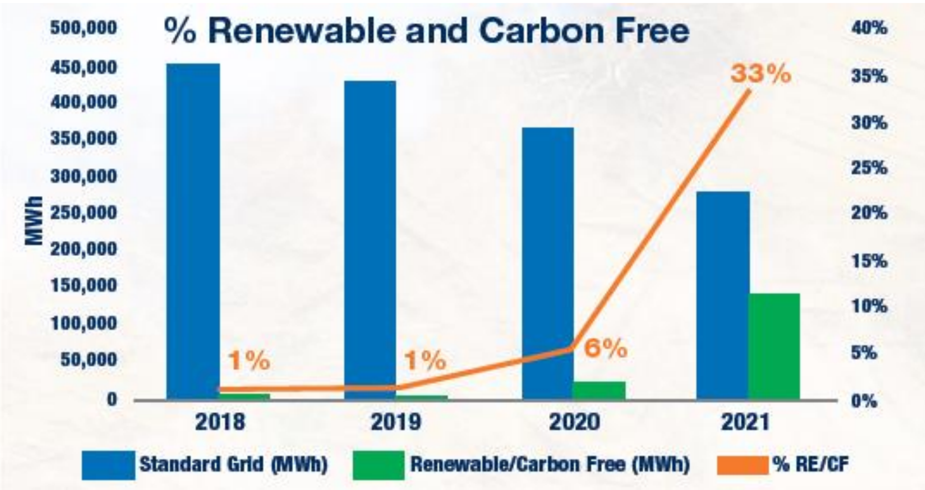
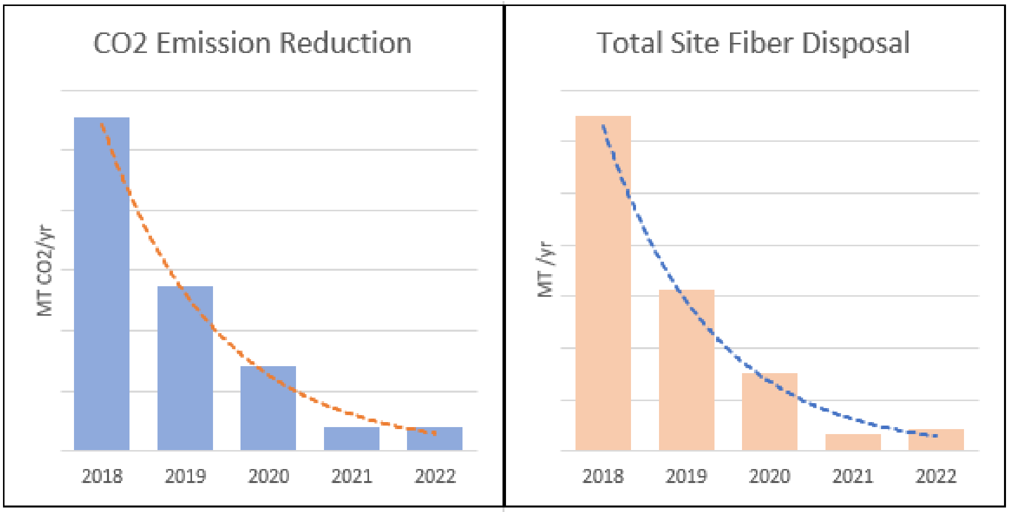


Figure 4: Morgan Advanced Materials' Transition to Renewable and Carbon-Free Electricity (2021)

Another way to tackle GHG emissions is to focus on recycling opportunities. Finding ways to utilise what were previously waste streams makes the process more efficient on a mass basis. This results in reduced raw materials given the same output level and reduced GHG emissions. A common barrier to process improvements related to recycling is extended payback compared to other projects. All companies must work to understand the balance of sustainability's economic and environmental pillars prioritising projects according to each company's policy.

Recycling of "cullet glass" waste material was implemented at another Morgan site. This was the primary contributor to waste and saved 120 MT of ceramic fibre waste/month. The impact of this program is substantial, as can be seen in the below CO_2 and material savings.



Figures 5 and 6: Morgan Advanced Materials "Cullet glass" Process Improvement – CO_2 and Waste Disposal (data not verified/assured)

Lastly, to achieve the net-zero CO_2 target for 2050, furnaces will be evaluated for the transition from natural gas to electric or alternative fuel. Between now and 2050, the electricity cost per kWh is expected to drop below natural gas prices. Preparing for this inflexion point is key to both the environmental and economic sustainability of Morgan Advanced Materials and is a key focus for our transition pathway. Our CO_2e in 2021 was 33% below the 2015 annual levels.

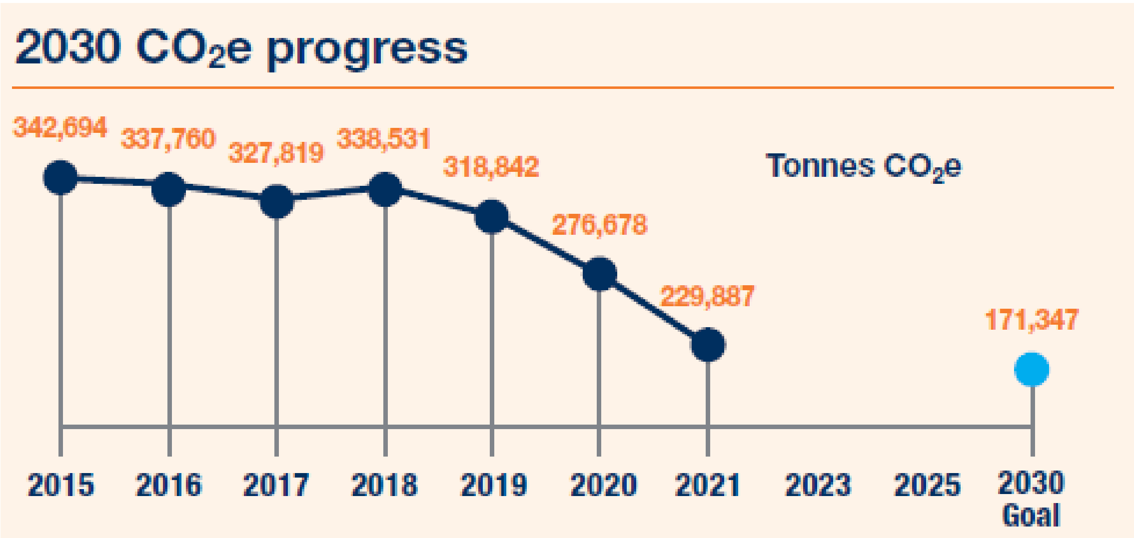


Figure 7: Morgan Advanced Materials 2030 CO_2e progress (2021)

Life Cycle Assessments

Understanding the environmental impact of various products is crucial to making ethical decisions as a consumer. A "Life Cycle Assessment" systematically analyses the environmental impacts across a product's life. Unfortunately, our society's interconnectedness can make a comprehensive assessment difficult: manufacturers can calculate the impact they have but may need more visibility of their products' upstream and downstream effects. The first stage is raw material extraction and marks the beginning of a product's life. This stage is frequently referred to as the "cradle" stage. The raw materials then go through their first stage of manufacturing or processing. Those raw material products then undergo some amount of transportation and finally get used by the refractory manufacturer. By the time the product reaches the end user, it has gone through numerous manufacturers' hands. After the product completes its use, it is then disposed of.

Figure 8: Common LCA Path

A complete analysis of a final product includes the use and recycling stages. This is referred to as "cradle-to-cradle." Including manufacturing and use, but not recycling, is called "cradle-to-grave." This is only possible after every manufacturing level performs a "cradle-to-gate" assessment. Cradle-to-gate refers to all environmental impacts associated with a product until it leaves the refractory manufacturer's site. It includes the impact of:

- Raw materials
- Transportation of raw materials from the last manufacturing/processing site
- Manufacturing impacts

Environmental impact encompasses many categories, including, but not limited to climate change (CO_2e), ozone depletion, acidification, and resource use, to name a few. While the focus in the short term is on carbon footprints from greenhouse gases due to climate change, other environmental factors will become more critical in the future.

Within Thermal Ceramics, we have prioritised our product portfolio and can provide LCA information for several products. As we perform our "cradle-to-gate" assessments, we request LCA information from our raw material suppliers to offer similar LCA information to our customers. As we get closer to achieving our goals, evaluating the environmental impact of which raw material to purchase in the procurement process, along with the price, will become increasingly important.

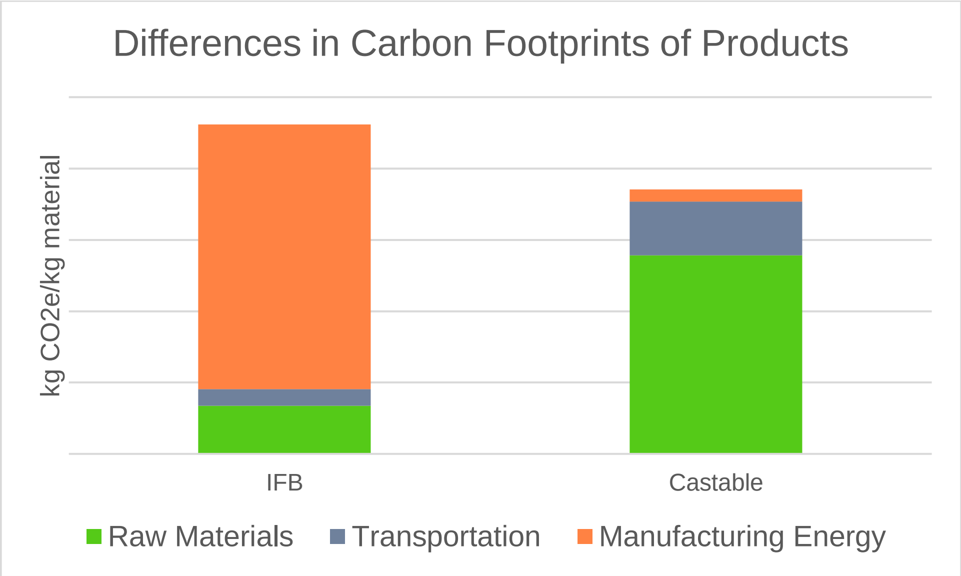


Figure 9: Typical Difference in Carbon Footprints of Common Refractory Products

Different products have varying energy demands depending on processing needs. For example, as seen above, the carbon footprint for an Insulating Firebrick (IFB) generally comprises primarily manufacturing energy (mostly from firing with natural gas). By contrast, the majority of CO_2e within castables comes from raw materials. Supplier energy contributions include everything from mining to calcination to crushing and drying. This cradle-to-gate analysis uses the LCA information provided by suppliers (raw materials in green) with the site's transportation and energy inputs. Customers can then add their additional manufacturing energy or input the CO_2e value into their production for an entirely new product.

To further reduce environmental impact, involving suppliers in the process is imperative. Developing a supply chain committee and supplier code of conduct focusing on sustainable procurement is beneficial. It begins by reaching out to top-tier suppliers to understand their sustainability commitments and ESG policies. Suppliers need to fill in an ESG questionnaire as part of the supplier procurement process for new suppliers, and their policies should match the company's ESG pillars.

Future Trends

Since the Industrial Revolution, the refractory industry has made continuous improvements. At its core, the refractory industry provides mechanical, chemical and temperature resistance to enable high-temperature industrial processes. Technological advancements have reduced heat loss through improved thermal properties, allowing us to stretch one kWh further, retaining heat and reducing energy costs. Continued improvements in refractory technology will focus on extending the performance or "life" of materials to reduce the frequency of replacements, and/or increase the use of consumed refractory into reusable and recyclable raw materials.

One way to reduce the environmental impact of refractories is to examine new methods of lower CO_2 production. Comparing products' environmental impact through life cycle assessments is helpful, but it is only one of the components for choosing an environmentally friendly product. Since refractory materials are sometimes used for insulation, lower thermal conductivity values will yield energy savings. Systematic analysis of various linings produces a variety of energy costs and subsequent savings for the end-user, a primary driver of system design within Morgan Advanced Materials.

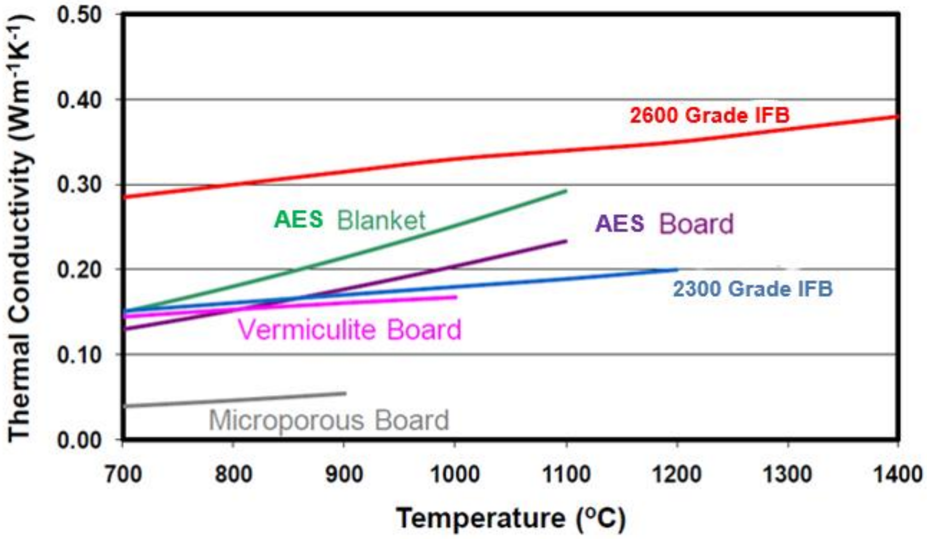


Figure 10: Thermal Conductivity across Common Refractory Product Line

Within the industry, a point of focus over the coming decades will be increased rates of hydrogen firing. With hydrogen use being more environmentally friendly than natural gas, ensuring adequate support from the refractory industry is key. Varying types of hydrogen yield different levels of CO_2e savings. Blue hydrogen, or hydrogen produced from natural gas and supported by carbon capture and storage, will likely change the landscape of hydrogen firing. Hydrogen's thermal conductivity is approximately seven times the thermal conductivity of air. In a 100% hydrogen atmosphere, the heat flow through a porous insulation product would be over double the heat flow in air. Combustion temperatures are likely to rise, requiring refractories and insulation with higher purity and refractoriness. This increased heat flow presents challenges for refractory materials in these applications. Last month, February 2023, Thermal Ceramics joined with numerous partners for the official kick-off of an EU-funded project to explore the use of hydrogen in the aluminium and steel industry and understand best practices. Collaborative projects are necessary to improve refractory products in more environmentally friendly atmospheres such as hydrogen.

Conclusion

As refractory companies prioritise environmental commitments, the industry can move to a more sustainable world. Balancing the economic and environmental pillars requires prioritizing projects not necessarily based on financial assessment but mostly on the positive environmental impact. This will increase the use of recycled raw materials in-house and for external applications.

The need for collaboration on life cycle assessments across the refractory industry is key to evaluating carbon footprints. Suppliers, manufacturers, and end-users must partner closely to provide their cradle-to-gate evaluation to create a cradle-to-cradle LCA. A key takeaway is that LCAs have come to stay and are a commitment to the next generations and the environment.

Constant improvements in refractory technologies lead to improved thermal conductivities. Improved refractoriness and insulation result in energy, cost, and CO_2e savings. Examining these factors is vital in picking an environmentally friendly, appropriate product for installation.