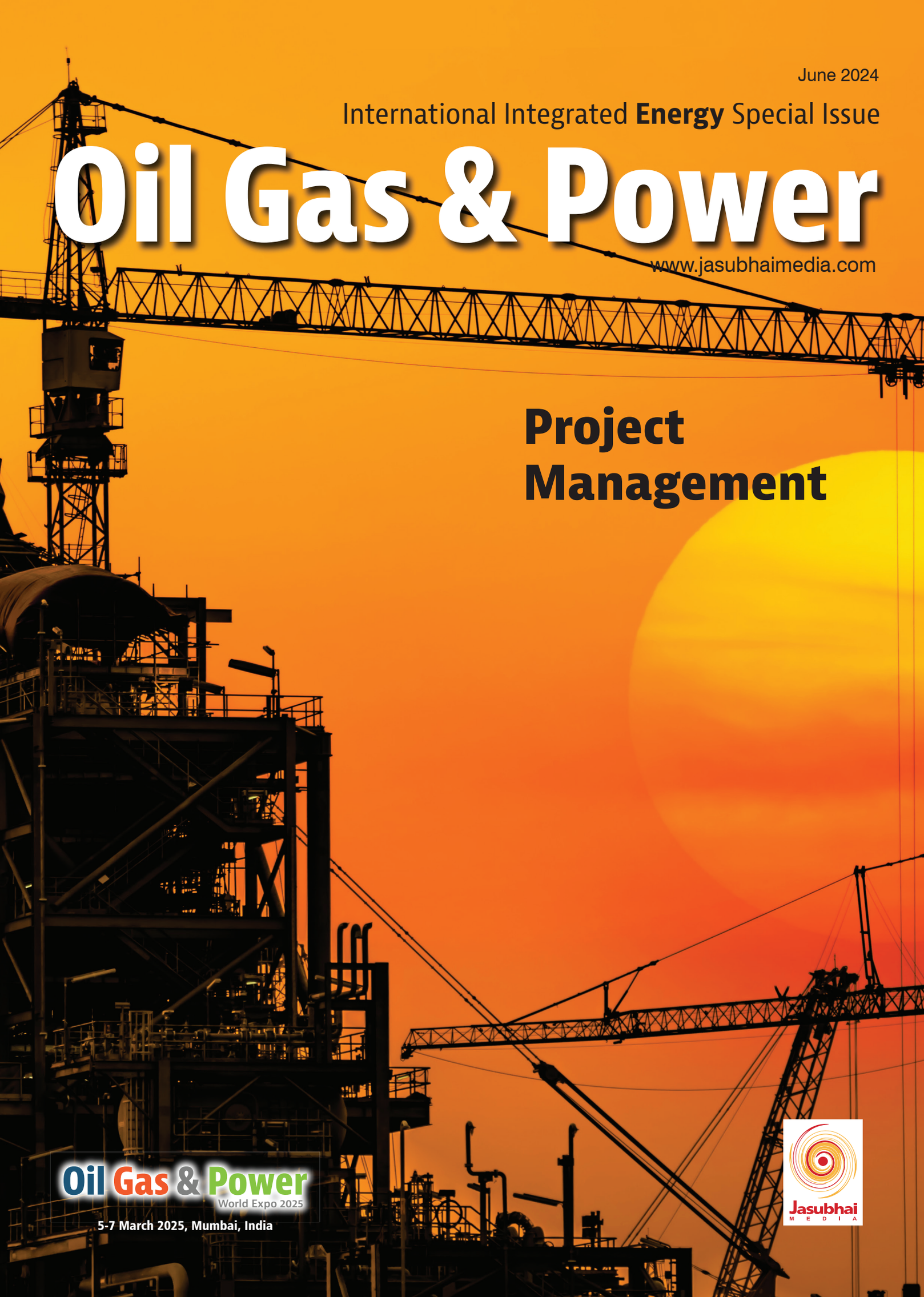
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Optimizing Refinery Operations with Advanced Process Simulation Tools

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The global energy landscape is evolving, compelling refiners to adapt to challenges such as geopolitical instability, technological advancements, and sustainability needs. Refiners must balance competitive operations with environmental responsibilities. KBC's process consulting and technology, including digital simulations and AI, help refiners improve profitability and adapt to change. This article will introduce KBC's latest developments and discuss how these solutions help refiners maintain sustainable operations on their decarbonization journey in this evolving world.

The global energy landscape is undergoing a significant shift, compelling refiners to adapt to emerging challenges and opportunities. Amidst the challenges posed by geopolitical instability, technological advancements, regulatory changes, and the pressing need for sustainability, refiners must balance competing priorities to stay competitive while upholding their environmental, social, and regulatory responsibilities.

This pursuit of safe, responsible, and profitable operations has become increasingly demanding, requiring refiners to continuously improve their processes and embrace innovative solutions.

Digital technologies are key to helping refiners navigate these pressures, with the rise of cloud and artificial intelligence (AI) techniques providing the building blocks, plus allowing refiners to grow towards more autonomous and optimal operation.

For over 40 years, KBC's process consulting and technology have been helping the refining industry improve profitability and adapt to change, using process simulation solutions and techniques based on fundamental engineering principles. We have been continuously advancing our technology, including the addition of adding first-principles physics-based modelling of energy transition processes and by taking advantage of AI and digital technologies.

This column will introduce KBC's latest developments and discuss how these solutions help refiners maintain sustainable operations on their decarbonization journey in this evolving world.

Simulations Support Decarbonization Journey

Refiners face a myriad of ways to reduce their energy and carbon footprints while producing sustainable fuels. To achieve this, refiners must benchmark their operations and make informed decisions regarding capital investments, which are key to creating a successful roadmap towards sustainability.

KBC supports this roadmap activity in two ways. Firstly, our Petro-SIM™ simulator capability has grown to include modeling new process technologies, such as renewable diesel and sustainable aviation fuel production, as well as the characterization and co-processing of biogenic feedstocks, electrolysers for hydrogen production, and carbon capture, as depicted in Figure 1. They also enable integrated modelling of utility and energy systems, carbon intensity tracking and associated economics in ways that let you explore different processing options and evaluate roadmaps over time.

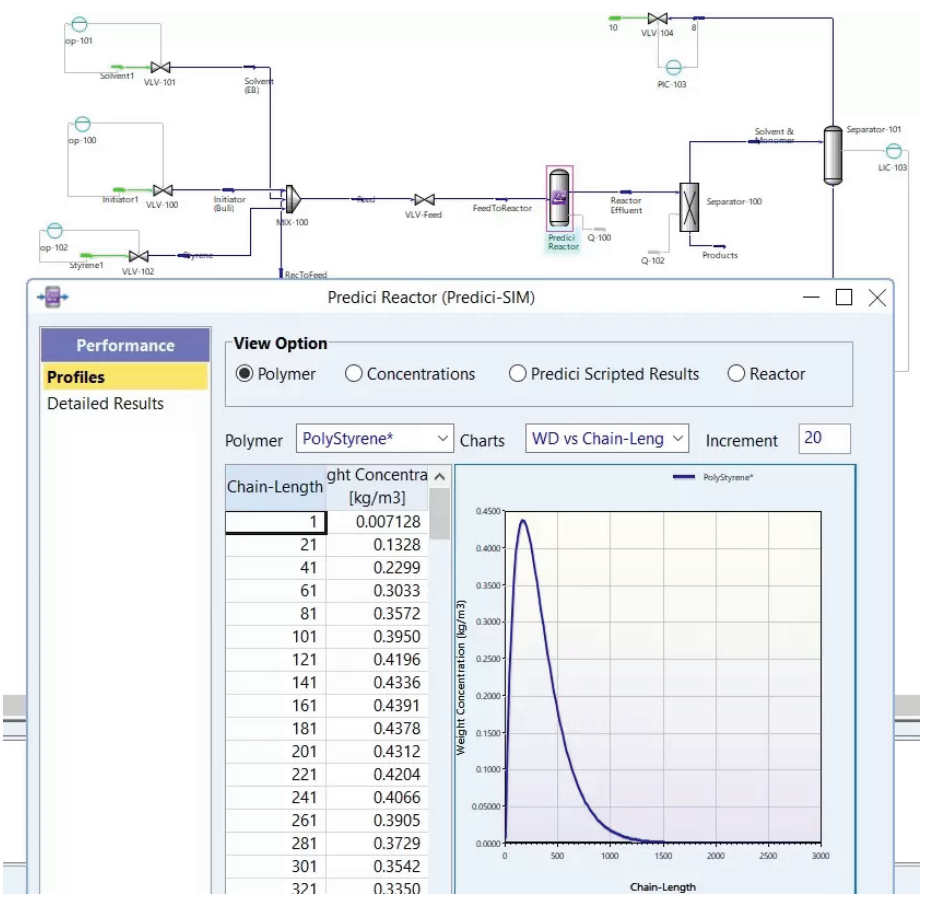


Figure 1: Petro-SIM process simulator dashboard

Secondly, KBC has enhanced its Profit Improvement Program consulting methodologies to assist refiners in asking the right questions, ensuring refiners get the expertise needed as they plan their journey towards reaching their net zero goals.

Sustainable Real-time Optimization

Increasing demands for operating

flexibility have led to growing interest in real-time optimization (RTO): automated systems that can operate in closed loop to keep process units running optimally. While RTO principles themselves are not new, they have historically presented challenges such as poor uptime, high maintenance costs, reliance on steady state conditions, and often low convergence rates.

KBC has introduced a unique approach to real-time optimization, addressing challenges faced by traditional methods. This dynamic solution combines the power and accuracy of online, rigorous Petro-SIM simulations models with a proven platform for advanced control and estimation (PACE), as shown in Figure 2. We separate the process modelling from the optimization itself by using a calibrated and tuned Petro-SIM model to calculate non-linear gain updates as plant operations shift, transferring these gains to dynamic optimization every few hours, or as needed. Optimization cycles run every 5 to 10 minutes, eliminating the need for steady-state conditions and increasing the RTO benefits over traditional approaches.

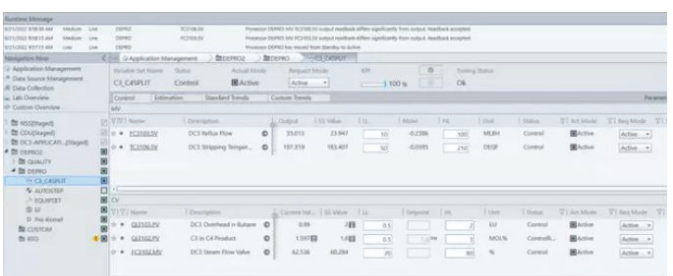


Figure 2: Pace dashboard

We improve maintainability of the overall solution by using the same process models for gain generation as are used by plant engineers for offline unit troubleshooting and scenario analysis. Additionally, we incorporate new automated techniques for validating and updating the models themselves, which are discussed in the next section. This approach enables engineers to build and maintain consistent Petro-SIM models for monitoring, and troubleshooting, as well as real-time optimization, significantly reducing the knowledge and effort needed to keep systems operational. Hence, we believe our approach makes RTO systems more sustainable and efficient.

Sustainable Process Digital Twins

Process digital twins, in our definition, model the process aspects of refinery units. These digital twins accurately predict the yields and qualities of unit and intermediate stream, adjusting to changes in feedstocks and operating condition. Process digital twins should respond as the plant responds and should handle fixed bed reaction systems where catalyst activity decays, as well as regenerating systems and all necessary aspects of separation and heat integration. Our process digital twin systems predominantly use first-principles modelling, allowing augmentation with machine learning models running alongside within the same simulation platform.

There are two key challenges with process digital twin models for operations. Firstly, engineers need assurance that the model results are reliable. We routinely address this by automatically comparing the models against actual data on a daily or weekly basis. This information provides engineers with performance trends and KPIs, allowing them to build trust in the models. Over the past 15 years, KBC and our clients have successfully been building and implementing systems that meet this challenge, making our technology and underlying models highly reliable.

However, it's important to acknowledge that all models have limitations. While models can be calibrated to match current operation, the real question is how they respond to changing feeds, operating conditions, and catalyst performance. Will a well-tuned model continue to operate effectively as the plant's operating window evolves? This is the second challenge we face, as poor models can impact achieving optimal performance.

Our traditional model assurance techniques help us understand when models need attention, but human resource limitations often mean engineering teams lack the staff to update models in a timely manner.

To overcome this challenge, we recently launched a new solution called KBC Acuity™ Process Twin Pro. This cloud-based solution gives engineers an AI-based model health index, alerting them when models need attention. It filters the bad data and prediction blips and offers AI-enabled model tuning algorithms that automate the tuning process, as shown in Figure 3.

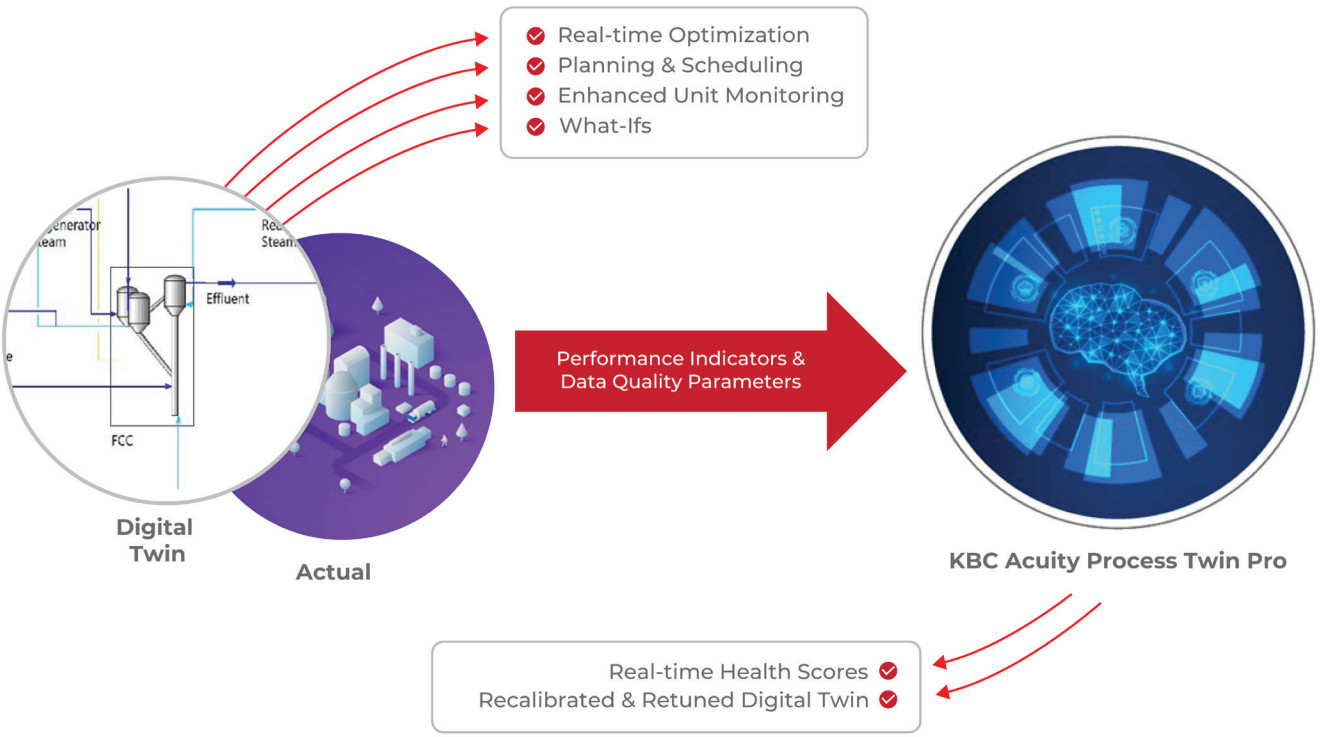


Figure 3: KBC Acuity Process Twin Pro workflow

With this solution, engineers dramatically reduce the skill, time and effort required, ensuring the long-term reliability of their model fleet.

Enabling Platforms

Cloud technologies have been chosen for the new KBC Acuity Process Twin Pro solution because it offers a host of benefits to simplify deployment. With the help of scalable computation resources and a reliable AI platform, the application can be easily updated as we learn, and algorithms improve. This not only streamlines the process but also reduces the IT burden on the refiner.

Furthermore, this work is part of a broader effort to embrace true cloud-native deployment across our technology suite. This approach enables seamless integration with refiners and third-party systems, fostering new integrated workflows. While we cannot have a complete picture of the technologies and workflows needed for the Energy Transition and journey to net zero, we are preparing our systems to be agile and adaptable. Our aim is to future-proof our solutions as much as possible.

Conclusion

In conclusion, the use of cloud technologies is transforming businesses by providing scalability and flexibility. With advanced process simulation tools like Petro-SIM, refiners can optimize their operations and stay competitive in the changing energy landscape. Real-time optimization, digital twins, and cloud-native deployment enable refiners to navigate industry complexities and achieve operational excellence. Embracing these technologies is a strategic move that positions refiners for sustainable growth in the global energy market. By prioritizing innovation, the company ensures customers stay ahead of advancements while Bringing Decarbonization to Life™. ■