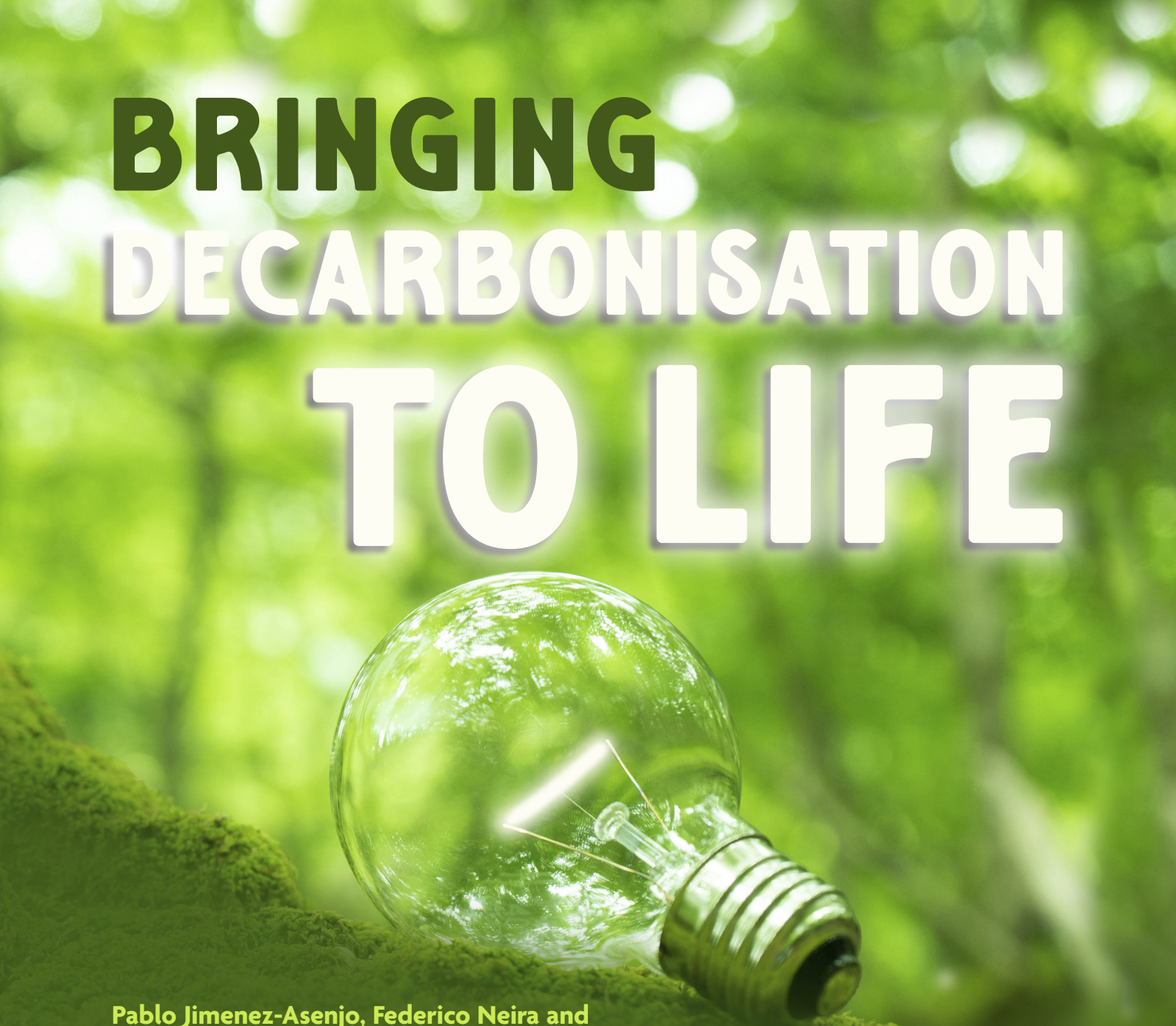
BRINGING DECARBONISATION TO LIFE



Pablo Jimenez-Asenjo, Federico Neira and Nicolas Visuara, KBC, alongside Rafael Rebouças de Araujo, Joana Variani and Juan Carlos Moreno, Acelen, explore how real-time emissions monitoring drives decarbonisation.

The Brazilian refining industry is a significant contributor to the world economy. Not only is it a crucial player in meeting energy, raw material, and chemical needs, but it also has a promising future. According to the US International Trade Association, Brazil will be responsible for producing around 50% of the world's offshore oil in 2040, about 5.2 million bpd.[1] As a prominent energy producer, Brazil's government has worked to increase domestic oil production. In addition, discoveries of pre-salt oil deposits have propelled Brazil into the top 10 of global liquid fuels producers, as reported by the US Energy Information Administration (EIA).[2]

However, the process of refining raw petroleum into marketable fuels and chemicals is energy intensive, resulting in carbon dioxide (CO_2) emissions. Statista reports that Brazil's refining industry generated about 0.49 gigatonnes (Gt) of CO_2 in 2021.[3] The Carbon Emission Accounts and Datasets-Global Refinery Emission Inventory (CEADs-GREI) estimates that oil refineries worldwide could generate up to 16.5 Gt from 2020 to 2030.[4]

Refineries are an indispensable link in the energy supply chain. They also have the power to contribute towards decarbonisation. To achieve this, refineries can implement various mitigation strategies. They can upgrade heavy oil-processing technologies, improve refinery efficiency, use alternative power sources, and integrate energy initiatives with other local manufacturing plants to create an industrial cluster strategy. These solutions have the potential to reduce global cumulative refinery and petrochemical emissions by 10% from 2020 to 2030, according to the CEADs-GREI research.[5] To reach these goals, accurate reporting of greenhouse gas (GHG)

emissions is paramount. This helps refineries identify areas where they can reduce their emissions and improve their environmental performance. Accurate reporting can also lead to higher credit ratings for disclosing refineries.

Therefore, implementing a GHG emissions management software solution is crucial. This advanced technology measures the composition and concentration of the main emissions from multiple sources throughout the plant and across all its assets – from key stacks, or even a select few. Besides calculating emissions, it also tracks energy production, energy consumption, and process efficiencies. By tracking their performance in real time, refineries can take prompt action.

Case study: Acelen, Brazil

The Acelen Mataripe refinery in Brazil is a key player in the country's energy sector and has made energy transition one of its top priorities. With a production capacity of 300 000 bpd of oil, Acelen is committed to decreasing GHG emissions from its operations. This effort is crucial considering Brazil's pledge to reduce GHGs by 50% in 2030 compared to 2005, per Enerdata.[5]

Therefore, refineries such as Acelen play a crucial role in global sustainability, but how can they ensure their operations do not harm the environment? The answer lies in embracing advanced technologies that continuously monitor GHG emissions and other pollutants. Carbon monoxide (CO), nitric oxide (NO), particulate matter (PM), sulfur dioxide (SO_2), and volatile organic compounds (VOC) are some of the contaminants that refiners need to monitor.

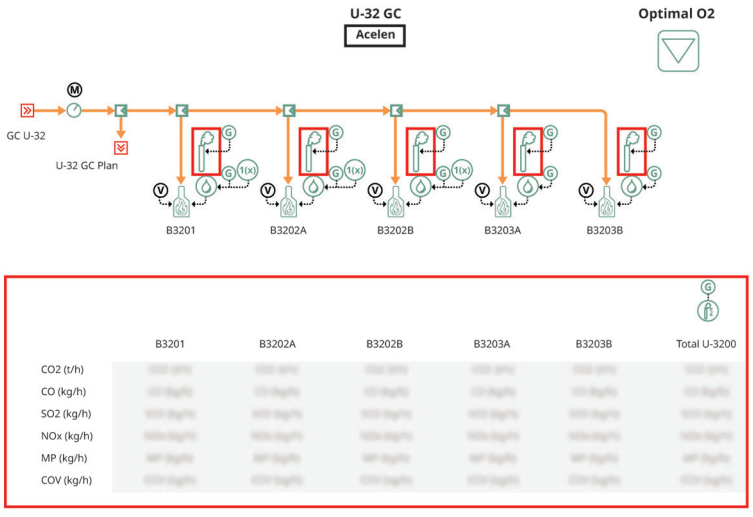


Figure 1. VM-GEM emissions management software represents emissions data in a single pane of glass.

Table 1. Emissions correlations

Emissions component	Correlation
CO	(1.3452/1000) x (volume flowrate)
NO_x	(0.00495/1000) x (volume flowrate)
NO_x	(0.004/1000) x (volume flowrate)
PM	(0.1217/1000) x (volume flowrate)
VOC	(0.0881/1000) x (volume flowrate)

Using a model-based approach

Acelen is taking strides to improve its emissions data accuracy and reporting by implementing an energy and emissions management system that uses a model-based approach. Automating data collection leads to more reliable results while minimising human error.

The GHG emissions management software calculates GHGs and other emission pollutants, such as CO, NO, PM, and VOCs, as shown in Figure 1. Engineers can quickly scan this data from a single pane of glass to identify patterns and/or anomalies and make informed decisions.

To ensure accuracy in emissions calculations, the emissions module uses production accounting technology. In addition, a GHG factor is commonly used. This factor considers the characteristics of the fuel, combustion conditions, and other relevant factors, such as combustor type, as shown in Table 1. By multiplying the emissions factor by the corresponding activity data, the emissions can be calculated.

It should be noted that measuring emissions depends on specific emission and regulatory requirements. The following is a general explanation of how emissions are calculated:

- A mass balance approach is often used to determine emissions, such as CO_2 and SO_2. This involves gauging the plant's inputs and outputs to determine the corresponding emissions based on chemical reactions and stoichiometry.
- Correlation models provided by governmental organisations, such as the US Environmental Protection Agency (EPA), are used to calculate emissions including CO, PM, and VOCs. These models establish a relationship between certain process parameters and the corresponding emissions.

Calculating fuel gas composition

At the core of every refinery lies the process of crude production. Refining crude oil involves a complex system that involves the use of furnaces and considers each energy vector, including fuels and power, that produce Scope 1 and 2 emissions. For refiners, accurately calculating these emissions is essential, not only to comply with regulations and achieve environment, social and corporate governance (ESG) goals, but also to maintain their reputation as responsible corporate citizens and avoid costly fines. By doing so, refiners can enhance transparency and trust with stakeholders, while also identifying opportunities to reduce costs and improve efficiency within their value chain.

Furnaces module

Furnaces play a pivotal role in the refining process as they help transform crude oil into a range of products. However, burning fuels in these furnaces can trigger the release of GHGs and other emissions, demanding effective monitoring to control emissions.

The Acelen refinery employs GHG emissions management software to track all relevant emissions. These sources include all of the process furnaces, fired boilers, gas turbines, flares, and a detailed model of the fuel gas system. By incorporating the details of the fuel gas system, the model calculates the composition of the fuel gas in real time. This data, combined

with measurements of fuel volume flow or mass flow for each source, provides the ability to calculate emissions for each specific emissions component. Further details are provided in Figure 2, which illustrates the furnace module.

Fuels module

The emissions management solution encompasses multiple fuel sources, whether they are internally produced or imported. It involves tracking and recording data related to various energy sources, which for Acelen includes natural gas, propane, hydrogen, and power. This comprehensive approach is facilitated by a single platform that allows for efficient monitoring and management of emissions.

Within the fuels module, as shown in Figure 3, there are interconnected blocks that link to the burners. This configuration enables the calculation of emissions for each emission source. By accurately measuring and assessing emissions at these specific points, refiners gain insights into the environmental impact associated with their fuel use and can take appropriate measures to reduce emissions as necessary.

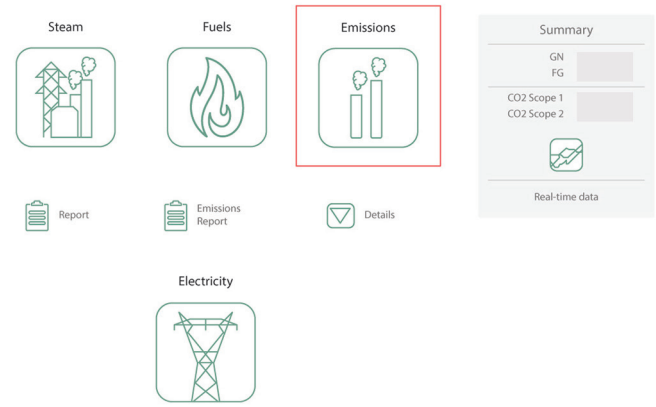


Figure 2. VM-GEM emissions management software dashboard depicts flow gas and Scope 1 and 2 emissions output from the furnaces module.

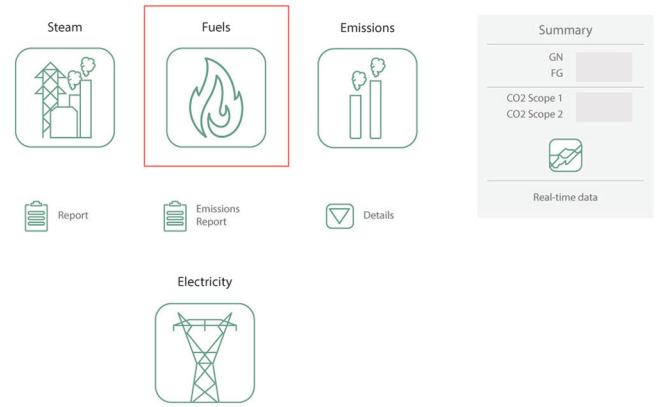


Figure 3. VM-GEM emissions management software dashboard depicts flow gas and Scope 1 and 2 emissions output from the fuels module.

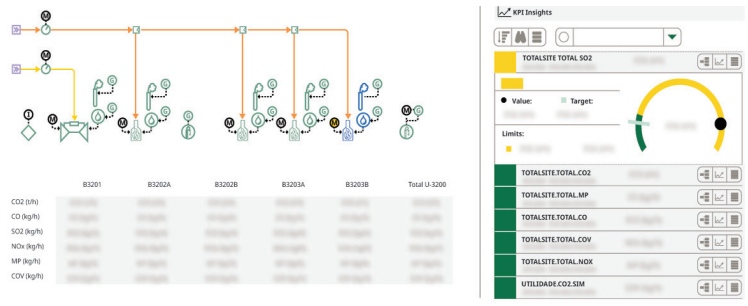


Figure 4. VM-GEM emissions management software continuously tracks and alarms emissions-related KPIs in real time.

Visualising KPIs

Acelen employs a system that encompasses multiple modules as depicted in Figures 2 and 3. These modules include the emissions and fuel model networks. Each allows for frequent monitoring of key variables related to energy, such as fuel usage and related emissions. Figure 4 shows that key performance indicators (KPIs) related to emissions are continuously monitored and flagged in real-time, and can be inspected using the software's drill-down feature.

Reporting emissions

The standard protocols for producing quarterly or annual emissions reports can be tedious and time-consuming. As a result, most refineries opt to submit their emissions reports annually, some on a quarterly basis, and even fewer on a monthly basis. Generally, ESG corporate functions prepare these reports using averages, yet the information is not shared or derived from operations. This approach creates a disconnect between the two, making it difficult to take corrective action in case of deviations from targeted emissions.

To bridge this communications gap, Acelen is taking a different approach that uses an emissions reporting module to streamline its reporting process. By pulling data from various sources, including mass balance calculations, correlations models, and GHG factors, refiners can generate comprehensive, real-time reports. This unified reporting system provides a holistic view of the refiner's emissions profile, enabling engineers to identify areas for improvement, track progress, and take corrective actions swiftly to comply with regulatory bodies.

Furthermore, this software operates in an auditable environment, ensuring compliance with strict emissions standards. The availability of auditable reports is important in terms of transparency and accountability. With full life cycle tracking, the data's reliability and consistency ensure legal compliance.

Making decarbonisation a reality

Currently, optimising emissions is not typically included in real-time operational variables. However, with the escalating cost of carbon and the growing influence of carbon tax credits on daily trading activities, refiners will soon be more motivated to reduce their emissions on a daily basis. As a result, refiners will likely shift from annual, quarterly, and monthly targets to daily emission goals.

The ability to report emissions more frequently can be achieved through automatic, unattended energy real-time execution. This technology has a

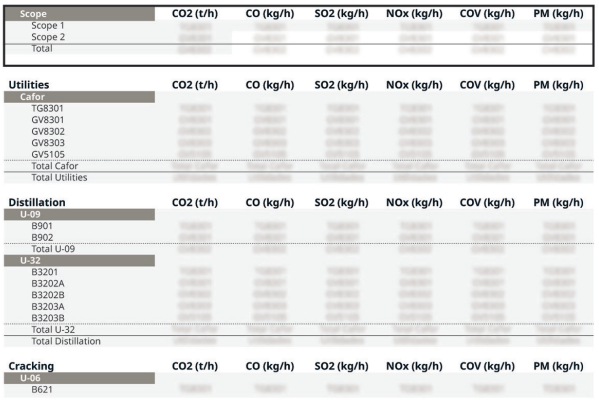


Figure 5. VM-GEM emissions management software provides comprehensive energy and emissions reporting campus-wide.

proven track record in the refining industry and is the foundation of online optimisation.

Acelen intends to use GHG emissions management technology to monitor and automatically report Scope 1 and 2 emissions data from plant operations in real time using digital data sources. Based on the energy usage and emissions patterns shown in Figure 5, refiners can optimise their operations and reduce emissions by making data-driven decisions. By meeting emissions reduction targets, Acelen anticipates that all aspects of its ESG practices are in line with the UN Sustainable Development Goals.

As Brazil introduces its latest carbon pricing system, the GHG emissions management technology will prove to be a critical tool for Acelen in meeting the country's emissions reduction targets. This two-system initiative consists of an energy trading system (ETS) and offsetting system. Together, these systems aim to establish a carbon market and incentivise emissions reductions.

Acelen, like many refineries, uses ongoing performance monitoring and analysis to optimise operations, reduce emissions, and improve the accuracy of emissions reporting. For instance, Acelen reported reductions including a 6% decrease in electricity consumption, a 268 000 t reduction in CO_2 emissions, and a 41% reduction in sulfur emissions. These reductions were a result of Acelen's teams prioritising energy efficiency initiatives, ranging from the recovery of important systems and equipment, improving work processes, and optimising operations. Overall, the use of GHG emissions management technology has helped the refiner to measure the impact of these actions in emissions, highlight bad actors, and consequently meet their corporate responsibility goals while bringing decarbonisation to life.

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