Strategizing Sustainability into Core Industries, One Application at a Time

Industry is decarbonizing, and these examples show how various companies are accomplishing this and garnering reduction.

Globally, atmospheric carbon dioxide has been on the rise for decades, so it is easy to accept that it will take decades to reverse the trend. Yet, it is imperative for industry to take action, one process area at a time. Climate change and the need for Net Zero targets has dominated the media in recent years. So as a response, industry has focused its attention on its own emission footprint. But just as there are many sources of emissions, there are just as many ways to reduce it.

Three carbon-intensive processes

- Oil refining and chemical manufacturing, where hydrogen for use in hydrotreating processes is made by steam methane reforming (SMR) of natural gas, releasing resulting carbon dioxide to the atmosphere. The same process is also used for manufacturing ammonia used for fertilizer production.
- Iron and steel, where a blast furnace and basic oxygen furnace both create enormous amounts of carbon dioxide when making the conversion from iron ore to iron, and iron to steel.
- Cement and lime manufacturing, where calcination of calcium carbonate emits large volumes of carbon dioxide.

These processes are major emitters, but not the only ones. However, we also recognize these industries are necessary to support global manufacturing and essential infrastructure. According to the International Energy Agency, within the overall industrial sector in the U.S., five industries represent approximately 51% of energy-related carbon dioxide emissions and the majority of the worldwide CO_2 emissions (Figure 1).

Direct CO_2 Emissions from Industry in the Net Zero Senario, 2000–2030

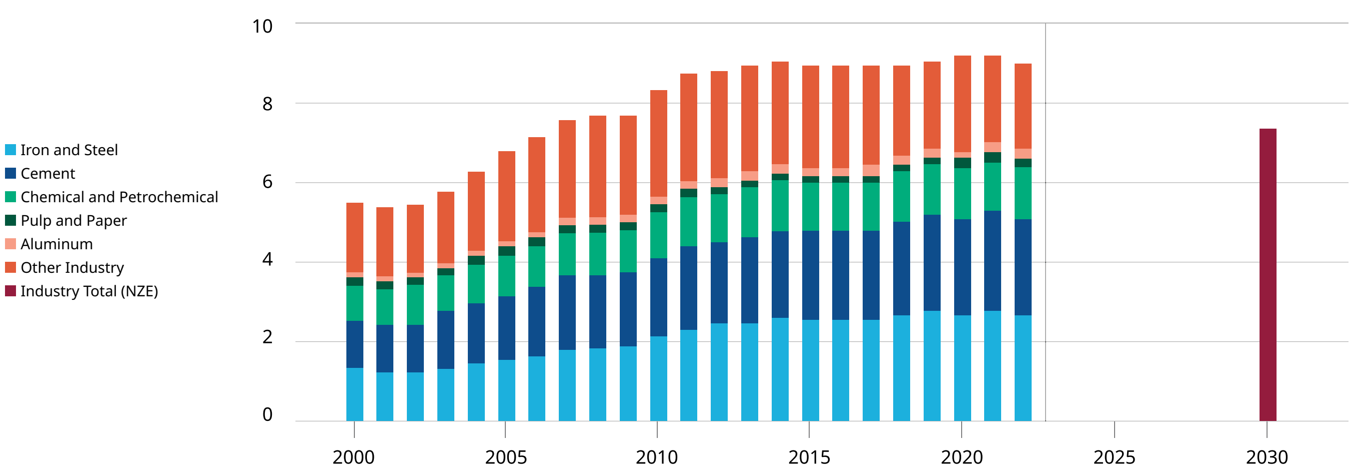

Figure 1: *Direct CO_2 emissions from industry, 2000-2030.*

Source: IEA (2023), Direct CO_2 emissions from industry in the Net Zero Scenario, 2000-2030, IEA, Paris

The question quickly emerges, how do companies set environmental, social, and governance (ESG) goals when carbon dioxide emissions are an intractable element of their process? Moreover, how do companies confidently quantify a return on emission reduction project aimed at achieving environmental goals and business strategy? In regions where carbon pricing is established, which according to a 2024 ***World Bank report*** covers 24% of global emissions, a carbon price can form a strong basis to define the economic return of an emission reduction project or strategy.

For companies that use offset emissions as they approach, several options exist: buying offsets through legislated local instruments such as an Emissions Trading Scheme (ETS) or pay Carbon Taxes or implement emission reduction projects ahead of their net zero deadlines. For many companies in the industrial and manufacturing sector, it can be difficult to have a clear picture of the current emissions profile based on production levels, seasonal or market variability. In such scenarios it is worth embarking on an energy optimization and emissions reduction program that typically starts with measuring, tracking and modeling emissions and energy usage across industrial assets. This then forms the basis for identifying, quantifying and justifying (with an internal or external carbon price) emissions reduction projects and ultimately the implementation of an Energy and Emissions Management System.

Intersection of energy intensity and process emissions

The types of emissions just mentioned are only part of the picture because many carbon dioxide-creating processes operate in highly energy-intensive environments, and thus need reliable, and preferably carbon-free, sources for this energy

Refineries typically have five major production units: hydrocracker, atmospheric distillation, fluid catalytic cracking, SMR, and catalytic reforming (Figure 2). These units have multiple boilers, fired heaters, and other heat generating sources. Most are fired by natural gas, or to a lesser extent oil, but in a refinery, there are often opportunities for using low-value byproducts as fuels when such are available. Normally, these are all derived from fossil fuels, and can have high variability for energy content. Consequently, burning low-quality fuels usually makes combustion harder to control and less efficient, creating higher emissions. SMR units creating hydrogen from natural gas typically consume an additional 50% of the feedstock volume as fuel for the hydrogen they produce.

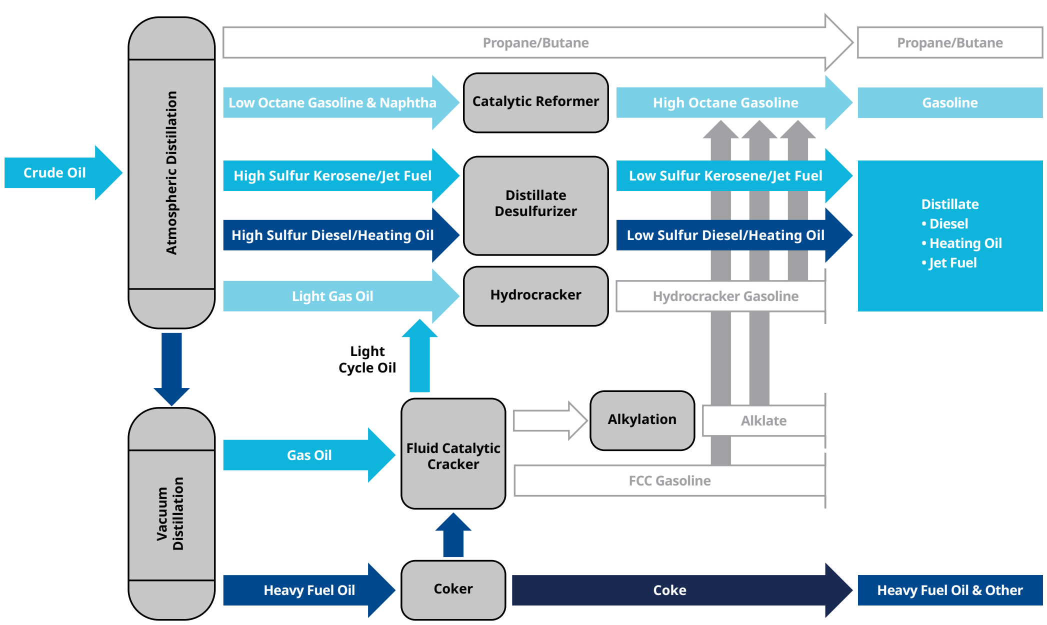

Figure 2: *Diagram depicts the complexity of the refining process.*

The iron and steel industry is one of the most energy intensive globally and a major carbon dioxide contributor (Figure 3). There are critical chemical processes involved, as mentioned earlier, necessary to reduce iron ore to create pig iron, along with reducing the proportion of carbon to turn iron into steel.

For example, in a blast furnace, coke (made by partially burning coal, creating its own emissions) and limestone are added to the mix, both of which create carbon dioxide as they burn off. In a basic oxygen furnace, pure oxygen is injected into molten iron to burn off excess carbon, also resulting in carbon dioxide. This is in addition to enormous amounts of natural gas necessary as fuel to support continuous casters, hot rolling mills, and other forming operations.

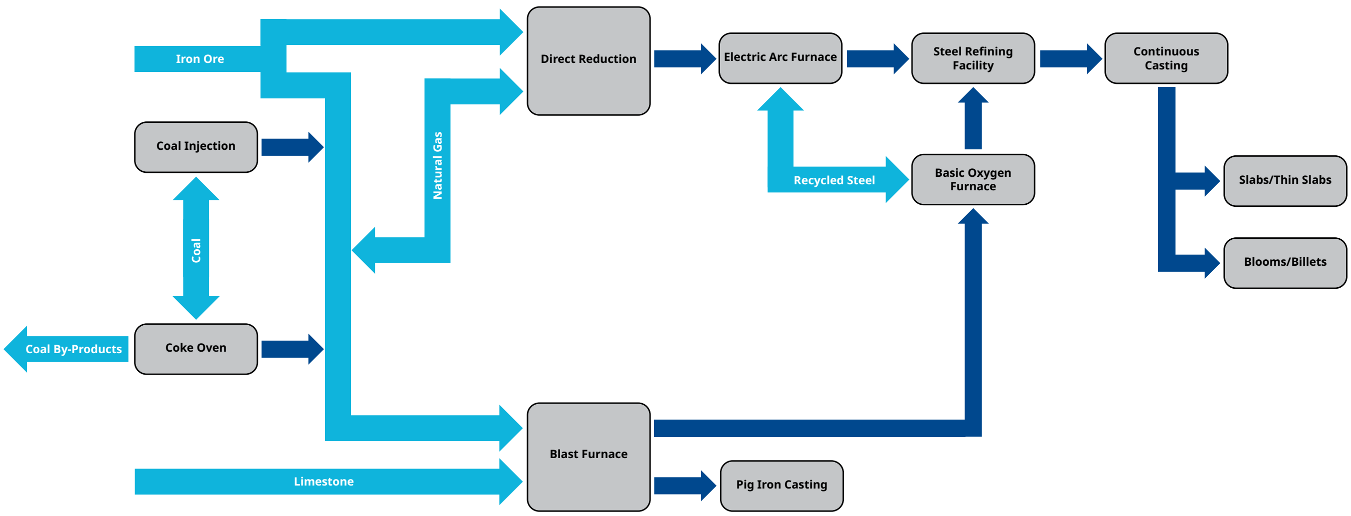

***Figure 3:** The iron and steel industry has many energy-intensive processes that result in carbon dioxide emissions.*

Cement and lime manufacturing both use rotary kilns to calcine limestone and other minerals, resulting in carbon dioxide creation. While rotary kilns (Figure 4) can burn a variety of fuels, across the installed base, almost 90% were designed to use coal or petroleum coke. These plants are also a means to burn hazardous liquid waste and tires. The efficiency of a specific plant depends on the age of the equipment, as old installations had less sophisticated preheater systems, reducing heat recovery and efficiency.

As mentioned, while it is possible for these industries to use renewable fuels to reduce net emissions, it is not practical to totally eliminate carbon dioxide from every process, but much can be done.

***Figure 4:** Rotary kilns have a wide range of efficiency ratings, often related to age.*

Four pillars supports a sustainability business strategy

1) Energy and Emissions Management: Reducing or eliminating emissions from operations calls for creative thinking and considering new ways to do things, with workflows that minimize or even eliminate carbon dioxide sources. Eliminating emissions from every source, such as carbon dioxide from a calcining process, may not be possible, but it is important to look at how each process is supported, and the process itself. Some underlying assumptions may need adjustment.

2) Energy Source Decarbonization: Energy sources that have no carbon content are available, primarily hydrogen, and these create no greenhouse gases (GHGs). Green hydrogen (made by electrolysis of water using renewable electricity) is the best example. The use of biofuels, refined from crop waste and other agricultural leftovers, support traditional combustion processes, but they avoid use of fossil fuels, reducing the net increase of atmospheric carbon dioxide.
3) Electrification and Grid Systems: Many heating applications can be supported by electricity rather than combustion, and this reduces emissions, provided the electrical energy is generated via a clean source, such as wind, solar, hydro, or nuclear. Many process manufacturing facilities can, and probably should, deploy their own photovoltaic farm, even if it's modestly sized, to create carbon-free electricity. Alternatively, renewable fuels, which do not add to the net increase of carbon dioxide resulting from fossil fuels, can be used where more traditional combustion is needed.
4) Circularity and Waste Management: Tightening production control to reduce the amount of off-spec product reduces emissions overall since it requires as much energy to create waste, but there is no ultimate benefit. In some cases, waste can be reprocessed and used as feedstock. For a refinery, it is often just as likely that waste will be flared, creating emissions but nothing of value. Waste streams of any kind must be minimized, but also examined to determine if there is some other more useful purpose. This can be extended to post consumer recycling, creating a circular economy, where trash, such as aluminum and plastic, can be processed and used again.

Let's look at these four pillars more closely and see actual examples, some of which span more than one category.

Emissions from operations

One approach when examining how emissions result from day-to-day operations is quantifying emissions per unit of plant production after waste and off-spec products are backed out. This suggests emissions can be reduced by using less energy combined with less waste. Sometimes it is possible to change the nature of the process to consume less energy, or a less carbon-intensive form. In other cases, the process itself can be reimagined. Let's look at examples of both.

Offshore oil and gas production platforms are generally conceived as self-supporting operations, creating their own energy simply by using the available natural gas to drive engines and fuel boilers. Consequently, some amount of gas is consumed to support the operation, creating emissions per unit of oil and gas delivered. Equinor operates a platform with a different approach.

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Equinor, a Norwegian state-owned multinational energy company, operates their Martin Linge field, and it calculates that avoiding the use of natural gas as fuel on the platform and avoids 200,000 tons of carbon dioxide emissions each year. This is a net environmental improvement because the platform is provided with electricity from shore via an undersea cable, and most of Norway's electricity is produced from hydroelectric plants (88%), with much of the balance from wind turbines (10%).[1]

The platform is operated mostly from Kollsnes, minimizing headcount on the platform. Emerson provided automation for the operation at both ends, based on its DeltaV™ control system; wired and wireless instrumentation; emergency shutdown and isolation valves; and asset management software.

Another company, one that has completely rethought some chemical manufacturing processes, is Syzygy Plasmonics. The company has developed a technology platform using light-driven chemistry instead of heat to produce high-value molecules, all without combustion processes and resulting emissions. Syzygy's reactors are now being used to produce hydrogen by reforming methane without the associated combustion. The process can also produce methanol from methane and carbon dioxide, effectively reusing emissions from a previous process.[2]

Energy addition

This category includes two possibilities: energy that does not involve carbon at all, such as green hydrogen, or sources that do not involve fossil fuels, such as biomaterial. Burning fossil fuels creates a net increase in carbon dioxide because that carbon was formerly sequestered in the ground. Here are examples that illustrate both possibilities.

Albioma is a French energy company, with the stated goal of replacing coal with new forms of biomass. As an example, Bois Rouge, a 108 MW power plant it operates on Réunion Island in the Indian Ocean, is being converted from burning coal to wood pellets. Other plants on the island burn bagasse from local sugar cane processors. Emerson has worked with Albioma on these projects, providing Ovation™ automation technologies, instrumentation, and general biomass know-how.[3]

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Albioma is expanding its infrastructure on the island to increase production and maintain 100% renewable electricity production. This includes bagasse processing, along with wood pellet unloading and storage, to ensure consistent production.

On the other side of the world in Bécancour, Québec, Air Liquide has completed construction of the world's largest proton exchange membrane (PEM) electrolyzer to produce 8.2 tons per day of low-carbon hydrogen using Hydrogenics technology. Renewable power to drive the 20 MW electrolyzer will come from Hydro-Québec. The company says that compared to traditional hydrogen production processes, this unit avoids emission of around 27,000 tons of carbon dioxide per year.

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Much of the hydrogen produced will be used for fuel-cell-based transportation and stationary remote generation installations.

Emerson has provided DeltaV SIL 3 Safety Systems, CHARMS I/O, Tescom field devices, along with services for commissioning and startup.

Renewable and alternative clean energy

There are a variety of clean and renewable energy sources, sometimes coming from some unexpected areas, capable of displacing fossil fuels.

Alaska is experiencing some challenges related to climate change given the region's extreme weather. One utility in the state, Golden Valley Electric Association (GVEA), built its Eva Creek wind farm (Figure 5), producing 25 MW of reliable, low-cost electricity across rural parts of the state, while reducing fossil fuel use. The company has partnered with Emerson, applying an end-to-end wind farm management solution built on Ovation automation, AspenTech Monarch™ software, and OSI Digital Grid Solutions. The result has been a 65% reduction in operations and maintenance costs, while delivering higher reliability of the wind turbine fleet.[4]

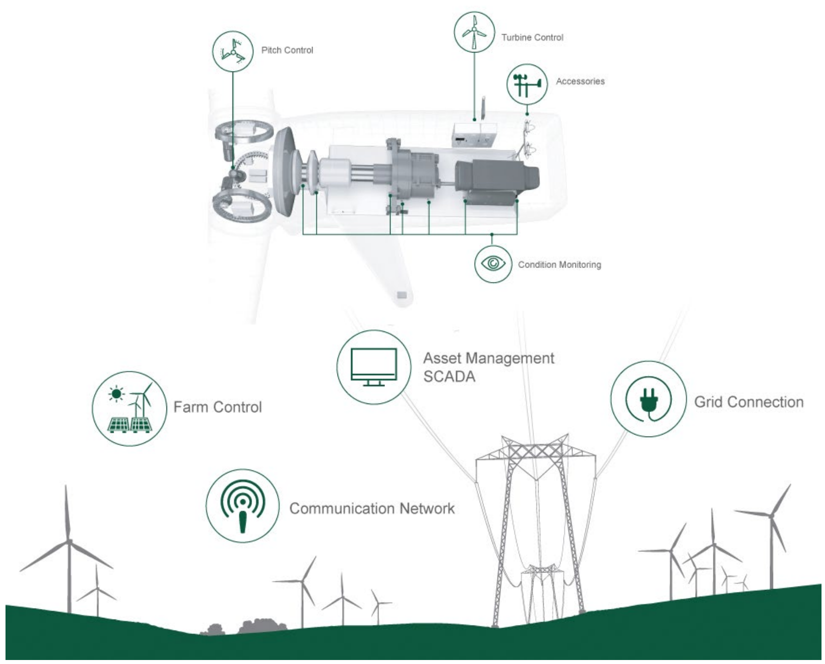

Figure 5: *Ovation Green integrated wind solutions.*

Another company manufactures hydrocarbons, useful as chemical feedstocks, fuels, and refining blending stocks, from plastic waste. ReNew ELP is a subsidiary of Mura Technology, and its HydroPRS plastic recycling process produces specific types of oil products and gases, even with mixed plastics and non-plastic material such as paper as feedstock. This process requires tight control of the actual heating process, using supercritical water and steam, combined with catalysts and separation steps. In the reactor, the polymeric bonds break down, creating useful short-chain, stable hydrocarbons, which are then separated.[5]

Some of these hydrocarbons can be used as feedstocks for manufacturing new plastic, while others can be used in fuel blending. The process requires use of some natural gas, but once the process is in operation, some of the gases produced help sustain the reactor. The main advantages are that plastic waste is being recycled, and chemicals and fuels are being created, all with minimal fossil fuel use.

ReNew ELP has partnered with Emerson to provide DeltaV for process control, and a variety of instrumentation to support the HydroPRS process.

Reducing waste and off-spec products

The same emissions result from manufacturing rejected product as good product, so eliminating waste reduces overall emissions, and lowers emissions per unit of salable output. Let's look at two examples where tightening production had this beneficial effect.

Braskem Idesa is a joint venture to produce high- and low-density polyethylene in Coatzacoalcos, Mexico. The plant has an ethylene cracking capacity of 1.05 million tons annually using natural gas as feedstock. The company set very ambitious goals for operational and financial performance, including resource utilization. To achieve these, it engaged Emerson to implement its Operational Certainty Methodology across four critical areas:

- Physical loss control
- Information management
- Production and energy optimization
- Reliability and energy efficiency

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The company is on track to reduce GHG emissions by up to 15% by 2028, with full carbon neutrality by 2050. Emerson's digital automation technologies and services, including Rosemount™ instrumentation and Fisher™ valves, are helping to make attainment of these goals a reality.[6]

Crude tall oil (CTO) has been a byproduct from kraft paper production forever, but never received much attention. It is extracted from black liquor and tall oil soap, and when refined, can be separated into tall oil fatty acid, tall oil rosin, distilled tall oil, and pitch. Interest in CTO has grown in recent years as a source for renewable fuel feedstocks, prompting Fintoil to build a new refinery in HaminaKotka, Finland to process 200,000 tons annually. It started operation in 2022.

The facility uses Neste Engineering Solutions' NEXPINUS technology, which it says consumes 40% less energy than conventional CTO refineries. Much of the production becomes feedstock for renewable diesel production, plus a variety of chemicals.[7]

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Emerson was involved with the project planning from the outset using its Project Certainty Methodology and Lifecycle Services Commissioning Software. The plant operates daily using DeltaV as its main process automation platform, supported by Emerson's broad portfolio of valves and instrumentation.

Calulating an ROI

One final component of a sustainability business strategy is a return on investment (ROI) calculation. This process is complex encompassing three core areas: economic, environmental, and social value.

Economic ROI:

- *Cost Savings & Project Feasibility:* Efficiency measures (e.g., energy and waste reduction) as well as validating CAPEX decisions, meeting financial objectives and increasing speed to market.
- *Risk Mitigation:* Sustainable practices reduce regulatory and compliance risks.
- *Investment Appeal:* Companies with sustainability targets attract socially responsible investors.

Environmental ROI:

- *Carbon Footprint:* Emission-reduction initiatives support climate goals.
- *Circular Economy:* Recycling and reusing materials reduce raw material costs and waste.
- *Innovation:* Eco-friendly products enhance competitiveness in green markets.

Social ROI:

- *Community Impact:* Sustainability investments build brand loyalty through community support.
- *Brand Reputation:* A strong sustainability profile boosts reputation and customer loyalty.

Whether planning for capital expenditures or adjusting operations and maintenance practices, the full impact of decisions is difficult to fully assess. Emerson software solutions provide detailed analysis and can help guide strategic decisions for project prioritization and better decisions using a consistent costing model from conceptual to detailed engineering.[8]

A look ahead

There's an old saying, "The more pipes there are, the more ways to plug the drain." Let's rethink that notion more positively: "The more sources of carbon dioxide there are, the more ways to reduce total emissions." The discussions and solutions in this white paper do not promise to solve all problems all at once. At Emerson, we know that real-world companies don't normally look at a major issue and try to solve it in one fell swoop. The more effective way to approach a large-scale problem, such as carbon dioxide emission reduction, is by dividing it into more manageable parts, and dealing with each individually.

When working with clients, we look for solutions that help solve one or two things at a time, and then build on success, such that the next solution builds on the first, and savings helps to justify the next improvement. Reducing emissions from a large fossil fuel fired heater by improving combustion control today can be followed by using carbon capture and storage tomorrow somewhere else in a facility.

Emerson provides automation hardware and software to take on these challenges. Through advanced automation, data can be liberated to unleash the power of software to drive maximum performance. This is supported by advanced instrumentation, creating a network of intelligent instrumentation capable of delivering data from diverse operations. When this kind of analytical power is available, selecting projects to reduce emissions is much easier and more effective.

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Industry Perspectives

Growing Regulation of the Chemical Industry

For better or worse, much of the chemical industry has been under the radar of environmental regulators, allowing emissions of carbon dioxide and various toxic gases. This is changing as GHG concerns get tighter, but how quickly? The U.S. is the world's second largest chemical producer, so this discussion has serious consequences.

The American Council for an Energy-Efficient Economy (ACEEE) recently published a white paper calling for a national plan to reduce emissions from the chemical sector. Citing the white paper, Anna Johnson, senior researcher for ACEEE, wrote:

"A new ***ACEEE white paper*** evaluates whether current U.S. initiatives are sufficient to decarbonize the chemicals sector. We identified over 50 programs across nine different federal agencies that reduce carbon emissions within the chemicals industry. Our conclusion? These programs are too small or fragmented to move the market. The United States does not yet have a national strategy with the scope and resources to pull the sector into a clean manufacturing future."

ACEEE suggests that what programs there are concentrate on a given facility and what their people are doing inside their own fence, or what is shown as Scope 1, while the bulk of emissions are going on elsewhere in the supply chain, Scope 2 and 3. Naturally, every company is responsible for its own actions, but leveraging a partner's expertise, technologies, and know-how to solve emissions can accelerate plans, regardless of the industry.

The activity that will drive change industry-wide is responsible companies taking appropriate actions to drive the other companies they work with through their supply chains to do the same. This can extend to selecting partners such as Emerson, since our company is implementing its own emissions-reduction strategies.

Reducing Carbon Emissions from Refining

The refining industry is one of the biggest users of hydrogen for hydrotreatment in processes from renewable diesel manufacturing to desulfurization of various products. The vast bulk of that hydrogen starts as natural gas and undergoes SMR or auto thermal reforming to create hydrogen and carbon dioxide. Both these processes create gray hydrogen since the carbon dioxide is normally released to atmosphere.

These are both textbook examples of processes ideal for conversion to blue hydrogen by capturing and storing the carbon dioxide. They're ideal because they produce a stream of high concentration carbon dioxide suitable for injection into the ground at an appropriate site. This is a major environmental advance, but it still uses fossil natural gas as the feedstock, plus around half-again as much natural gas for the heating processes.

The SMR unit for most refineries already has a carbon dioxide capture section, so it creates a stream of virtually pure carbon dioxide, ideal for carbon capture and storage (CCS).

A emissions-free solution is green hydrogen, possible in areas where sufficient renewable electricity is available to produce sufficient volumes for the required applications. Even if it isn't possible to make a complete conversion to green hydrogen, any reduction in blue, or especially gray hydrogen use, is a big step toward decarbonization. Emerson can create solutions to support any of these scenarios, with the necessary control and instrumentation solutions to monitor production and custody transfer along the CCS value chain.

Carbon Emissions and Mining Operations

Every mining operation should be looking at its own carbon footprint and what can be done to reduce it, even if it is only a link in a longer chain. Let's think about two approaches to reduce emissions at mine sites.

First, diesel engines, whether powering trucks, or generating off-grid electricity for the site, are a huge source of emissions. New technologies, between electrically and powered trucks, can replace diesels, provided the electricity production method isn't worse than the diesel it's replacing. A reliable grid connection to a responsible electric utility can make a big difference by eliminating diesel fuel use.

Second, improving control of mine site operations can reduce waste and minimize overall energy consumption. If we think of traditional processes at the mine site, they include grinding, screening thickening, flotation, and others. These depend on effective automated process control to maximize recovery of on-spec product in a cost-effective manner. Eliminating waste can reduce overall energy consumption per ton of production, reducing carbon dioxide emissions and increasing profitability.

Emerson has helped many mine sites on this very point by providing automated process control, instrumentation, and its broad valve portfolio.

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