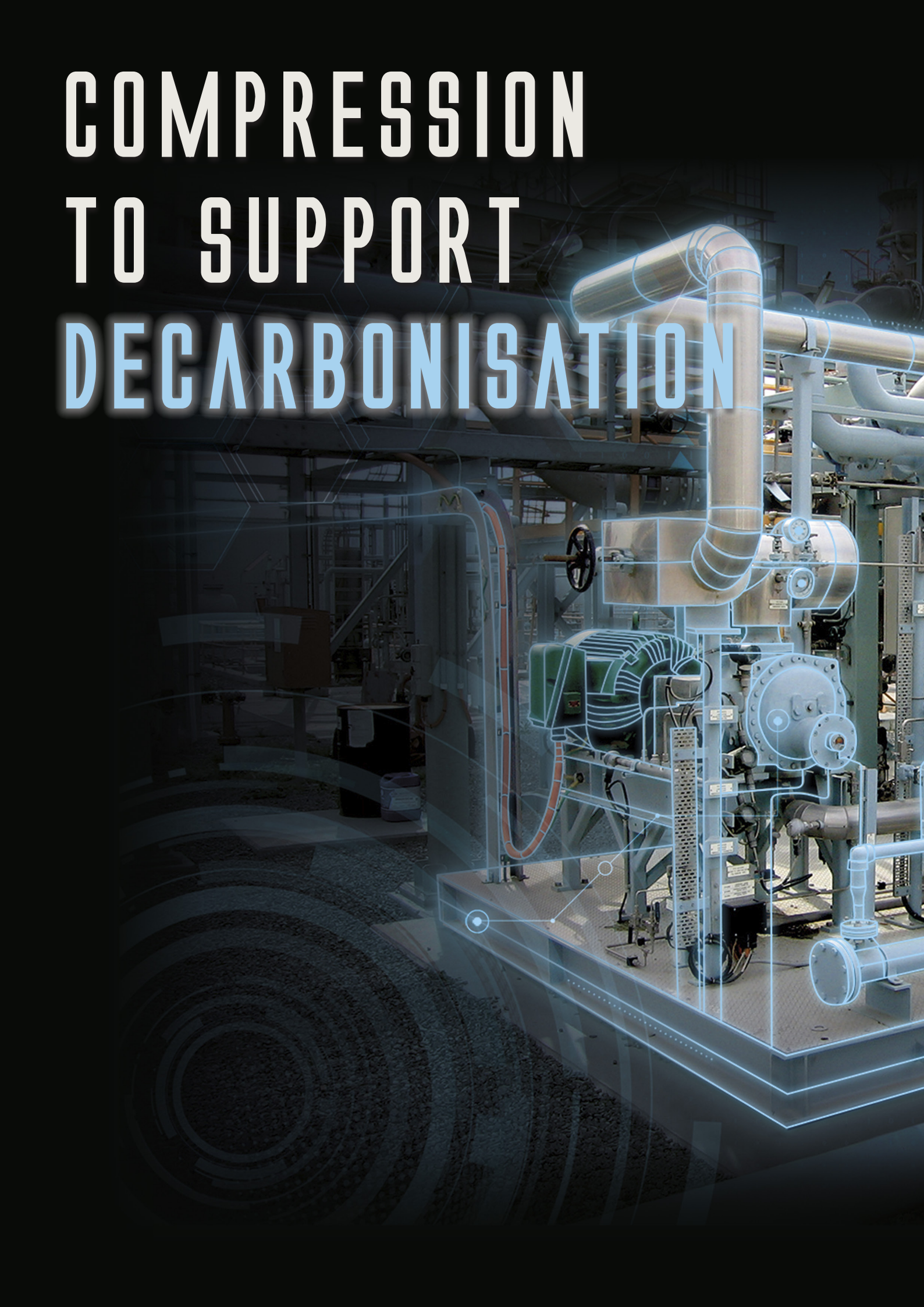
COMPRESSION TO SUPPORT DECARBONISATION



Marie-Laure Gelin, Howden, a Chart Industries Company, the Netherlands, explains why compression is such an important process within the hydrogen value chain.

Amidst growth in the clean energy technology sector, and continuous energy efficiency improvements, global energy-related carbon dioxide (CO_2) emissions grew by 0.9% in 2022, reaching more than 36.8 Gt, according to a report from the International Energy Agency (IEA).[1] The net zero imperative remains, and so should the will to integrate and leverage innovation to accelerate progress towards decarbonisation, sustainability and electrification.

Decarbonisation is a key component of the future energy map to enable a zero-carbon society to grow, while reducing greenhouse gas (GHG) emissions. This implies upgrading production sites to produce energy in a cleaner manner, while nurturing the development of a global and domestic hydrogen value chain. Hydrogen needs full recognition as a secondary energy source that acts as an energy carrier that is able to be stored and converted to serve a myriad of applications in industry, transport, power generation and building. Achieving a successful energy transition is possible with current technologies that leverage hydrogen and carbon capture value chains.

There have been efforts to deploy renewable energy-based projects, with the intention of including all emerging and developing economies in this new energy move. All countries that are willing to deploy renewable energy projects face similar financial, administrative and regulatory hurdles that need to be addressed by the different private, public and institutional stakeholders at international, national and regional levels.

These hurdles contribute to the delays in the number of renewable energy projects reaching the final investment decision (FID) stage. One of the factors behind the lagging scale-up of hydrogen production, transfer and distribution may be the lack of infrastructure serving the hydrogen value chain to allow it to become a 'consumable product'. To overcome this situation, gas pipeline mitigation and hydrogen derivative products use existing infrastructure in ports and airports where possible. Under these conditions, it is difficult to assess whether this infrastructure is supporting or indeed slowing down the development of a hydrogen value chain.

The hydrogen industry needs to address the challenge of scaling up production to deliver the required quantities at the speed and price that end users can work with within their specific applications. One answer to this complex goal is to create integrated hydrogen value chains.

Compressed and liquid hydrogen

Companies are currently investing in cleaner ways of producing energy, by rethinking existing processes and implementing new processes. Unleashing the power of hydrogen molecules requires operators to move them to a supply site as and when needed, which is why storage options are important, whether as compressed gas, liquid hydrogen, hydrides, or liquid organic hydrogen carriers.

Figure 1. A green hydrogen compression solution with a containerised Howden diaphragm compressor.

Figure 2. A Chart hydrogen tank at the storage stage of the hydrogen value chain.

Depending on a value chain's characteristics, liquid hydrogen is usually preferred for long storage periods and long transportation distances in large quantities. This form of hydrogen can be associated with compression in accordance with the final destination and use of the hydrogen, as well as liquefaction itself. Storing, transporting, transferring and converting (gas to power) hydrogen is challenging due to its poor volumetric density.

Liquid hydrogen and gaseous hydrogen technologies can respectively support a hydrogen value chain from production to final usage. Currently, depending on application requirements, infrastructure cross border trade, inland infrastructure, technology availability and market adoption, one value chain may associate liquid hydrogen and gaseous hydrogen stages.

Ultimately, the application's purpose and customer circumstances are best to define what to use and where in the hydrogen value chain, as both liquid hydrogen and gaseous hydrogen come with their respective challenges and benefits. The question is not to prefer to manage low, cryogenic temperature properties or high pressure hydrogen. Rather, what is going to be the easiest given customer constraints and needs. Similarly, liquid hydrogen is more volumetrically efficient than gaseous hydrogen (e.g., liquid hydrogen is three times more dense than the common 300 bar pressure gaseous hydrogen transports). This said, gaseous hydrogen is serving today's applications that need local distribution and modest volumes.

Compression is a key aspect of the hydrogen value chain, but not the only one. A hydrogen value chain demands coherence and integration, from hydrogen production through to its final usage point.

Market segmentation: demand/supply/infrastructure

Primary energy sources such as natural gas and conventional fossil fuels, as well as renewable energy sources, surplus energy (heat and electricity), and biodegradable waste can all be used as feedstock for hydrogen when using electrochemical (electrolysis), thermochemical (gasification, pyrolysis, steam reforming) and biological processes. The produced hydrogen can be liquefied to allow for transportation by sea tanker, trucks, and railway tankers for international shipping or domestic distribution.

In parallel, traditional industries are discovering cleaner ways to produce end products such as green steel, green and blue ammonia, e-methanol, renewable diesel, and biofuels (e.g. sustainable aviation fuels [SAFs]). All of these products follow strict processes, and require hydrogen compression.

The energy transition makes up a significant portion of Chart Industries' business – consisting of hydrogen, biofuels, LNG with carbon capture, utilisation and storage (CCUS), nuclear power, electrification and water treatment.

Compression is a key element of the hydrogen value chain, starting at its production site to ensure that its pressure is relevant to its further transportation, distribution and utilisation. Renewable hydrogen production by way of electrolysis, followed by compression, would appear to be a cleaner way to produce energy. However, until this process scales up, many alternatives exist, such as blue hydrogen.

When producing clean hydrogen using carbon capture, specific CO_2 compressors are required as part of the

Figure 3. Global service team working on a compressor.

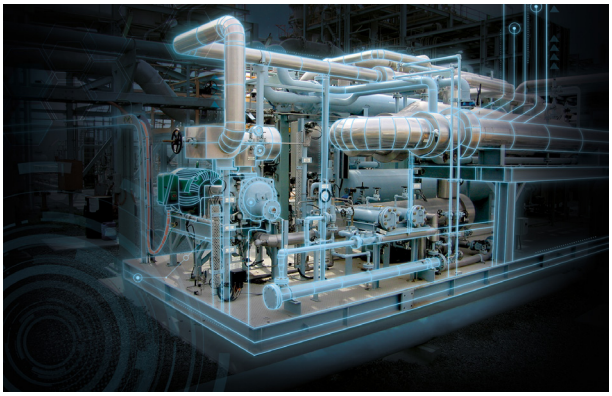


Figure 4. Integration to the unmanned concept of the plant using uptime (digital driven advantage and digital twin).

value chain. During hydrogen liquefaction, compressors are required for the feed to the liquefaction process itself (pre-cooling and cooling). Once the liquid hydrogen reaches a port, regasification occurs, so hydrogen molecules can reach their final destination using pipeline, tanker and bottling.

Compression technology based on reciprocating piston, diaphragm, centrifugal, screw or turboexpander technology enable large and low volumes of hydrogen and associated low or high pressures to obtain the required energy values, while managing pressure differences through the transfer and storage of hydrogen, with the highest gas purity when required. Developments in materials, lubricants, seal and valve design – together with computer-aided analysis and design – have resulted in proven marginal improvements in efficiency, reliability, and extended mean time between maintenance (MTBM).

At every stage of the value chain, hydrogen safety is paramount in order to erase the possibility of leakage, as its dangers can translate physically through embrittlement and failures; physiologically by asphyxiation; and chemically in the case of fires and explosions.

The first page of Chart's safety manual illustrates the company's values: "If it can't be done safely, don't do it. A job is well done only if it is done safely. Most accidents and injuries are preventable – no business objective is so important that it will be pursued at the sacrifice of safety."

The Chart team continues to meet international safety standards and obtain certification. Many of the company's safety programmes and practices reflect requirements of the ISO 45001 Occupational Health and Safety standard for management systems. Chart voluntarily certifies certain manufacturing and fabrication facilities to this internationally recognised standard to increase safety and reduce workplace risks. Many of the company's Specialty Products; Repair, Service and Leasing; Cryo Tank Solutions; and Heat Transfer Systems sites are ISO 45001 certified, and the company also assists sites that increase their work scope or are newly acquired in becoming certified.

Safety is the top priority and in 2Q23, Chart reported its lowest total recordable incident rate (TRIR).

Responding to a situation at the compression level

Compression at a hydrogen production site guarantees hydrogen gas transfer further down the value chain. In regions where renewable energy is produced a long way from where it is consumed, customers order diaphragm compressors as a compression solution for tube trailer filling so that hydrogen can be dispatched where required.

Downstream compression enables hydrogen gas to be delivered at the pressure that is required by the end use application, and so with the help of compression technologies, deploying green hydrogen at scale can become a reality. When compressed, the gaseous hydrogen can be used to decarbonise heavy-duty trucks.

Chart's Howden diaphragm compressors enable the safe and efficient transportation of compressed gaseous hydrogen, ensuring its availability as a clean fuel source for heavy-duty trucks. This solution focuses on ensuring the safety and efficiency of hydrogen compression, while providing ongoing support to optimise plant performance and reliability.

Compression is involved in the production process of biofuels and e-fuels to decarbonise the transportation sector. Hydrogen compressors have the capacity to serve container vessels operating on carbon-neutral fuel produced from green hydrogen. This is in line with the adoption of the Marine Environment Protection Committee in July 2023 – a revised strategy to significantly curb GHG emissions from international shipping, with the ultimate goal of achieving net zero emissions by 2050. Chart's Howden compression solutions support the production process of hydrotreated vegetable oil (HVO), leading to SAF production from bio and waste feedstocks, and sequestering CO_2. Compressors are in action in various parts of the world, supporting synthetic processes to deliver e-methanol.

Conclusion

In support of the energy transition and the drive towards cleaner and more efficient operations, Chart Industries is involved in a number of projects in all parts of the world. The company has a number of different gaseous and liquid hydrogen technologies to help meet current challenges and customer expectations, depending on the application.

Reference

1. 'CO_2 Emissions in 2022', International Energy Agency (IEA), https://www.iea.org/reports/co2-emissions-in-2022

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