**Sustainability becomes a driver for chemical plant construction**

*These are the birth pangs of a new economy: the increasing demand for chemical products is bringing growth to the industry, which at the same time has to cope with the necessary transformation towards climate neutrality. For chemical plant construction, both of these factors mean a lot of work in the coming years - in addition to enormous challenges, huge opportunities await.*

The energy crisis resulting from the Russian war of aggression on Ukraine has sent shock waves through the global chemical industry in 2022. Germany and chemical nations in Europe, which have few energy resources of their own, have been hit hard by the rapid rise in gas prices. As a result, the pressure for more efficient processes and new energy sources has increased significantly. But a rethink of the raw material and energy base was already underway. This is because chemical nations and global chemical companies have long been working towards the goal of "Net Zero" and want to end greenhouse gas emissions by 2070 (India), 2060 (China and Russia) or already by 2050 (all other chemical nations).

The project is ambitious: in Europe alone, the chemical industry will have to invest 1 trillion euros for this purpose, according to estimates by the consulting firms Accenture and Nexant ECA. 400 to 600 billion euros will be spent on modifying and building new production plants for the eight most important chemicals: ammonia, ethene, propene, nitric acid, carbon black, caprolactam, soda ash and fluorochemicals. In the USA and China, investments will be much higher. Chemical plant construction has a key role to play here: the mammoth task is to scale up new technologies to large-scale production in the shortest possible time - actually the industry's paradigm discipline.

**Decarbonisation picks up speed**

For several years now, companies in the plant engineering sector have been registering growing interest among their customers for solutions to decarbonise chemical value chains. In view of the high prices for natural gas and other energy sources, the development has gained significant momentum in 2022. Across the board, global chemical plant suppliers report an increasing share of orders for sustainable solutions in their latest annual reports. But the market has changed significantly compared to the Corona years of 2020 and 2021: The traditional oil and gas business is also humming. Increased prices for crude oil and natural gas have led to a revival of upstream activities in 2022. With projects worth over 2 trillion US dollars, oil and gas industry investments reached a new record high in 2022. And because the largest chemical plant construction companies usually also have a foothold in the oil and gas business, plant construction capacity is becoming scarce.

The demand for plant engineering solutions is also intensified by politics: it is estimated that the Inflation Reduction Act (IRA) passed by the US government in 2022 alone could lead to investments of 369 billion US dollars in the area of energy security and climate neutrality by 2030. The EU Commission is planning on a similar scale with its REPowerEU programme, and Japan also wants to invest massively as part of its Green Transformation programme.

Multinational suppliers such as Fluor, Worley, Technip and Samsung Engineering have recently reported not only a significant increase in incoming orders, but also spectacular decarbonisation projects by their customers. In December, for example, the start of construction for a new steam cracker in the port of Antwerp caused a stir: the British petrochemical group Ineos is building an ethane cracker there under the title "Project One", which, after commissioning in 2026, is to emit around 50 % less greenhouse gas than the most efficient plants of this kind to date. At 3.5 billion euros, it is the largest investment project in the European chemical industry in the past 25 years. The contract for the technology licence and the front-end engineering and design (FEED) has been secured by Technip Energies. Only formed in 2021 from the French Technip FMC, the plant engineering company focuses on engineering and technology solutions for energy transformation.

**Intensive cooperation between chemistry and plant engineering**

The spectacular project is just one of many: Almost all chemical companies that operate steam crackers are now working on climate-friendly solutions for the cracking furnaces - because ethene is the starting point for many plastics and basic chemicals, and to date almost 700 kilograms of carbon dioxide are produced per tonne of ethene. The project is so huge that it requires new cooperative ventures between plant builders and operators - and even cross-competitive ones: BASF, Sabic and Linde are currently jointly developing an electrically heated cracking furnace. At the same time, Dow and Shell, together with researchers from the Dutch TNO, are pushing ahead with the electrification of steam crackers. Together with the plant manufacturer Fluor, Dow wants to build a steam cracker with net zero CO2 emissions in Fort Saskatchewan, Canada. The Brazilian chemical company Braskem wants to electrify its crackers together with the Finnish technology and plant engineering company Coolbrook.

And time is pressing: Because large-scale chemical plants in particular will be operated for several decades, projects planned today must be net-zero-capable with a view to 2050. Promising new processes such as methane pyrolysis or methanol synthesis from biomass or electrolysis hydrogen are not yet available for large-scale use. As soon as the processes have been developed in the laboratory, plant engineering will have the task of scaling up these "first-of-a-kind" solutions from the laboratory to the industrial scale.

A key role is therefore played - at least as a bridging technology - by the capture and storage of CO2, known as Carbon Capture and Storage (CCS). Dow and Ineos, for example, are relying on this approach in their current cracker projects, but the net zero target can also be achieved for other chemical processes such as ammonia production. In March 2023, the first ship transport of carbon dioxide captured in an Ineos chemical plant in Antwerp caused a sensation: this marked the start of the cross-border Greensand project, in which up to 8 million tonnes of CO2 are to be stored annually in a depleted oil field off the Danish North Sea coast. In addition to Ineos, the energy company Wintershall DEA and the engineering company Aker Carbon Capture are involved in the project. Also in Antwerp, the chemical company BASF is developing a CCS project with the plant engineering and industrial gases specialist Air Liquide. The Global CCS Institute has researched 200 commercial CCS projects in 2022 - a total capacity of 244 million tonnes per year. But this is just the beginning: the United Nations IPCC estimates that at least 4 gigatonnes of CO2 will have to be saved annually by 2050 via carbon management and removal technologies in order to reach the 1.5 degree target. For this to become a reality, intensive cooperation between chemical companies that supply technologies and chemicals for CO2 capture and plant engineering companies with scale-up expertise is necessary.

CCS also has what it takes to massively accelerate the transition to a climate-neutral hydrogen economy: Because water electrolysis from sustainably generated electricity will not deliver the quantities of green hydrogen needed by industry and the chemical sector for a long time yet, blue hydrogen is a climate-friendly option that is available very quickly: In this process, hydrogen continues to be produced from natural gas, but the carbon dioxide produced in the process is captured and stored.

**Mammoth task of decarbonisation changes chemical plant engineering**

However, it is clear that the mammoth task of decarbonisation is also changing chemical plant construction itself. In recent years, the flood of projects and rising prices have already led to a paradigm shift in contract design. While clients were able to commit their contractors to fixed-price contracts a few years ago, the wind has now shifted in favour of EPC providers: chemical plant builder Worley, for example, reports that the share of fixed-price contracts (lump sum turn key) in turnover has fallen to 1 %. The company now bills 80 % of its contracts on a reimbursable basis.

In the future market of hydrogen, manufacturers of electrolysis plants are planning to massively expand their capacities. These include, for example, Thyssenkrupp Nucera, ITM Power or Siemens Energy AG, which is cooperating with Air Liquide for the scale-up of electrolysis capacity. The chemical plant construction sector will be investing massively in its own technology and corporate development in the coming years. And because investors are increasingly attaching importance to sustainable business models, companies in the chemical plant engineering sector must themselves operate according to ESG criteria. This is why almost every annual report in the industry recently contains a reference to progress in the areas of environmental, social and responsible corporate governance.

The focus on a value contribution to solving the climate problem and sustainable management is also important for plant engineering for another reason: attracting talent through employer branding. After all, one of the biggest challenges currently facing the industry is the lack of qualified specialists.

**Automation of the engineering processes and the construction site**

Because not only personnel but also other resources important for chemical plant construction will remain scarce in the coming years, the industry is focusing on increasing productivity: digitalisation and automation of engineering processes and artificial intelligence are just some of the levers with which the industry is tackling the issue. The Korean chemical plant manufacturer Samsung Engineering, among others, is pursuing a radical approach: already this year, the company wants to change its EPC processing in such a way that the effort in engineering and on the construction site is halved compared to 2018. A key role is played by data-driven engineering, which focuses on an engineering data platform instead of documents. This allows planning processes to be automated to an unprecedented extent. A similar approach is also being pursued by the Danish plant manufacturer Haldor Topsoe, which has set itself the goal of realising more projects at lower costs through data-centric engineering.

Other chemical plant builders are also increasingly using machine learning and artificial intelligence to identify risks in projects, for example, or to read P&ID drawings and make them digitally evaluable. In the future, robots, drones and 3D printers will also be used on the construction site to shorten construction time. A striking example is the HUGRS project of the Saudi petrochemical group Aramco, where Samsung Engineering is creating a building entirely from a 3D printer for the first time.

Conclusion: With its solutions expertise, the global chemical plant engineering industry is an important enabler for the decarbonisation of chemistry and the energy transformation of the economy. The industry is tackling the challenge of scarce human and engineering resources through digitalisation and investment in its own business.

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