



The chemical industry's road to net zero

Costs and opportunities of the EU Green Deal

Foreword

Our European chemical industry was one of the first sectors to come out in support of the European Green Deal and Europe's ambition to become climate neutral by 2050.

Knowing the direction, we now need to turn the "what" into the "how." Better understanding what we need to do in the coming years is the basis to develop the solutions and pathways allowing chemical production in Europe to become climate neutral, digital and circular, and meet the objectives of the chemical strategy for sustainability by 2050.

The assessment of impacts has always been a key prerequisite for sound policy making. In the field of climate and energy, most of those impact assessments are based on macroeconomic modeling.

But the agreement on the EU Climate Law has now emphasized the importance of looking with greater attention at individual sectors and regional and site-specific solutions as there will be no single silver bullet or one size that fits all. There is a clear need to start sector-specific climate dialogues to understand better the necessary investments toward the transition to a climate-neutral economy.

We therefore greatly appreciate the work conducted by Accenture and NexantECA. Such in-depth research can help to build a picture of the investments required and the financing gaps, how essential chemical products can be expanded into carbon-neutral and renewable applications in the future, and the cost competitiveness of European industry on a global scale. These are vital considerations as our sector prepares for the biggest transformation in its history.

We want to see our European chemical industry lead the transition globally by offering European solutions to global challenges. And we are confident we can build a concrete path toward climate neutrality, together!



Marco Mensink
Director General
Cefic

Announced by the European Commission in 2019, the EU Green Deal is a set of policy initiatives targeting a highly ambitious goal—creating a climate-neutral Europe within the next three decades.



Specifically, the Green Deal calls for reducing greenhouse gases (GHG) 55% by 2030 (compared to 1990) and ultimately reaching “net-zero” GHG emissions by 2050—goals that apply to each individual industry and even each plant.¹ While the goals are straightforward enough, they will require sweeping and complex change across industries.

The Green Deal will have an especially powerful impact on the chemical industry. Indeed, it will require the reinvention of an industry that has evolved over centuries, and now encompasses more than 400 plants² and more than 3 million employees³ producing 100,000-plus products.⁴

For the chemical industry, meeting the 2050 net-zero goal presents an especially significant challenge. An analysis by Accenture and NexantECA shows that it will require an estimated €1 trillion of investment, disrupt operations and bring changes in plant networks, employment and communities. And it will require new technologies and processes—some of them not yet developed.

But the chemical industry is in a unique position to benefit from the European Union’s (EU) journey to net-zero emissions. As the “industry of industries,” it will be able to provide new offerings that help its customers—the brand owners and manufacturers in other industries in Europe and around the world—achieve their net-zero commitments and meet growing end-consumer preferences for environmentally friendly products. As customers look to the chemical industry for increasingly net-zero focused innovations, demand will grow.

In short, reaching net-zero emissions by 2050 will present some real challenges. But the transformation it requires is likely to be worth it because it will create growth opportunities and competitive differentiation for chemical companies. It will also enable them to play a key role in addressing GHG emissions and climate change in Europe—and globally.

The EU Green Deal will have an especially powerful impact on the chemical industry. Indeed, it will require the reinvention of an industry that has evolved over centuries.

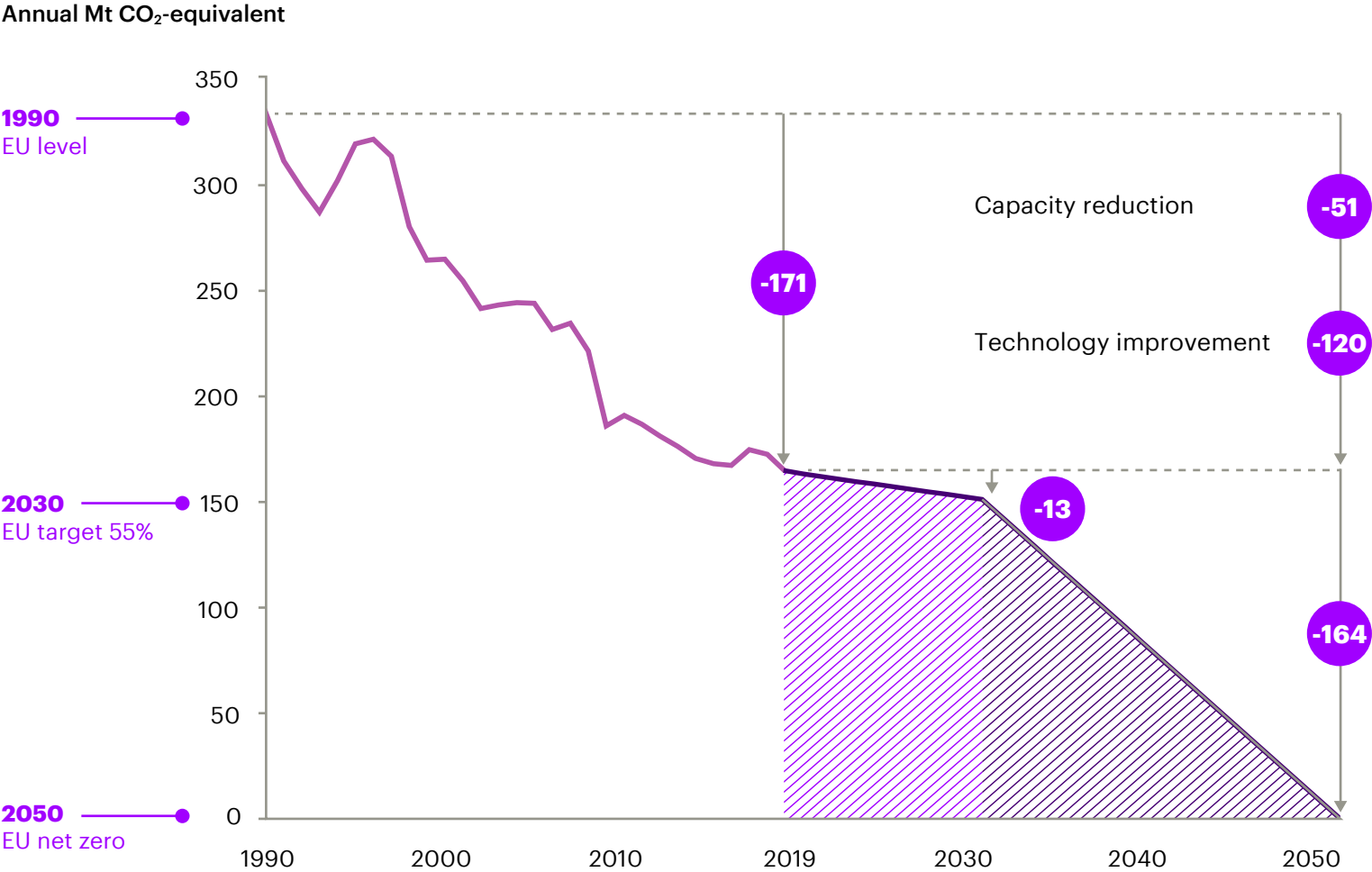
The GHG reductions gap

The industry's GHG emissions come primarily from two sources. One is the significant amount of energy needed to break and reform chemical bonds; about 60% of the industry's emissions are from burning fuel to produce the steam, heat and pressure used in that process. The other source is the carbon dioxide (CO₂), nitrogen oxides (NO_x) and other GHGs generated in the chemical reactions themselves, which account for about 40% of industry GHG emissions.⁵

In the last three decades, the European chemical industry has made significant strides in reducing its annual GHG emissions, cutting them by 171 million tons (Figure 1). This was achieved in part by improvements to technology and processes, and the resulting shutdown of the highest cost and most polluting assets. But reductions were also due to the industry's changing production footprint that saw capacity reductions and plant shutdowns that resulted in reduced emissions. For the same period, ammonia production in Europe decreased 12%, while global capacity increased by 159%.⁶ Overall, the EU share of total global chemical production decreased from 31.6% in 1993 to 14.4% in 2020.⁷

In essence, those reductions in GHG emissions came from taking advantage of "low-hanging fruit" opportunities. Meeting the goals of the coming years will be more difficult.

Figure 1: Chemical industry GHG emission reductions in the EU, 1990–2050

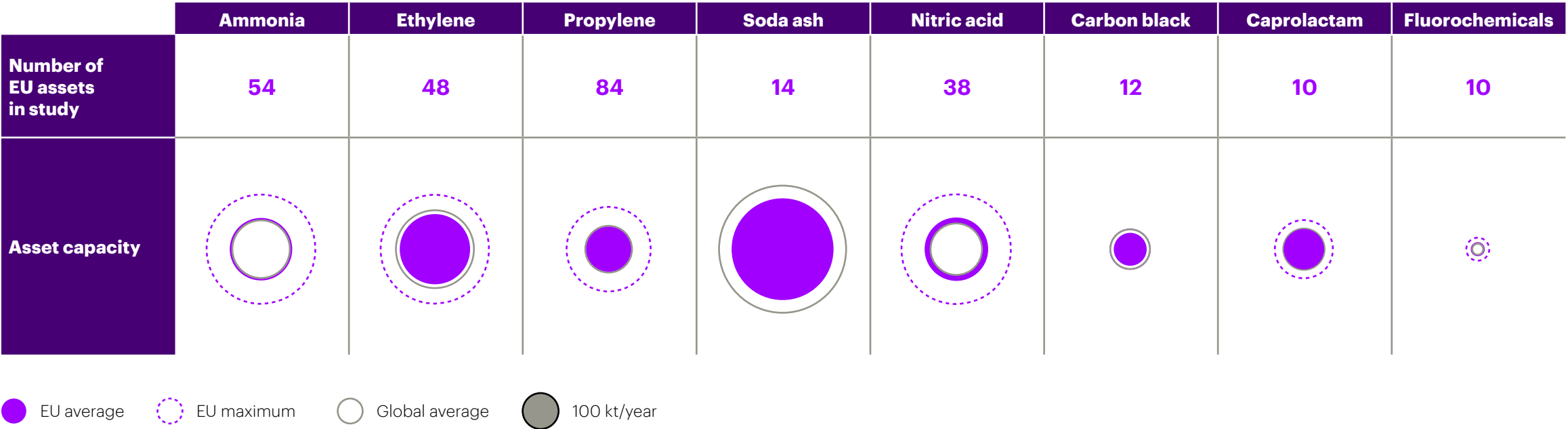


To reach the EU’s 2050 net-zero goals, the chemical industry will need to reduce its GHG emissions by approximately 164 million tons from 2019 levels (Figure 1), according to the European Environment Agency (EEA). However, the EEA reports only include GHG emissions from regulated plants. A closer look shows that 75% of industry emissions are created by the production of eight products—ammonia, ethylene, propylene, nitric acid, carbon black, caprolactam, soda ash and fluorochemicals. These are made in 236 plants across the EU, including some non-regulated plants (Figure 2). When the total number of plants is considered, the overall GHG emissions reductions that will need to be addressed by 2050 increases to 186 million tons per year.

A closer look shows that 75% of industry emissions are created by the production of eight products—ammonia, ethylene, propylene, nitric acid, carbon black, caprolactam, soda ash and fluorochemicals.

Source: EEA, Accenture

Figure 2: Asset capacity for eight target chemical products



Note: Number of assets by plant capacity may include processes not reviewed in this study due to very little utilization in Europe.

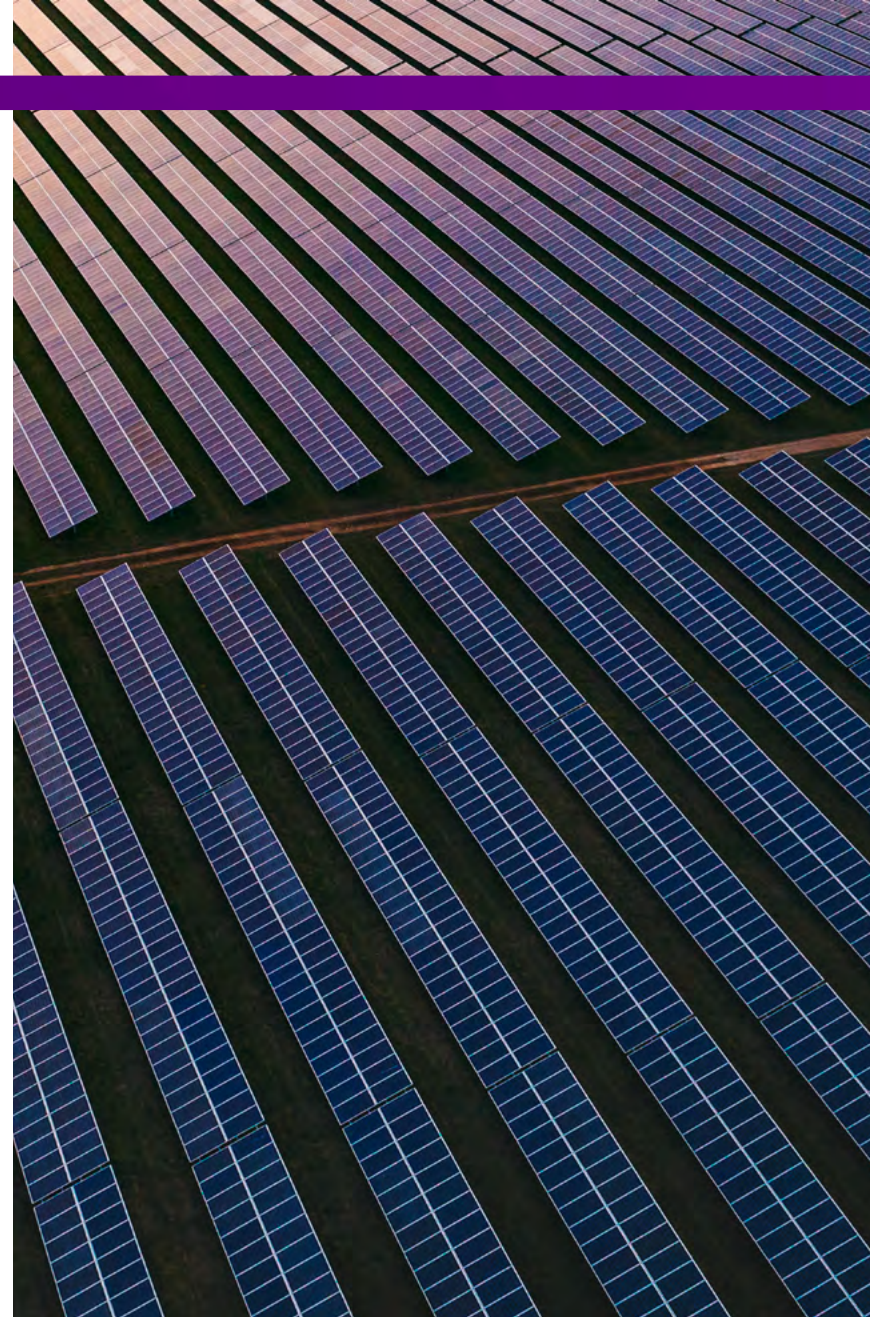
Source: NexantECA, Accenture

Totaling up the costs

To determine the cost of the EU Green Deal's net-zero target, Accenture and NexantECA looked at the production technology process routes used across European chemical plants for those eight chemicals. Utilizing the NexantECA database, the research determined that meeting the 2050 goal for the production of these chemicals will require €400 billion to €600 billion in capital expenditures for core equipment and the design, construction and modification of facilities.

Making the transition will entail another €200 to €300 billion in standstill costs—essentially, lost profits due to halted production as plants are retrofitted, improved or rebuilt. In addition, the research estimated that transitioning production of the other chemicals beyond these eight would add another €250 billion to €350 billion to costs, putting the overall “bill” at more than €1 trillion.

The EU chemical industry invested €21.5 billion in capital projects in 2019.⁸ Typically, about 25% of this total is used for regulatory compliance, as well as maintaining a safe and reliable operation to generally “keep assets running.” Thus, about 75% is available for large new projects, such as those needed for GHG emissions reductions. Shifting those capital-project funds to transition existing asset capacity to net zero will enable chemical companies to address the challenges faced in meeting the Green Deal's net-zero target. This will also reduce the amount of investment available for additional capacity required to meet global demand growth.

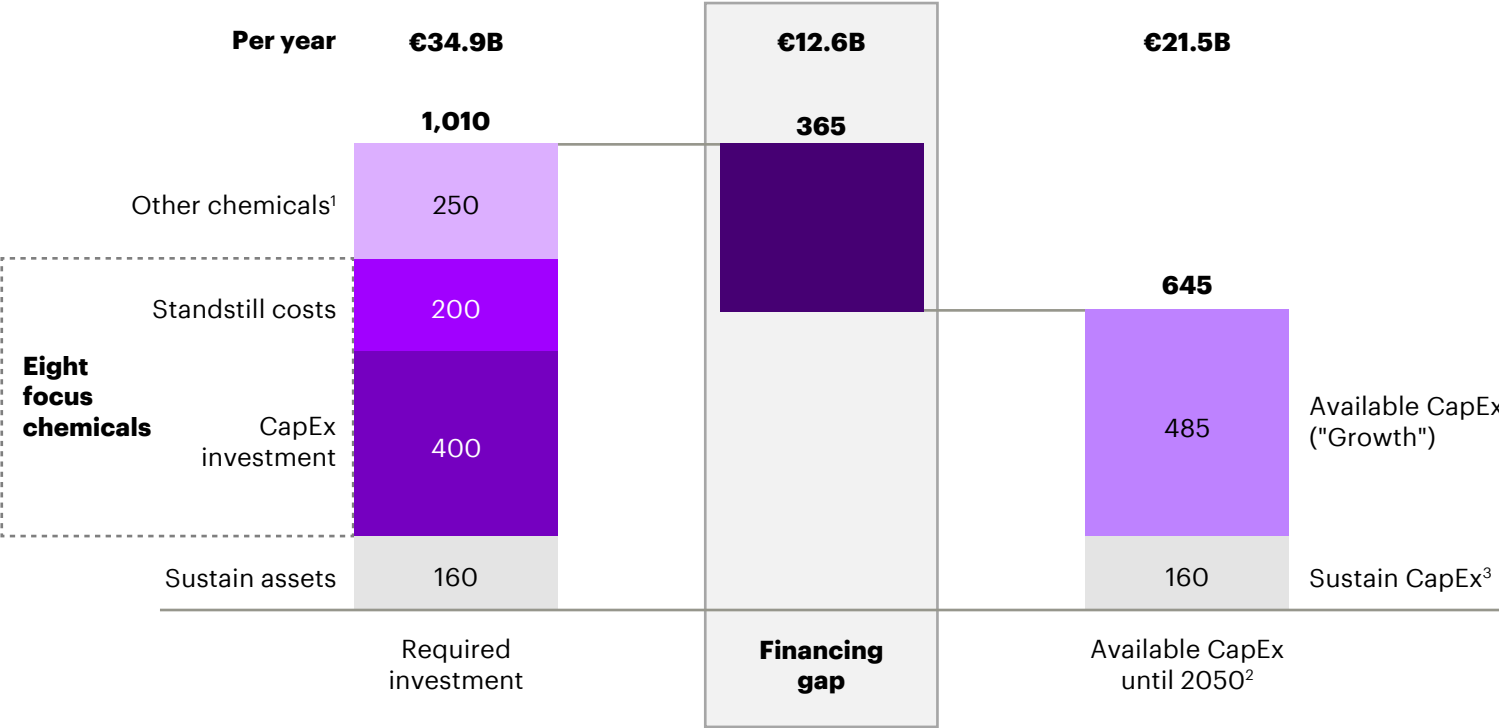


These figures show that the industry faces a gap of about €365 billion over the next three decades to fund net-zero initiatives, requiring an increase in capital investments of more than €12 billion a year (Figure 3).

What’s more, the GHG abatement investments will require incentives and support to generate similar returns to chemicals producers as their conventional investments.

Beneath these broad figures is the reality that reducing GHG emissions will happen at the individual plant level, and plants will vary in their needs and paths to net-zero emissions. To understand how these costs would be incurred, it is useful to take a closer look at two of the most energy intensive and largest greenhouse producing activities in the chemical industry—*ammonia production* and the *steam cracking process used to produce ethylene*.

Figure 3: The industry’s EU Green Deal funding gap, 2021–2050 (€ billion)



Notes:
1. Extrapolated based on determined costs for eight chemicals covered in detail.
2. Extrapolated based on 2019 CapEx spend within EU27 countries by chemical companies.
3. Assuming approximately 25% of CapEx spend relates to stay-in-business CapEx.

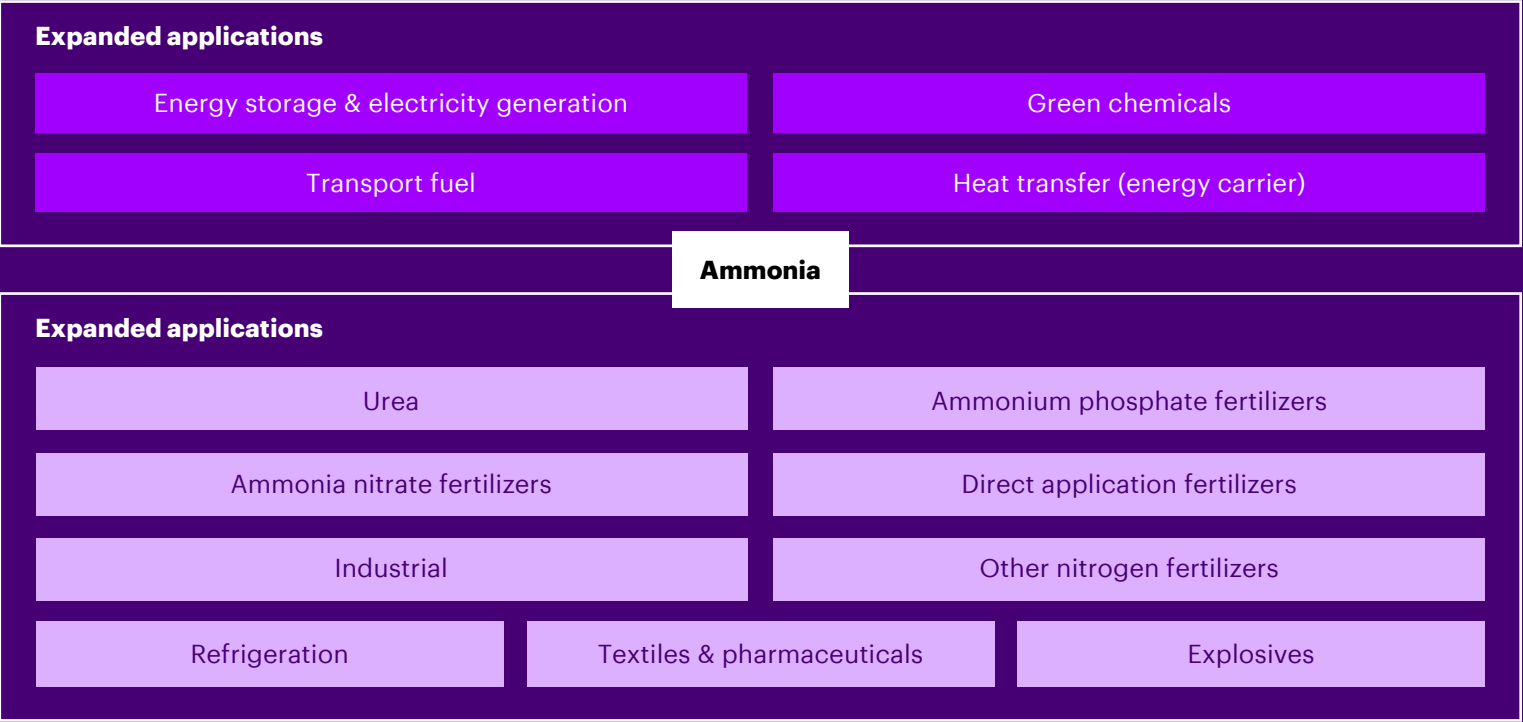
Source: Cefic, NexantECA, Accenture

Ammonia production

Ammonia is an essential chemical industry product—it is a key ingredient for the fertilizer industry that is vital for global food security and a basic building block for a range of chemicals, from pharmaceuticals to refrigerants. In addition, ammonia’s versatility can be extended to the renewable transportation sector, and it can be used as a medium for energy storage, both of which are key factors in meeting global sustainable development and climate neutrality goals (Figure 4).

In the EU, there are 40 ammonia plants, which have an average age of more than 30 years and an average capacity that is approximately one-third that of a new world-scale unit. Ammonia is produced by synthesis of hydrogen and nitrogen, and its production is one of the biggest GHG emitters in the EU chemical industry. Typically, the hydrogen is produced via a process called *steam reforming*, in which high pressure steam reacts with natural gas or fuel oil. This process is very energy intensive, requiring up to 25 bar of pressure and temperatures of up to 1,000 °C. In addition, reformers also emit carbon monoxide (CO), CO₂ and NO_x from reactions and fuel combustion.

Figure 4: Current and future areas of use for ammonia



Source: NexantECA, Accenture

Fortunately, many of the technologies required to significantly reduce GHG emissions in ammonia production are already available and have been successfully demonstrated for commercial use. These include carbon-free hydrogen production via electrolysis of water rather than steam reforming of natural gas or fuel oils, and the generation of heat and pressure based on renewable energy, rather than fossil fuels.

However, modifying existing ammonia plants means modifying their core units, which would require capital expenditures of up to €90 billion (based on 2020 prices). This gives “net-zero GHG emission ammonia” a capital intensity that is about 4 times larger than that of the current conventional ammonia production route. The modification of a plant would take between 12 and 18 months, resulting in standstill costs of approximately €10 billion industry wide. In addition, tomorrow’s technology will be more expensive to run, which means that the shift to net-zero emission ammonia would increase operating costs significantly.

The Accenture and NexantECA analysis considered the different production process routes at the plant level across Europe to understand the abatement options available for GHG reductions. Current fossil fuel-based ammonia requires approximately 0.1 MWh of electricity and 9.2 million BTU of fuel gas per ton of ammonia to produce the heat and pressure required to drive the reaction in steam reformers. One potential alternative is to replace the heat from burning fuel gas with electricity generated from renewable resources.

Electric steam reforming using renewable energy would require 2.7 MWh of electricity per ton of ammonia. This would translate to an additional electricity requirement of approximately 55 TWh across Europe each year. This route only achieves net zero if the CO₂ and CO emitted by the reformers are abated or consumed—for example, in an integrated urea plant downstream of the ammonia synthesis unit.

To produce net-zero ammonia (“green ammonia”) without carbon abatement or downstream plant integration would require a complete replacement of the reformer with an electrolyzer. When renewable energy-based hydrogen is factored in, the overall renewable energy requirement increases to about 200 TWh,⁹ which is equal to 18% of today’s renewable electricity generation in the EU and equal to 7.2% of the EU’s total electricity consumption.¹⁰

Many of the technologies required to reduce GHG emissions in ammonia production have been successfully demonstrated for commercial use. However, modifying the core units of existing plants would require capital expenditures of up to €90 billion.

The steam cracking process

Steam cracking is used to convert naphtha or natural gas into chemical industry building blocks such as ethylene, propylene and aromatics, which are then used as inputs to the synthesis of a broad range of chemicals. The 44 steam crackers in the EU have an average age of 40 years, and 90% of them use naphtha as feedstock.

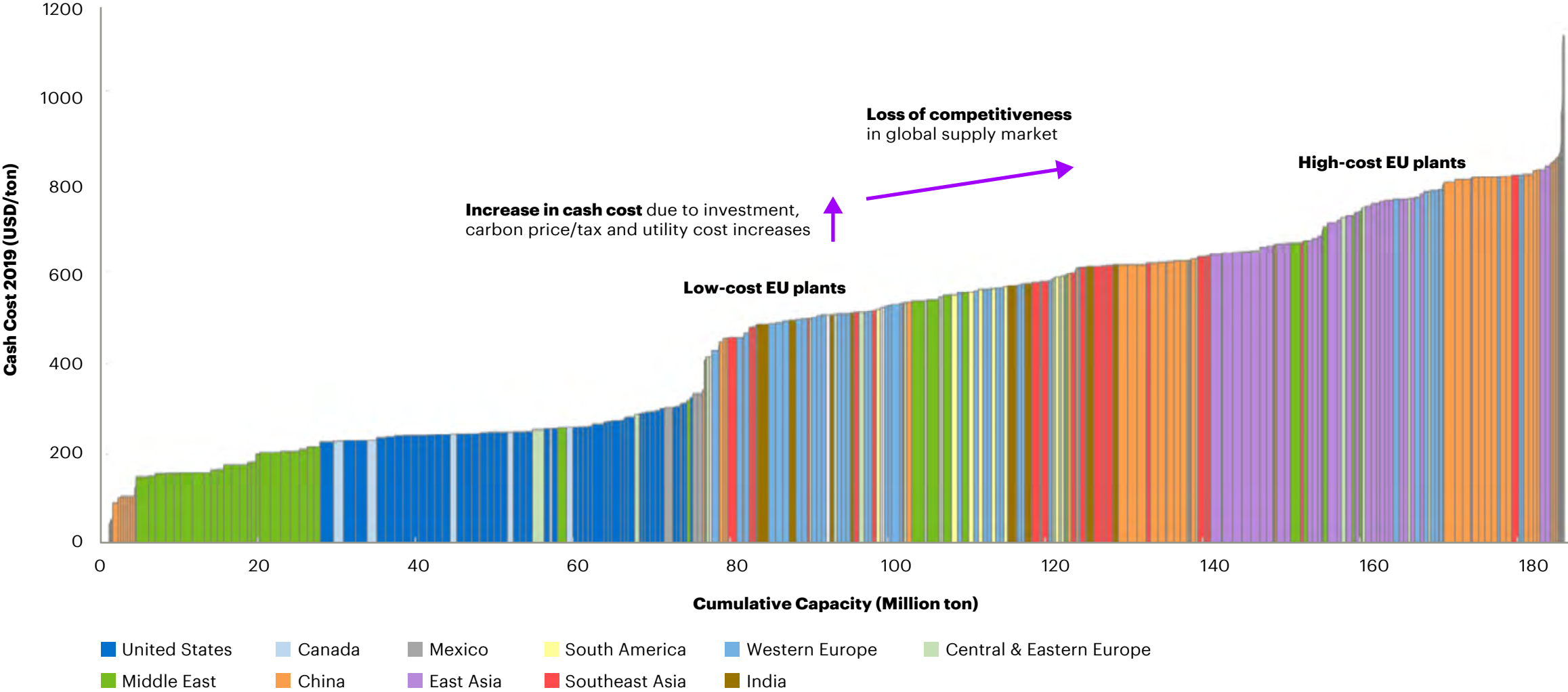
The furnaces in which the actual cracking of naphtha occurs account for a large share of chemical industry GHG emissions, and the process also generates GHGs as part of the stoichiometry of the chemical reaction itself. Modifying the furnaces, the steam cracker's core component, is a massive undertaking that involves replacing fossil fuel-based furnaces with electric furnaces, which could take 12 to 18 months for one cracker alone. Doing this across the EU would require an estimated €200 billion and generate standstill costs of €100 billion in foregone profit.

Because steam cracking requires temperatures of above 850 °C, the energy demand of these electric steam cracker furnaces would amount to an additional 200 TWh, which as previously noted is equal to 18% of today's renewable electricity generation in the EU and equal to 7.2% of the EU's total electricity consumption.¹¹

Today, most EU steam crackers already operate at higher costs compared to those in the Arabian Gulf region and the United States, due to the EU plants' smaller scale, greater age and more expensive feedstocks (Figure 5). Retrofitting the EU steam crackers to reduce GHG emissions will increase this disadvantage, typically in the range of €400 to €500 per ton of ethylene, turning the EU's steam crackers into the least cost-competitive facilities, globally. This will affect not only direct steam cracker products such as ethylene, propylene or aromatics, but also all the chemical products that build on steam cracker-derived raw materials.



Figure 5: Global cost competitiveness of steam crackers, by region



Source: NexantECA

Addressing the plant network



The modern EU chemical industry evolved over more than a century, with plants being built close to customers, near rivers and in landlocked areas. Assets tend to be older and smaller, compared to plants in other regions, and material flows are often integrated, enabled by the physical proximity of plants. Achieving net-zero goals with this infrastructure will require a series of product, process and asset-specific abatement interventions. While being highly complex, the historically grown industrial clusters with a tight interlock between the involved parties also provide opportunities to jointly address the full breadth of emissions, including Scope 3 (indirect emissions in a company's value chain).

Many older plants in Europe are fully depreciated, and often operate with cost structures that are close to their cash costs. They also tend to lag behind newer, non-EU plants in scale and automation level. When it comes to GHG reductions, these assets raise a number of questions: Does it make sense to invest in reducing emissions at a very mature asset? Is it more attractive to close a plant and replace it with a new one? When building a new plant, should it be in Europe or elsewhere—especially if it produces products that are largely exported?

To define a pathway to GHG reduction, companies need to assess each plant's future competitiveness through several lenses. Will investment lead to differentiated offerings, such as net-zero or low GHG emission products? Will consumers be willing to pay the additional cost of net-zero goods? Will future production costs and the resulting margins be in line with global competition and the required return on investment? And to what extent does the plant need to be integrated with other plants? These questions can help determine whether a plant should be closed, moved or modified.

Beyond the core costs

There are challenges beyond the financial factors. Many of the chemical processes and technologies needed to reach net zero are not mature enough to be implemented in production. Thus, the industry needs to demonstrate the effectiveness of new technologies, such as the electrification of steam cracking and carbon capture and utilization.

While 2050 is many years away, that is actually a fairly short timeframe for the industry's traditional investment cycles. Designing new processes, procuring equipment, and building and commissioning a new plant can easily take five to eight years—if the technology involved is mature. If it isn't, piloting and scaling new technologies

can double that timeframe—or more, if those efforts run into setbacks or failures. Increased digitalization of engineering and construction, more streamlined permitting and closer collaboration with partners to scale up technologies could help chemical companies move forward more quickly.

Achieving net zero will significantly increase the demand for renewable energy. Accenture and NexantECA project that an additional 3.2 PWh of renewable energy will be required, about five times the renewable energy generated in the EU today. And developing this capacity will cost approximately €200 billion. This will require efforts from utilities and governments, and these efforts will need to be coordinated with chemical companies' efforts, because the two go hand-in-hand. Electrification of chemical plants cannot be justified without the availability of renewable energy, and the building of new renewable energy generation cannot be justified without the demand created by modified or new plants.



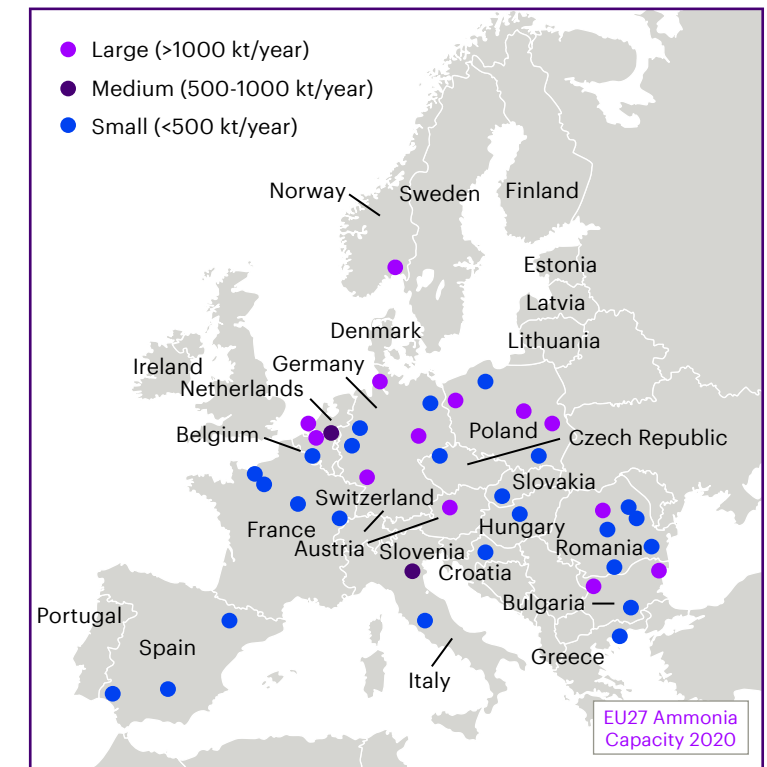
This increased demand for renewable energy will require changes in current plant locations and plant networks. Today, most ammonia plants are landlocked (Figure 6), but offshore wind farms are one of the best sources of renewable energy. To ensure that ammonia plants have access to the affordable renewable energy they need, chemical companies will need to collaborate with electricity providers, transmission and grid operators, government and permitting authorities, and funding sources.

Changes to plants and plant networks will require large increases in capacity at equipment manufacturers and in the engineering, procurement and construction (EPC) industry. A 50% increase in capital investments would be expected to drive the need for a similar percentage increase in that capacity.

Finally, governments and businesses will need to address the social impact of the industry’s pursuit of net-zero goals. Plants will incur significant downtime for improvements. Other plants will undoubtedly close. And new plants will be built in new locations to take advantage of nearby renewable energy sources, biomass materials or GHG capture facilities. These shifts will affect employment and communities, and may require programs designed to limit their impact on society.

It’s important to note that the Green Deal does address some of these factors. For example, it calls for EU support for more renewable energy generation; for regulatory changes to support low-GHG products and solutions; and for programs to protect against “GHG leakage” by stopping the importing of non-compliant products. It also calls for sustainable financing to help companies and industries fund their net-zero initiatives—support that will be especially critical for the chemical industry as it looks for ways to pay for its extensive transition.

Figure 6: Distribution of ammonia production in the EU



Source: NexantECA



From daunting challenge to greater growth

Without question, reaching net zero by 2050 is a challenge for the chemical industry. But there is also a tremendous opportunity as Europe moves toward reduced emissions.

Chemical industry products are already essential for many industries—and they will play an even bigger role in helping to reduce GHG emissions in the value chains of those industries. Chemical products are vital to everything from insulation that reduces heating and cooling requirements to electric vehicle batteries, windmills and solar panels.

Thus, the Green Deal will bring increased demand for the industry's net-zero products. This trend can already be seen in the sustainability commitments made by companies in many customer industries. In addition, Accenture research has found that globally, 81% of consumers expect to buy more sustainable products in the near future, and half would pay a price premium for such products.¹²

It is important to note that this increase in demand will be global. The shift may be faster in some regions than in others, but it will continue. And many of the net-zero commitments being put in place are coming from global companies and will apply to their global operations. By successfully responding to the Green Deal, European chemical companies will be early movers in the race to deliver lower carbon, sustainable and circular economy-related solutions, which could translate to a competitive advantage in global markets.

Rebuilding and transforming the chemical industry will be a massive and complex effort. Each company will need to develop a detailed roadmap that defines and integrates its technology plans, business portfolio strategy, targeted cost-efficiency gains and growth programs. In addition to guiding projects and initiatives, this will help reduce investors' uncertainty about free cashflow projections, which will be key to future share prices.

Those company roadmaps will be critical, but they will not be enough. Achieving net zero will entail a range of interlocking and interdependent activities involving customers, suppliers and partners—including some from other industries. Thus, the chemical industry will need sectoral roadmaps that can help coordinate, sequence and synchronize activities across these groups. This will enable these parties to reserve capacities, which are likely to be constrained as the industry is transformed. It will also be key to bringing together public-private partnerships, renewable energy initiatives, customer commitments to sustainable products, innovation efforts and technology plans. To execute these roadmaps, chemical companies will need to integrate their investment plans with those of suppliers and partners, and build the in-house capabilities that will allow them to manage more of those external parties.

Reaching net-zero emissions by 2050 will not be easy, and it will require huge investments, innovation and broad collaboration. But for the chemical industry, this challenge also holds tremendous promise in terms of new net-zero offerings, growth and competitiveness—and perhaps most important, the opportunity to play a key role in addressing the global challenge of climate change, and achieving the broad social and economic benefits that will bring.

“A carbon-neutral EU chemical industry will still produce the plastics and chemicals needed by manufacturers and downstream industries. However, it will use different sources of energy to drive these chemical processes, and it will be keenly focused on further development of innovative products to meet the consumer’s renewable requirements.”

Richard Sleep
NexantECA President

About the research

To understand the cost of the EU Green Deal for the European chemical industry, Accenture and NexantECA conducted a plant-by-plant assessment of 236 chemical plants in Europe. This assessment, done in 2021, looked at the age and scale of plants, process variants and inputs, potential GHG abatement measures, and new production costs that would be incurred after implementation of those measures.

These factors were used to calculate the cost of achieving or moving close to achieving net-zero GHG emissions. Key assumptions in developing the required capital cost were:

- A stable product mix and production level—that is, all chemicals produced in the EU today will be produced through net-zero GHG emission processes. Thus, costs were calculated based on the current EU chemical product portfolio and current production volumes.
- Costs were estimated using current prices—for example, assuming equipment prices remain at today's levels.
- Investment costs cover the core units of chemical processes and did not include costs for outside infrastructure or other industries.
- Availability of renewable energy in a timely manner and at a cost of €50/MWh.
- Availability of engineering and construction capacity assumed to match requirements based on asset changes.
- Profit-loss calculations due to standstill during plant modification were based on 2020 average profit margins.



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