Riding the Waves of Transition to a Sustainable Chemical Industry

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Introduction

The chemical industry showed resilience in addressing economic turbulence and supply chain disruptions during post-pandemic 2022. The Ukraine war and energy security crisis in Europe, along with high inflation worldwide and a slower-than-expected recovery in China forced chemicals producers' hands in 2022.

Despite these shockwaves, the industry suffered only marginal losses. Even with higher sales revenue (coming primarily from price increases), destocking and lower-volume sales resulted in a decline of about 7% ($8B) in the top 50 chemical manufacturers' profits.

Besides remaining profitable while facing market uncertainties, the chemical industry must comply with environmental regulations imparted to offset climate change and pressure to address plastics circularity. Climate change and efforts to avoid it through the Paris Climate Accord, along with consumer preference and activism to pursue greener products, has led the industry to pursue new business models to address both challenges.

However, the exact path to net zero and plastics circularity remains unclear. What is certain—and essential to winning this fight—is rethinking how we produce, use and reuse energy and materials. To accelerate sustainability efforts, governments are actively engaging with the industry to set achievable milestones. This engagement comes in the form of generous incentives in the US and more prohibitive measures with caps and tax implications, as observed in the EU, Canada and China.

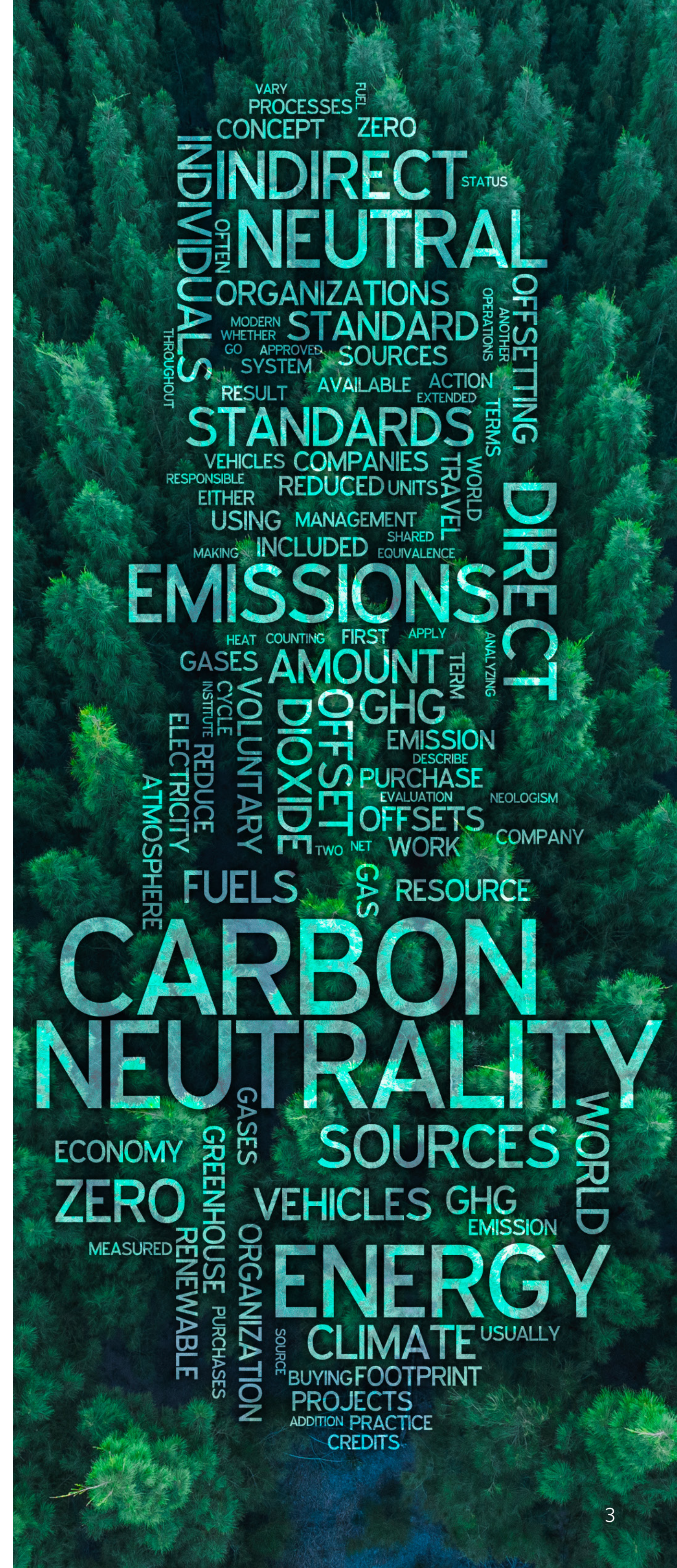
Effect of Net Zero & Carbon Neutrality Policies on the Chemical Industry

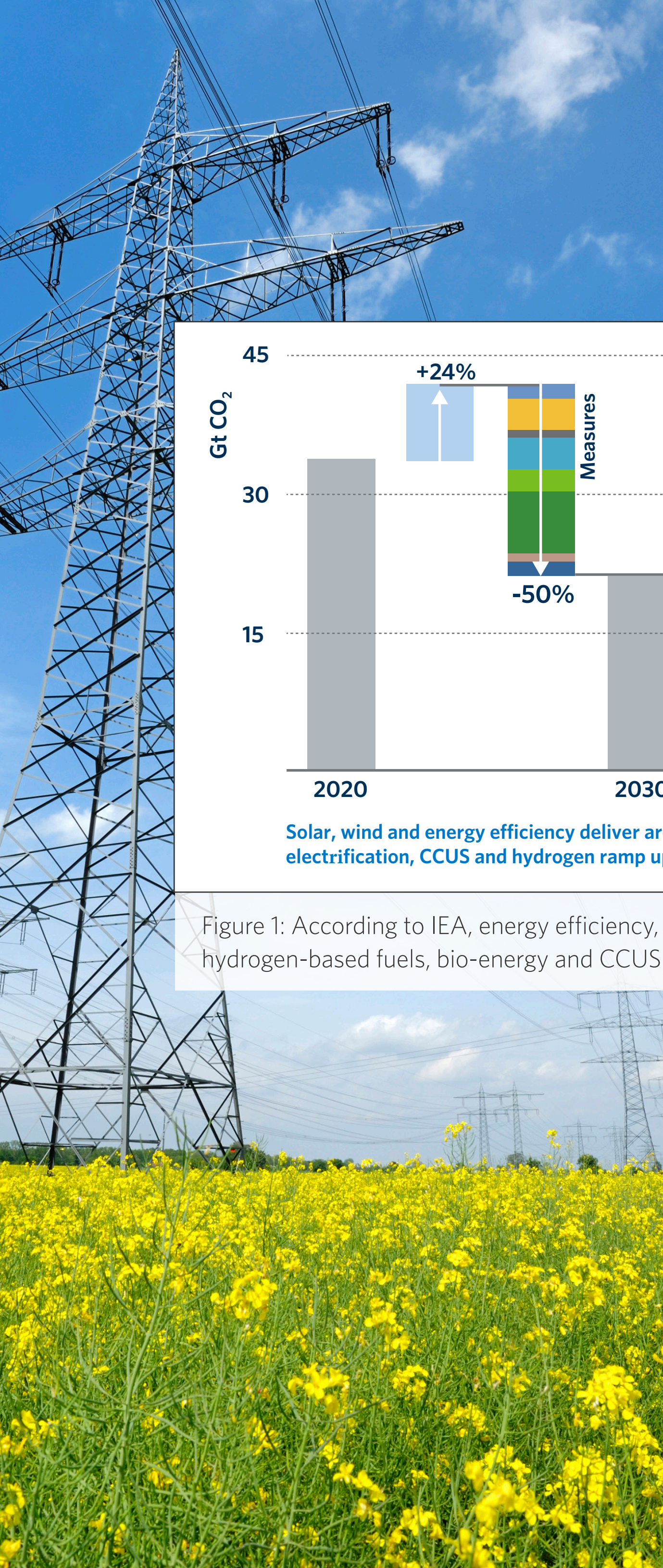
The US has made a strong push for energy and infrastructure legislation under President Biden's administration. While these policies aim to address and minimize climate change, they also set the stage for US leadership in a new net zero economy. The bipartisan Infrastructure Law ($1.2T), The CHIPS and Science Act ($280B), and the Inflation Reduction Act ($740B) passed between November 2021 and August 2022 make up the largest American infrastructure investments, of which chemical and energy companies are primary beneficiaries. Incentives for electric vehicle manufacturing, semiconductor production, de-risking clean investments and to guarantee energy security and control climate change through carbon capture solutions are generously offered through this legislation.

The European Climate Law is the cornerstone of the European Green Deal and was realized in July 2021. The law targets 55% reduction in emissions by 2030 and a neutrality objective for 2050. This translates to 50% reduction in energy consumption by 2040. The main mechanisms foreseen for this transition are the extension of public transportation networks and electric vehicle fleets, electrification in energy-intensive industries and a transition to renewable sources for remaining energy needs. The policy seeks to lessen emissions through carbon tariffs (CBAM) or emissions trading systems (ETS). This law also includes a circular economy action plan, sustainable and smart mobility, and a reevaluation of fossil fuel subsidies.

Similar to the US and Europe, climate change and energy transition policies have been introduced in other parts of the world. Article 6 for voluntary carbon markets between countries (agreed during COP 26 in Glasgow) plans to phase out coal in South Africa and Indonesia, and there are other examples, such as the emissions trading system in China and Canada's greenhouse gas offset credit system.

Even though governmental policies to control climate change are encouraging for the industry, uncertainties around these policies cast a shadow on their long-term effectiveness. In the US, the existence and renewal of these policies largely depend on the Democratic control of the congress and the government. It is possible that the next Republican administration would reverse these regulations and instead instill more fossil-fuel-based





incentives. Any change in the US's approach to climate change affects policies in other parts of the world as well. These policy uncertainties make clean energy investments riskier and are barriers to meeting net zero targets.

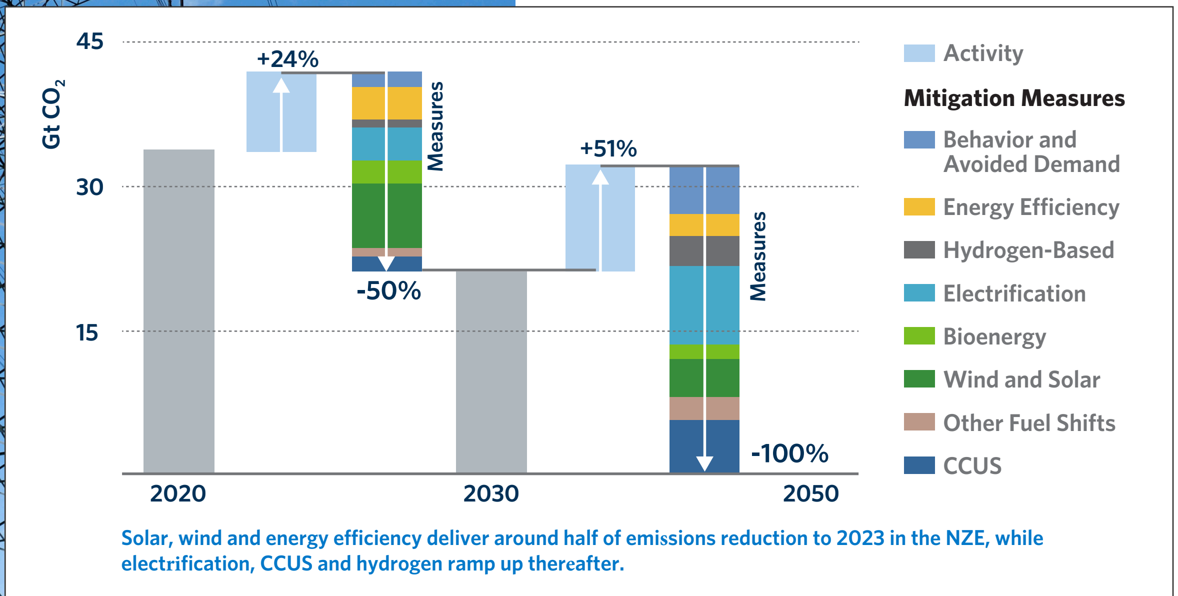


Figure 1: According to IEA, energy efficiency, behavioral changes, electrification, renewables, hydrogen and hydrogen-based fuels, bio-energy and CCUS are the key pillars of achieving decarbonization by 2050.

Shifting Business Models for Energy Transition, Carbon Neutrality and Plastics Circularity

Achieving sustainability targets is no simple task. It demands a collaborative and innovative approach to happen. The approach must address the entire value chain of products' carbon footprint, including raw materials sourcing, supply chain management, manufacturing and repurposing and recycling waste.

The International Energy Agency (IEA) in a 2021 study provided a net zero estimate (NZE) for the cumulative carbon dioxide released globally. According to this study, to move from a cumulative carbon dioxide release of about 43GT to net zero by 2050, a broad range of policy and technological changes are needed. According to IEA, the primary decarbonization pillars are energy efficiency, behavioral changes, electrification, renewables, hydrogen and hydrogen-based fuels, bioenergy and CCUS. IEA categorizes plastics circularity as part of behavioral changes and increased material gains.

Figure 1 summarizes potential effects of each major category. It is evident that for any meaningful change toward decarbonization, all means should be deployed, requiring new integrated business models that have not existed previously. These new business models will involve multilateral collaborations between small, innovative technology developers with established, well-capitalized producers.

To achieve net zero and carbon neutrality targets for chemical producers, a number of these initiatives are relevant:

- **Resource efficiency**, whether energy, materials or water, helps to cut back on the plant intake, which automatically translates into generating less waste. An energy-efficient operation results in lower overall emissions. Creating chemicals by incorporating biomass and green feedstocks lowers the carbon footprint of the operation.
- **Carbon capture and storage** technologies for major emitting sources, and CO_2 utilization as feedstock for new chemicals such as green cement can lower the footprint of chemical producers.
- **Reworking plastic waste** and turning it into valuable products eliminates/lowers the need for virgin feedstock and will lower the carbon footprint of the final product.
- **Electrification** of energy-intensive heat sources and management of micro-grids to incorporate renewable energy and storage solutions help to decarbonize the entire operation.
- Finally, **swapping fossil-based energy sources with hydrogen/clean energy** for the remaining energy needs of the operation can lead the way toward net zero goals.

The Role of Innovation and Digitalization

Looking at the broader net zero pillars, innovative new technologies such as green hydrogen, carbon capture and plastics upcycling technologies will need to be scaled up to become mainstream. Digital solutions will be a game-changer to develop new technologies, as well as to scale up and speed up deployments. Digital solutions can reduce the time to market for new technology by allowing for the screening of numerous operational conditions and materials in a fraction of time. Digital twins, real-time data collection and contextualization, smart process control, economic analysis and bridging gaps leveraging ML and AI bring tremendous value to a project that is otherwise almost unattainable.

Here are some of the challenges associated with net zero goals and how digitalization is helping chemical producers:

Energy Efficiency and Managing Scope 1 Emissions

Improving energy efficiency, along with accurate monitoring of emissions, is the first logical step toward carbon neutrality for chemical manufacturing. Ensuring optimal operational conditions through real-time monitoring enables plant managers to run operations with minimized energy cost. Creating a dashboard view of the entire operation's carbon footprint provides valuable insights to high-level decision-makers for reporting and mitigating purposes.

Industry example: Implementing AspenTech planning and scheduling tools, **Sabic** has cut back CO_2 emissions across 11 crackers by 20% without compromising ethylene production rates.

Biofeedstocks

Historically, biomass has been used to produce biofuels relying on first-generation feedstocks (that is, edible crops). Investments in developing new processes have been inconsistent depending on the price cycle of fossil fuels. Turning biofeedstocks to high-value chemicals would make sustainable chemicals while lowering the carbon footprint of the final product. Presently, these processes are mostly laboratory scale, and commercialization efforts are insufficient. Digital solutions enable accurate and rapid scale-ups to bring these chemicals to market at speeds not possible before.

Industry example: Implementing AspenTech Performance Engineering, **Biosprint** has designed and scaled a process to produce furan monomers from hemicellulose.

CCUS and Hydrogen

With the passage of Section 45Q, the IRA ACT of 2022 in the United States and similar tax breaks and carbon taxes in the EU, Canada, China and elsewhere, there is an abundance of financial incentives for CCS/CCUS projects. However, the technology is at a low level of maturity for such an undertaking. Much research and scale-up work is needed to increase CO_2 capture efficiency from direct emissions or make direct air capture (DAC) feasible.

Subsequently, proper use cases (mainly in enhanced oil recovery or injected in reservoirs) need a deep understanding of geological formations and injection prerequisites. Similarly, to generate green hydrogen, much research on membranes and electrodes is needed. Here, digital solutions enable project evaluations, optimized designs and successful project executions.

Industry example: The world's largest plant for testing and improving CO_2 capture technologies, **Technology Centre Mongstad (TCM)**, leveraged AspenTech's digital twin technology to build a realistic process model to maximize CO_2 absorption rates.

Waste Management and Plastics Circularity

For chemical manufacturers, generated waste streams are inevitable. Besides the negative environmental impacts, these waste streams have a carbon footprint and recur costs to reprocess or dispose of. Preventing waste formation (for example, flaring or liquid waste) in the first place via advanced process control or predictive maintenance is a proactive approach that can positively impact the bottom line and footprint of chemical manufacturing.

Plastics circularity, on the other hand, is a relatively new topic requiring many R&D hours for process development. From proper raw material sourcing, sorting, processing and upgrading, the plastics loop is barely closed. Huge gaps in proper collection and sorting methods hinder raw materials supply. Advanced recycling technologies are still immature, requiring validation and capital investments. Here digital solutions can play a prominent role by vetting technologies and accelerating scale-up work.

Industry example: AspenTech's Performance Engineering was used by a **major Indian polymer producer** to chemically recycle PET.

Supply Chains

Even though supply chains have started to detangle post-pandemic and some of the freight issues are resolved, chemical supply chains are far from ideal. Transparency, leanness and structured supply chains are the keys to success for chemical companies. With the added complexities of products produced comes the complexities of supply. Net zero targets mean the role of supply chains is essential to creating an operation with the smallest carbon footprint.

When it comes to achieving a circular economy, chemical supply chains are at the heart of closing the loop by bringing back materials to create a new life for them. Intelligent supply chains fed by operations and equipment data can help to minimize waste and production time and manage inventories consistent with lean operations.

Industry examples:

- A US-based **specialty chemicals company** used AspenTech's supply chain planner tools to predict enterprise wide, long-term GHG emissions and evaluated different Capex/Opex scenarios to achieve short- and long-term emission reduction goals.
- Leveraging AspenTech's supply chain management solutions, **F.P. Corporation** recycled 440,000 tons of food packaging waste into new packaging material.

Microgrids

For bulk chemical manufacturing facilities, proactive management of microgrids creates operational resiliency. Forecasting and managing peak demand enables a balanced generation. By controlling distributed energy sources, renewable energy can be introduced to the plant; energy stored or excess generation through turbines or HRSGs can be resold to the grid.

Industry example: Leveraging AspenTech's microgrid management tools, a **large industrial customer** is using a sitewide microgrid solution to ensure 100% availability of reliable power, incorporating renewable and captively generated energy.

Summary

The chemical industry is striving toward keeping carbon out of the atmosphere. Along with this momentous task, the industry is making hydrocarbons available in the form of products for a growing population. Executives are navigating through flurries of new laws and regulations, incentives and prohibitive measures, innovative technologies and new models of business operations. Partnerships between emerging technology makers and well-established producers are creating new business models.

Continuing the path of operational excellence to face economic headwinds and adopting sustainability measures to address pressing environmental challenges represent the future of the industry.

Digital solutions play a prominent role as the industry is standing up to the challenges. Depending on manufacturing priorities, digital solutions can be customized to unify entire monitoring and operational necessities.

AspenTech has helped chemical companies achieve operational excellence for over 40 years. With the latest solutions and technologies, we have partnered with leading chemical manufacturers to evaluate digitalization options throughout the entire production value chain to achieve their profitability and suitability goals.

About Aspen Technology

Aspen Technology, Inc. (NASDAQ: AZPN) is a global software leader helping industries at the forefront of the world's dual challenge meet the increasing demand for resources from a rapidly growing population in a profitable and sustainable manner. AspenTech solutions address complex environments where it is critical to optimize the asset design, operation and maintenance lifecycle. Through our unique combination of deep domain expertise and innovation, customers in capital-intensive industries can run their assets safer, greener, longer and faster to improve their operational excellence.

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