10 Primary chemicals industry net-zero tracker

To reduce emissions, the industry must prioritize CCUS, energy efficiency and plastics recycling now, while advancing electrification, fuel shifts, bio-based feedstocks and hydrogen for lasting impact.

- The increase in demand for primary chemicals over the past five years has driven a rise in emissions, as this energy-intensive industry relies heavily on fossil fuels for both feedstock and process energy, substantially contributing to CO_2 emissions.
- CCUS and chemicals recycling, along with electrification and energy efficiency measures, are expected to reduce around half of the emissions in the primary chemicals sector by 2050.

0.1%	2%	2%
Decrease in absolute CO_2 emissions (2022-2023)	Decrease in emission intensity (2022-2023)	Increase in demand (2022-2023)

*Primary chemicals include ethylene, propylene, benzene, toluene, mixed xylenes, ammonia and methanol

PRIMARY CHEMICALS

Key performance data 2023[450,451,452,453,454]

2.5%	0.94 Gt CO_2e	6%	1.27 Mt CO_2e/Mt
Contribution to global CO_2e emissions	Scope 1 and 2 emissions	Emissions increase (2019-2023)	Emissions intensity
2.2%	2.3 times	2%	$6.5 trillion
Decrease in emission intensity (2019-2023)	Demand increase in NZE scenario by 2050, compared to 2023	Current low-emission production	Additional investment required for net zero by 2050

Performance summary

- The emission intensity has been stable at approximately 1.3 Mt CO_2e /Mt chemicals[455] for the last five years. This is primarily due to the industry prioritizing addressing supply chain disruptions and commodity price volatility.
- The absolute emissions[456] for primary chemicals has seen 6%[457] rise in the 2019-2023 period, driven by an increase in demand for ammonia by 4%, methanol by 19% and high-value chemicals by 9%.[458]
- Low emission production accounted for only 2%[459] of the total emission production worldwide in 2022. Only 8% of current plastic production is through recycling.[460]
- In 2022, the energy mix for primary chemicals was composed of 55% natural gas, 36% coal, 7% electricity, 1% oil and 0.6% biofuels.[461]
- Current infrastructure stands at less than 1% for CCUS, clean power and hydrogen of the required infrastructure capacity by 2050 for net-zero emissions.[462]

Future emissions trajectory

- The industry is forecasted to reduce emissions intensity by 28%[463] by 2030 compared to 2023 levels, according to IEA Net Zero Scenario. Absolute CO_2e emissions are expected to be 0.77 Gt in 2030.[464]
- 90%[465] of publicly traded companies in primary chemicals industry consider climate change in their operational decision-making processes, and 58%[466] of companies have approved Science Based Targets initiative (SBTi) targets.

Readiness key takeaways

Technology	3	– CCUS, chemicals recycling, bioenergy, renewables and hydrogen usage are all in the demonstration stage (TRL 7) with CCUS and chemicals recycling being the most mature (TRL 8).[467] – Electrification is in the prototype stage (TRL 5).[468]
Infrastructure	2	– CO_2 capture capacity is projected to grow to 52 Mt by 2030, a significant increase from 4 Mt in 2022.[469] – Current capacities are insufficient, as less than 1% of CCUS infrastructure and clean power infrastructure required by 2050 is available for the industry.
Demand	2	– Less than 2% of low-emission primary chemicals are currently being produced.[470] – The green premium for primary chemicals is estimated at 55%[471] for manufacturers on average and 1-3%[472] for end user products.
Capital	2	– Over $6.5 trillion[473,474] additional cumulative investments are required by 2050, out of which 60% are expected towards green ammonia, 27% towards green methanol and 9% towards waste management. – Currently, the chemicals sector has an annual CapEx of $86 billion.[475]
Policy	2	– Policies promote the increased use of clean hydrogen to replace fossil fuels in chemical production, mitigate chemical pollution risks, set emissions reduction targets, minimize plastic waste and enhance recycling technologies.

Sector priorities

Company-led solutions

Mid-term (by 2030)

- Implement material efficiency measures.
- Retrofit existing facilities to use clean hydrogen for ammonia and methanol production.

Long-term (by 2050)

- Execute major retrofits to ethylene and polyethylene production plants to increase capacity and reduce emissions.
- Create facilities that convert captured CO_2 into methanol.

Ecosystem-enabled solutions

Mid-term

- Work on waste market access and waste flow orchestration.
- Develop the infrastructure needed to produce and distribute clean hydrogen and other clean fuels.

Long-term

- Invest in dedicated CO_2 capture and storage capacity.
- Digitize the value chain and disclose key environmental system data.
- De-risk large-scale financial investment.

Performance

The primary chemicals sector currently accounts for 2.5%[476] of global direct CO_2e emissions. Fossil fuels account for over 98%[477] of energy and feedstock consumption in the industry, making them a critical driver for emission intensity. The chemical sector is the largest industrial energy consumer and the third largest industry subsector[487] in terms of direct CO_2e emissions. The chemical industry has a multifaceted opportunity to lower their Scope 1 and Scope 2 emissions and downstream end-market Scope 3 emissions. Scope 3 represents the majority, at 64%, while Scopes 1 and 2 only represent 36%.

TABLE 16 **Primary chemicals industry performance**

Performance metric	Change (2019-2023)
Industry output	+37%[478]
Emission intensity (Mt CO_2/Mt chemicals)	-2.2%[479]
Total CO_2e emissions	+5.8%[480]

In the 2019-2023 period, industry output increased by 37%,[481] while total emissions increased by 5.8%.[482] The increase in emissions is primarily due to:

1. **Increased production demand**: Global demand for chemicals (such as plastics, fertilizers and industrial chemicals) grew due to expanding economies, especially in emerging markets. This led to increased production, which in turn raised emissions.

2. **Supply chain and operational disruptions**: Global events, such as the COVID-19 pandemic and geopolitical tensions, led to temporary shifts in supply chains and operations. Higher gas prices, which resulted in less efficient production processes, delayed efficiency improvements and raised emissions.

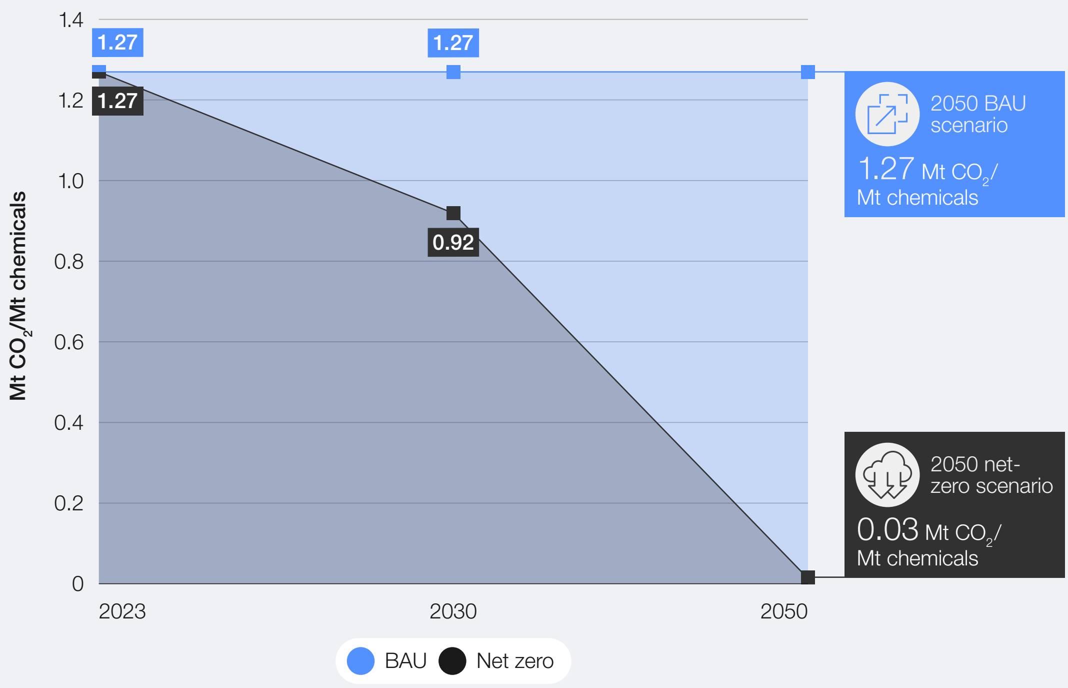
In 2022, the energy mix for primary chemicals consisted of 55% gas, 36% coal (mostly used by China), 7% electricity, 1% oil and 0.6% biofuels in 2022.[483] Key initiatives, including efforts to integrate circular economy principles, improve energy efficiency and explore alternative feedstocks such as bio-based chemicals, which are critical to achieving long-term emissions reductions. Currently, only 8%[484] of total plastics production comes from recycling. The development of advanced chemical recycling technologies, such as depolymerization and pyrolysis, offers a potential solution by enabling the recycling of mixed or contaminated plastics that are not currently recyclable via traditional mechanical methods. Companies like BASF[485] and SABIC[486] are investing in these technologies to create a closed-loop system for plastics. However, the challenge remains that plastics are typically difficult to collect efficiently, and the quality of recycled plastics often falls short of the standards required for certain high-safety applications, such as food packaging or medical use.

Leading companies such as Shell and ExxonMobil,[487] supported by both public and private investment, are developing scalable CCUS systems that aim to capture and repurpose the industry's emissions. In parallel, hydrogen-based chemical production processes are gaining traction as potential long-term solutions for reducing carbon intensity, though their adoption remains in early stages due to high costs and infrastructure limitations.

Readiness

FIGURE 59

Emissions intensity trajectory for the primary chemicals sector



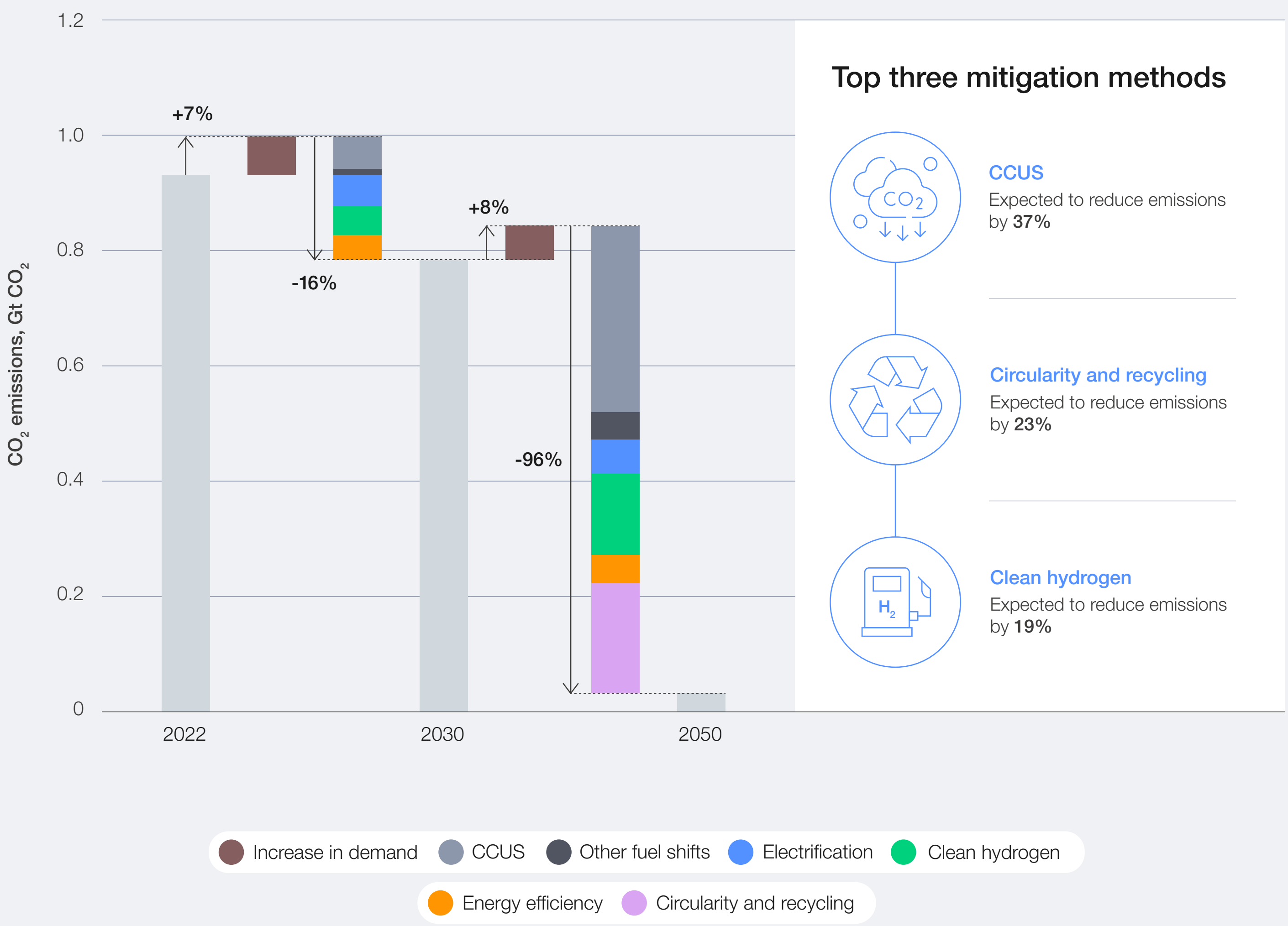
Source: IEA Net Zero Scenario.

Overall primary chemicals demand is expected to increase by 2.3 times[488] by 2050. By this time, green ammonia will represent 60% of demand (a fivefold increase from 2022) and methanol 20% (a fourfold increase from 2022).[489] Circularity can reduce demand by approximately 20%, saving $1 trillion[490] of CapEx needed to abate the system. Production volumes will more than double[491] overall by 2050, driven by new net-zero enabling chemical applications in other industries. Reducing demand is also essential to ensure that CCUS requirements remain manageable within current scaling limitations. The chemicals sector needs to decouple from fossil fuels and switch to renewable carbon feedstocks. As a feedstock, CO_2 is another decarbonization lever for the primary chemicals industry. Capturing CO_2 from industrial processes or the atmosphere and using it as a raw material to produce chemicals, fuels and materials (rather than simply storing it) aligns with the broader goals of carbon circularity, reducing reliance on fossil-based carbon sources. Its abundant availability, potential to close carbon loops and versatility in producing various chemicals make it an attractive alternative to both bio- and waste-based feedstocks.

Scaling circularity, switching production from fossil fuels to renewable feedstock sources, retrofitting legacy infrastructure and abating end-of-life chemicals are key operational pathways for achieving net-zero goals.

Clearer prioritization for deployment involves establishing a sequence of needs, starting with consistent global regulations to enable large-scale transformative investments. Next, political support for necessary infrastructure is essential, followed by customer willingness to pay, which helps secure the business case. Finally, case-by-case funding is needed to support implementation and manage associated risks effectively. Industry can start with the most cost-effective measures, using abatement cost calculations to ensure the transformation is feasible for society and customers. Energy transformation, being less expensive than material transformation in the chemical industry, is suggested to take priority. Additionally, using existing assets with renewable or recycled feedstock can accelerate deployment, as it is both cost-effective and less capital-intensive. While electrolytic hydrogen is costly for chemical use, blue hydrogen is a viable alternative, potentially reducing CO_2 emissions by up to 90%, with minimal additional cost.

FIGURE 60 | **Decarbonization levers and top mitigation methods (NZE Scenario)**



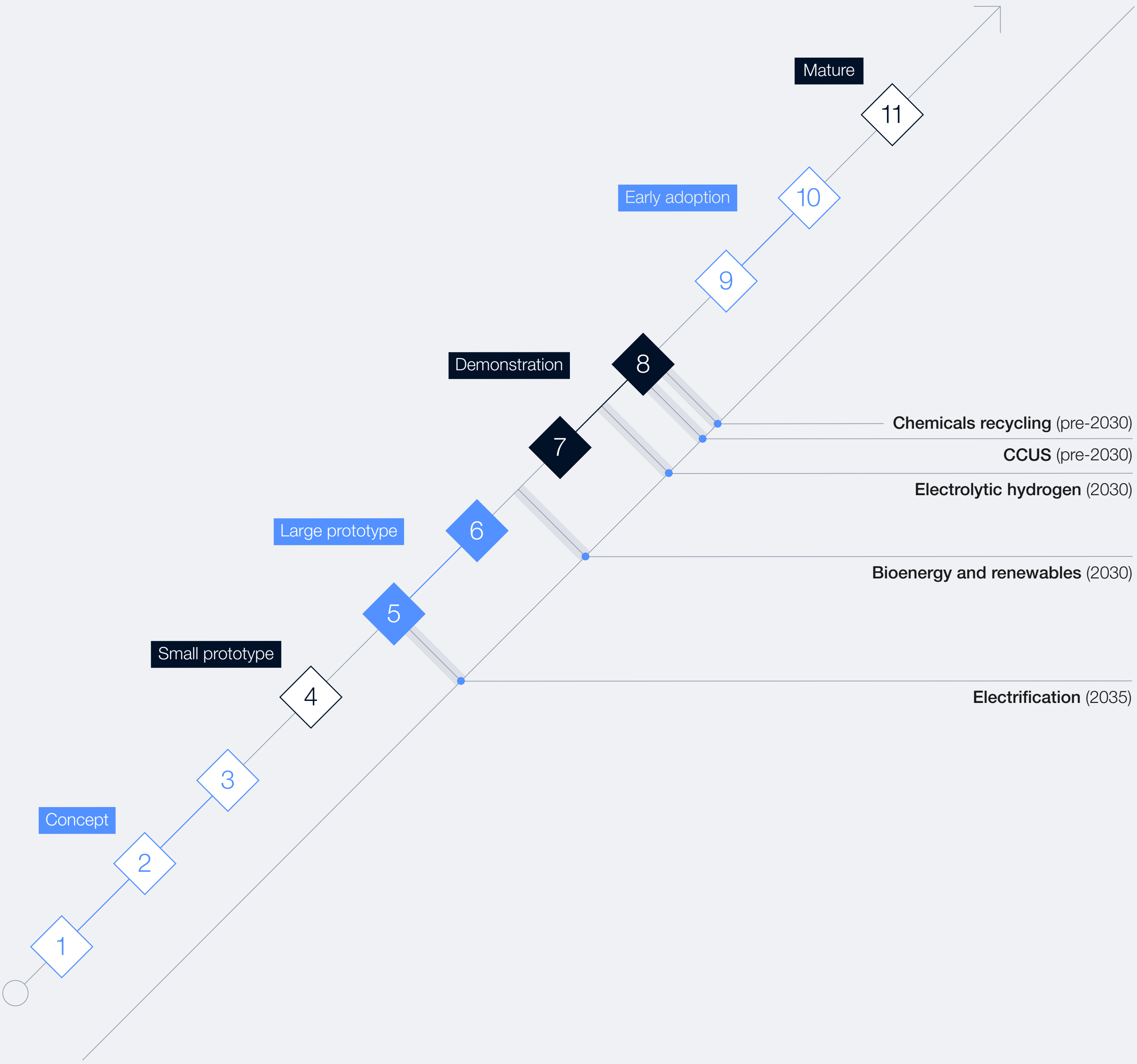
Source: Accenture analysis based on data from IEA.

PRIMARY CHEMICALS

3 Technology

Technologies to implement the decarbonization levers are at different readiness levels. Three leading pathways have emerged: CCUS, electrolytic hydrogen and circularity.

FIGURE 61 **Decarbonization TRLs and year of commercial availability**



Source: Accenture analysis based on data from IEA ETP Clean Energy Technology Guide.

Technology pathway 1: CCUS

In the primary chemicals industry, many capture technologies – particularly post-combustion capture using solvents (e.g. amines) – are nearing TRL 8-9,[492] indicating they are fully developed and have been demonstrated at industrial scale. However, novel capture methods (e.g. membrane-based or direct air capture) are at TRL 5-7,[493] indicating pilot-scale testing and demonstration projects have taken place, but not widespread commercial deployment.

Utilization technologies, where captured CO_2 is converted into value-added chemicals, are more advanced due to their integration with carbon-intensive processes and the potential to use captured CO_2 as a feedstock for products like methanol and urea.

Technology pathway 2: Electrolytic hydrogen

Alkaline electrolysis (ALK) is the most mature electrolysis technology, reaching TRL 8-9,[494] meaning it is commercially available and operating in industrial settings. Alkaline electrolysers have been demonstrated at large scale and are considered a mature technology for producing green hydrogen. Green hydrogen production using ALK and PEM electrolysers is already commercially available for specific applications within the chemicals industry, such as the production of ammonia and methanol, and energy use. However, current installations are often small-scale demonstration projects or pilot plants, as the cost of electrolytic hydrogen is still higher than hydrogen produced from fossil fuels. Clean hydrogen is playing a new role as an energy vector (new market) compared to its current role in chemical industry as material vector.

Technology pathway 3: Circularity and recycling

The concept of circularity in the primary chemicals industry includes strategies such as recycling, waste valorization, material efficiency, and substituting conventional materials with alternative or bio-based chemicals. Mechanical recycling (e.g. plastics recycling) is a mature technology with a TRL of 9,[495] meaning it is commercially available and widely implemented. The mechanical recycling of certain polymers, like polyethylene terephthalate (PET) and high-density polyethylene (HDPE), is already scaled. Advanced chemical recycling (e.g. pyrolysis and depolymerization), which breaks down plastics and other materials into chemical building blocks for reuse, are at TRL 5-7.[496] They are undergoing pilot and early-stage commercial trials but have not yet reached widespread commercialization. Key challenges include high energy requirements, scalability issues and economic viability. Waste-to-chemicals conversion, bio-based feedstocks, and material efficiency and substitution are pathways that can reduce demand and emissions.

2

PRIMARY CHEMICALS

Infrastructure

Transitioning to a net-zero chemicals industry by 2050 will require concerted investment and infrastructure development in CCUS, hydrogen production and clean energy generation. Presently, there are limited operational CCUS facilities, with most focusing on fossil fuel processing and industrial applications. Current capacities are insufficient, as less than 1%[497] of CCUS infrastructure and clean power infrastructure required by 2050 is available for the industry. The chemical sector can use CCU in ways that most other industries cannot, creating products such as synthetic fuels (e.g. methanol and aviation fuels), polymers and plastics (e.g. CO_2-based polyols for polyurethane production), chemical intermediates (e.g. formic acid and formaldehyde), and mineralized building materials (e.g. carbonates for construction). Unlike CCS, which primarily incurs costs, CCU allows the chemical industry to use CO_2 to create marketable products.

Renewable energy sources are increasingly being integrated into the power grid, but much more is needed to meet the projected demand. Current renewable capacity is 7 GW, and around 2200 GW of new renewable generation capacity will be required by 2050. Developing advanced energy storage technologies is essential to manage the intermittent nature of renewables and ensure a stable energy supply.

The existing hydrogen infrastructure primarily involves the production of grey hydrogen, which is derived from fossil fuels. There are only a handful of large-scale projects for clean hydrogen (green or blue hydrogen) that are currently operational. Companies like air products[498] are developing multiple hydrogen production facilities in the Netherlands, coupling steam methane reforming with CCUS to produce blue hydrogen while capturing and storing significant amounts of CO_2.

FIGURE 62 **Infrastructure for decarbonization capacity**

	Current capacity used	Capacity required (2050)
Clean power generation	7 GW	2,200 GW
Clean hydrogen production	0 MTPA	60 MTPA
CO_2 transport and storage	4 MTPA	640 MTPA

Source: Accenture analysis based on data from CGC.

Demand

Overall, by 2050, primary chemicals demand is expected to increase by 2.3 times.[499] By this time, green ammonia will represent 60% of demand and methanol will account for 20%.[500] Ammonia saw modest annual increases of around 1% and methanol of approximately 6.5% over the past decade.[501] However, production stagnation was noted in 2022, due to external factors like the energy crisis. While ammonia will grow significantly to full new net-zero applications such as shipping and power, non-ammonia chemicals will experience the greatest impacts of circularity.

To align with net-zero goals, the industry must pivot from fossil fuel-based feedstocks to more sustainable options. This includes increasing the use of electricity and bioenergy and enhancing recycling and material efficiency. Current reliance on coal, particularly in regions like China, is being scrutinized due to its high emission intensity, with expectations of a 30% reduction in coal use by 2030.[502]

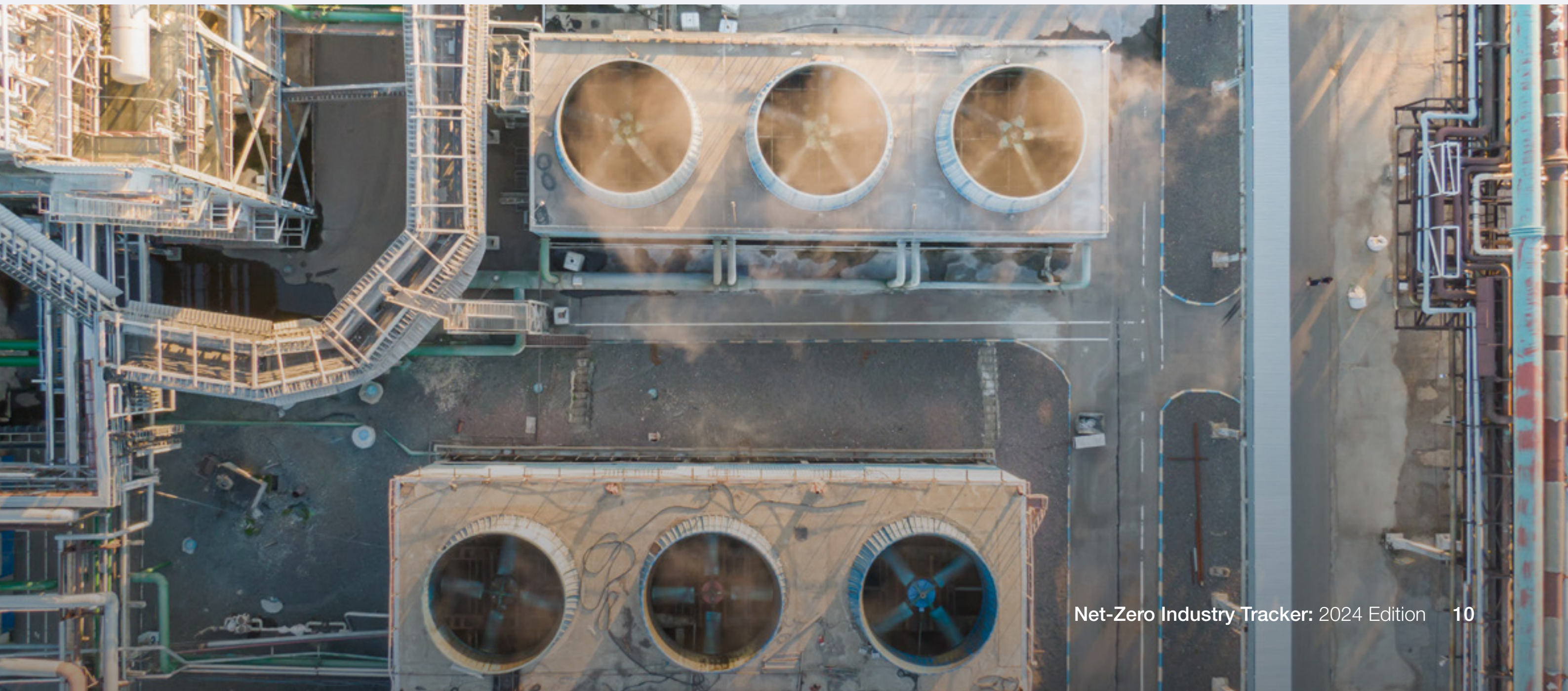
Despite the B2B green premium of 55%[503] on average, the impact of the increased manufacturing cost to end user products is limited to low single-digit percentages.

FIGURE 63 **Top countries/regions in primary chemical production and demand**

Chemical sales worldwide (2023)	
1 China	54.9%
2 US	11.2%
3 Germany	4%
4 India	2.3%
5 All other countries	27.6%

Percentage of overall consumption (2023)	
1 China	30.6%
2 US	6.9%
3 Germany	2.5%
4 India	2.4%
5 Japan	1.7%

Source: Statista.[504,505]



2

PRIMARY CHEMICALS

Capital

The primary chemicals industry will require additional capital investment of \$6.5 trillion[506,507] by 2050 to develop and implement low-emission technologies and infrastructure, 60% of which is for ammonia. Maximizing the efficiency of existing infrastructure will remain the most practical approach in the near term, which involves retrofitting existing plants and increasing circularity. However, the majority of future investments will focus on expanding capacity, necessitating the construction of new facilities. While optimizing current assets can yield immediate returns, long-term growth will rely heavily on better returns and low B2B premiums for the manufacturers.

The product carbon footprint (PCF) for each chemical product can vary significantly based on its production process, raw material sourcing and energy use. Transitioning to greener products often hinges on both the willingness of consumers and industries to invest in these sustainable options, as they typically involve higher costs.

A flexible allocation model like mass balance is an excellent approach in such cases. It allows manufacturers to balance renewable and non-renewable inputs without having to fully retool production for every single product. By using mass balance, companies can allocate a portion of their sustainable resources to specific products, effectively supporting the market shift towards greener products without making drastic, immediate changes to all production lines. This approach can accelerate the transition while remaining adaptable to evolving demand and willingness to pay for sustainable options.

FIGURE 64 **Investments required by the sector and enabled by the ecosystem**

\$6.5 trillion

required in investment by 2050

Investments by the sector (around 48% of investments)

- Switch production from fossil to renewable feedstock sources
- Invest in R&D for low-TRL technologies
- Retrofit legacy infrastructure
- Invest in CCUS and DAC technology
- Adopt measures for waste management
- Scale circularity and plastics recycling
- Abate end-of-life chemicals

Enabled by the ecosystem (around 51% of total investments)

- Digitize the value chain and disclose key environmental system data
- Renewable electricity production
- Demand creation via offtake agreements
- Build CO_2 capture plants
- Fast track critical innovations to commercial scale
- De-risk large-scale financial investment

Hydrogen, bioenergy and renewables | CCUS | Circularity and demand reduction

Policy

Global chemicals production is highly concentrated, with China contributing 44%[508] of the total production worldwide in 2023, followed by the EU and US. This underscores the importance of implementing effective and tangible policies to advance a comprehensive policy framework aimed at reducing industry emissions in key production regions.

Implementing standardized carbon accounting frameworks, clear scope definitions and consistent system boundaries is essential for promoting transparency and accountability. These measures are key to ensuring accurate emissions reporting and adherence to industry-wide guidelines.

Initiatives such as the International Council of Chemical Associations' (ICCA)[509] sustainability programmes emphasize the importance of standardization and collaboration among industry players to share best practices, particularly in adopting low-carbon technologies and alternative feedstocks. The ICCA, representing more than 90% of global chemical sales, recently announced the launch of three high-level ambitions on the sound management of chemicals and waste for the industry. By 2030, the industry aims to provide access to product safety and sustainability data, support chemical management systems in 30 countries, and guide product portfolios towards sustainable solutions.

TABLE 17 **Primary chemicals industry policy summary**

Policy type	Policy instruments	Key examples	Impact
Market-based	**Carbon price**	Canada's Carbon Pricing[510]	Firms are incentivized to adopt energy-efficient practices to minimize carbon tax payments. This leads to increased operational efficiency and potential cost savings over time.
	Border adjustment tariff	Proposed US Border Carbon Adjustment[511]	US chemical companies will benefit from a more level playing field, as foreign competitors will face similar carbon costs. This may spur US firms to invest more in decarbonization to maintain their export competitiveness.
	Product standard	California Safer Consumer Products Regulations[512]	The regulation encourages the chemical industry to phase out harmful substances and develop safer, greener alternatives in products.
Mandate-based	**Direct regulations**	REACH Regulation in the EU[513]	Chemical companies are required to evaluate and reduce the risks of substances they produce or import. This leads to better safety and environmental practices in chemical production, significantly reducing hazardous chemicals.
	Direct regulations	Toxic Substances Control Act (TSCA) in the US[514]	By regulating the manufacturing and use of toxic chemicals, the TSCA leads to a reduction in harmful chemical releases into the environment. It protects ecosystems and public health.
	Government targets	Germany's Climate Action Plan 2050[515]	The ambitious emission-reduction targets (61-62% by 2030) compel the chemical industry to adopt low-carbon processes such as electrification, hydrogen use and circular economy models. This accelerates industry-wide decarbonization.
Incentive-based	**Subsidies**	Germany's Carbon Contracts for Difference (CCfD)[516]	The CCfD helps cover the cost difference between conventional chemical production and low-carbon alternatives like green hydrogen or carbon capture. This incentivizes companies to make investments in these expensive but essential technologies.
	Direct R&D funds/grants	EU's Horizon Europe Program[517]	Funds from this programme encourage the development of sustainable technologies, such as recycling of chemical waste and energy-efficient processes.

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