



Pathway to Commercial Liftoff

The U.S. chemicals and refining sectors produce primary fuels for transportation, power, and heat, and provide essential inputs to widely used downstream products, including plastics, fertilizer, and pharmaceuticals. Chemicals production and oil refining accounted for ~38% of all industrial energy-related CO₂ emissions and ~11% of total domestic energy-related CO₂ emissions in 2021. Approximately 80% of chemicals production and refining process emissions are generated from five subsectors: oil refining, natural gas processing, ammonia production, steam cracking for ethylene production, and chlor-alkali processes.

Today through the mid-2030s, reducing ~20% production emissions in these sectors could be accomplished via a suite of measures that are currently deployable, including:

- Energy efficiency upgrades:** Reaching an average of ~10% efficiency improvement across all relevant facilities
- Electrification with clean high-capacity firm power:** Electrifying over 80% of natural gas processing compressors
- Clean hydrogen switching:** Substituting ~3-5 MTPA¹ of carbon-intensive hydrogen with clean hydrogen²
- CCS on concentrated streams:** CCS installed on >80% of natural gas processing facilities that do not already use it
- Developing additional, lower-carbon pathways to producing chemicals and fuels from sustainable feedstocks**

These interventions can take place within the existing footprint of a facility and offer at least a ~10% internal rate of return (IRR) in the current policy environment. 80% of chemicals and refining facilities must pursue these measures for the sectors to remain on the path to achieving net zero by 2050. Lastly, ~15% of production emissions in 2030 could be abated via grid decarbonization and demand reduction measures. This assumes reduced demand for traditional fossil fuels aligned with long-term strategies for vehicle electrification and achieving a 50% recycling rate of key plastics according to the EPA's goals to reduce virgin plastic production.

1. Million tons per annum 2. IRA assumptions as of September 2023

Market Status

Metric	Value	2030 Target
Total Clean Electricity Generation Connected to the Grid Source: EIA EPM August 2024	~1,800 GWh	None ³
Expected Capacity of Chemicals & Refining CCS Projects ⁴ Source: GCCSI 2024 Q2	~19 MTPA ⁵	28 MTPA
Clean Hydrogen for Industrial Decarbonization (Ammonia and Refining Offtake) Source: BNEF 2024 Q2	1.4 MTPA ⁶	~5 MTPA

3. While no formal target for this metric has been established, Liftoff analysis suggests that it would require 180 TWh of clean firm capacity by 2030 to fully electrify the domestic chemicals and refining industry 4. Includes CCS for hydrogen/ammonia/fertilizer, and natural gas processing 5. Million metric tons per annum 6. Includes non-binding agreements

Possible Near-term Actions

- Increase the availability of financial mechanisms to expand funding for asset decarbonization to lower the delivered cost of key technologies, e.g., public-private partnerships like DOE's carbon management portfolio, and OCED's Industrial Demonstration Program (IDP) and Hydrogen Hubs (H2Hubs)
- Promote creative offtake and/or advanced market commitments to improve the investment case for clean fuels and chemicals, including for hydrogen production, carbon dioxide removal (CDR), and shared infrastructure
- Improve permitting bottlenecks to reduce financing risk for clean hydrogen (pipeline siting) and CCS (pipeline siting and geologic storage sites); EPA is already striving to expedite permitting for Class VI carbon storage wells, though state regulators and industry must also improve their capacity to manage the application and permitting process
- Provide financial mechanisms for demonstration and deployment of low-carbon technologies to accelerate their adoption at scale
- Develop a clear and standardized process to measure and publish the carbon intensity of products to 1) create an auditable pathway for customers to abate their Scope 3 emissions by paying a premium for low-carbon goods, and 2) allow for alternatives to incumbent chemical and fuel processes to be compared on price and carbon intensity
- Integrate decarbonization plans early into long-term capital planning to reduce the time it takes for a facility to upgrade an asset, limiting downtime and costs
- Provide R&D funding for transformational lower and mid-range TRL technologies and expedite demonstration-stage projects such as CCS on dilute emission streams, advanced plastic recycling techniques, and bio-based chemicals and biofuel production