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Carbon capture technology

Targeting a critical need with innovation and investment

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Carbon capture technology is widely considered critical to any viable path to reducing global greenhouse gas emissions to net-zero. Long used to decarbonize oil and gas operations in some areas, it is generally seen as among the most plausible near-term options for decarbonizing sectors like steel, chemicals, and cement manufacturing. And it even can potentially remove excess emissions directly from the atmosphere.[1] Yet despite ballooning investment, expanded government incentives, and continuing innovation, most carbon capture technologies are still immature and costly. With researchers allocating to carbon capture a goal of reducing more than seven gigatons of emissions per year globally by 2050,[2] innovators, emitters, and governments have challenges to face—and opportunities to seize.

Most technology is at an early stage

Only two of the 12 most mature carbon capture technology categories have reached a commercial stage of development for any application, according to a GreenSpace Tech by Deloitte analysis: chemical absorption and physical absorption/adsorption. Of 14 carbon capture applications assessed by the International Energy Agency (IEA), a nonprofit organization that studies the global energy system and provides policy guidance, only three—natural gas processing and ammonia and methanol production—usually cost below $50 per ton with mature technologies (see Figure 1). Costs can be much higher for less mature applications like steel, cement, bioenergy, and particularly direct air capture (DAC), which can run up to hundreds of dollars per ton captured.[3] These applications are more technically challenging as they involve gas streams with relatively low CO2 concentrations. They also have higher capital costs. A Monitor Deloitte study found that the cost of capital for some steel applications, for example, can be up to five times higher than for coal power generation.[4]

Innovation is needed to address cost challenges. Novel capture technologies like membrane separation, calcium looping, and electro-swing adsorption could help, potentially cutting costs by more than 50% for some applications.[5] However, they remain largely unproven beyond the prototype stage. IEA modeling suggests that 55% of global emissions abatement from carbon capture by 2050 will have to come from technologies currently at the demonstration or prototype stage.[6]

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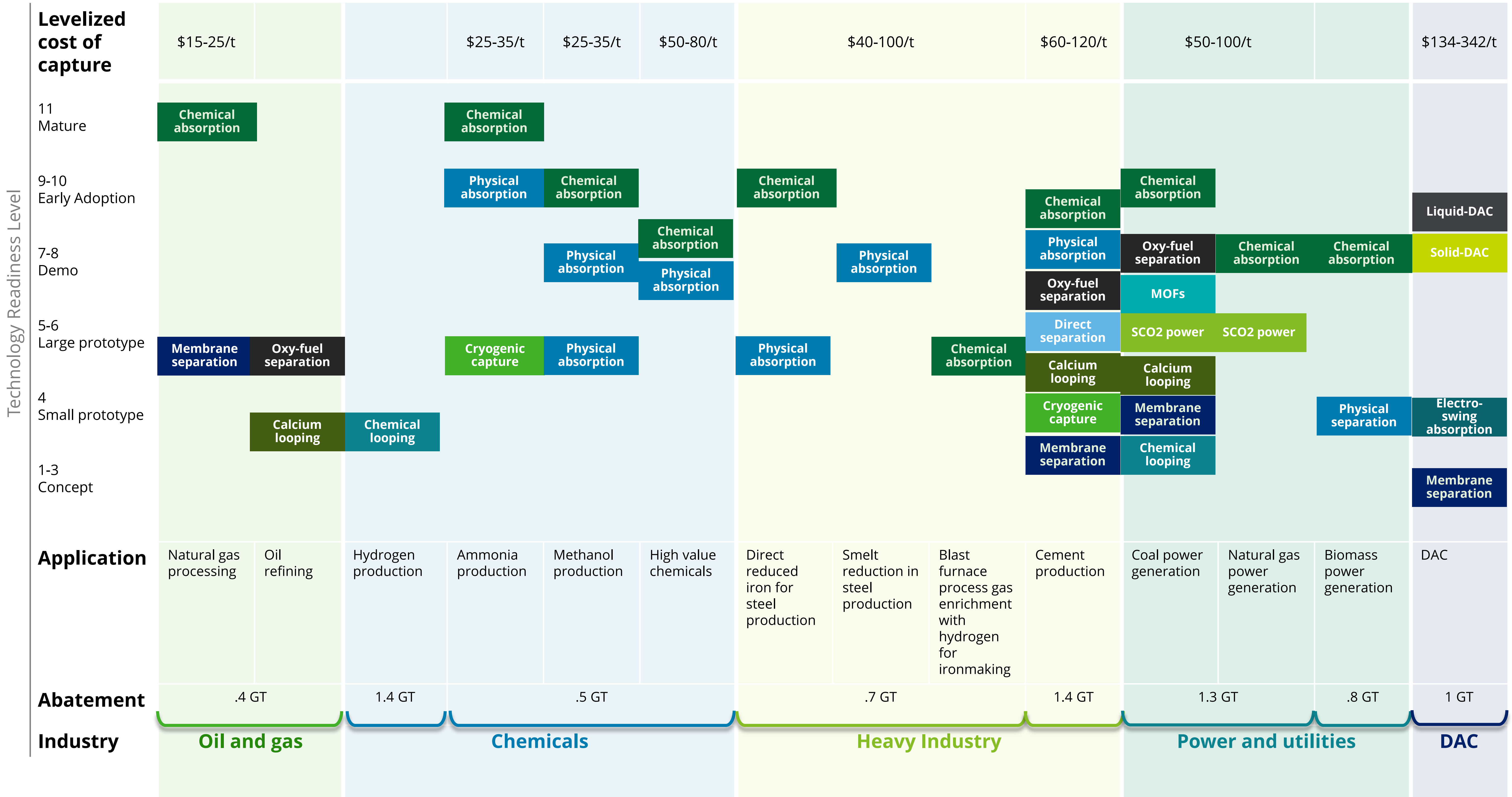
Capacity lags net-zero requirements

Carbon capture capacity has also lagged well behind what's needed to reach net-zero. Only 35 projects are in commercial operation today globally, collectively capturing about 45 megatons annually, mostly from natural gas processing and ammonia production.[7] Developers have announced plans to build 200 new projects by 2030, when global capacity is expected to exceed 200 megatons.[8] That is still a far cry, though, from the 1.6 gigatons the IEA says will be needed by that year, much less the 7.6 gigatons required by 2050 to achieve net-zero that year.[9] Half of that capacity will need to be dedicated to the less mature applications mentioned above. More investment is required to expand global capacity with new projects and to develop new, more cost-effective technologies.

Carbon capture technology maturity by application

Figure 1. Carbon capture technology maturity by application, with levelized cost of capture and abatement required in the IEA's Net-Zero Scenario.[10]



Source: IEA, GreenSpace Tech by Deloitte analysis

*Technology abbreviations: MOFs (Metal Organic Frameworks; SCO2 power (Supercritical C02 power cycles)

**Abatement refers to annual abatement needed by 2050 for net-zero gigatons (GT)

Public and private investment

Governments have responded to this challenge by expanding incentives for project development; investors by backing startups and investing in projects. 2022 saw record venture capital (VC) funding—more than 60 companies raised more than $1.5 billion.[11]

More than 60 companies raised more than

$1.5 billion in total

This was primarily driven by nine-figure rounds that had never been seen before in this space, including DAC company Climeworks' $634 million Series F round and a $318 million Series E round for Svante, and a $150 million Series C round for Carbon Clean, which both focus on capture for energy and industrial applications.[12,13,14,15] Meanwhile, the major expansion of the 45Q tax credit for carbon capture, utilization, and storage in the U.S. Inflation Reduction Act is already spurring new projects.[16] Governments in the EU, Canada, Australia, and South Korea have also introduced or proposed new funding for technology research and projects.[17,18,19,20]

Still, more investment is needed. Global investment in carbon capture—including VC funding and private and public sector financing for new projects—totaled $3 billion from Q1 to Q3 in 2022.[21] According to the IEA, to reach net-zero by 2050, however, annual capital investments will need to increase to $160 billion. Some environmentalists also oppose investment in carbon capture, particularly for the oil and gas and energy sectors, where renewables offer a more mature pathway for decarbonization.[22] This could make it challenging to garner policy support and funding. However, other industries, like steel and cement, cannot be decarbonized with electricity from renewables because of high heat requirements and process emissions.[23] Leaders in the public and private sectors will need to target these sectors with proper funding and support for carbon capture development regardless of how quickly renewable energy is scaled.

Challenges and opportunities ahead

The global effort to scale up carbon capture is surely a massive challenge. But it also presents organizations with a range of opportunities. Much of the activity and progress around carbon capture to date has come from the oil and gas and energy sectors. However, carbon capture technology will need to expand and mature in new sectors like steel and cement to reach net-zero, creating opportunities for providers of solutions tailored to the needs of those sectors.

Companies in the energy, chemicals, and industrial sectors may be able to mitigate high costs—reducing capital investment requirements by 20% to 95% by developing local and regional hubs with shared carbon capture facilities and infrastructure.[24] Oil and gas and chemicals companies that have utilized carbon capture for years can also expand incipient efforts to commercialize their carbon capture technologies.

The stakes are high

In multiple respects—technological maturity, adoption, and investment levels—the carbon capture market is still in its early stages. Like any early-stage market, it presents risks and opportunities. Unlike many markets, though, the risk of inaction is something we all bear.

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Together, we will connect climate technology innovation with industry to accelerate the solutions of the future.

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