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Financing the decarbonization of hard-to-abate sectors: trends, issues, and ways forward[1]

F Yilmaz,
KAPSARC, SA

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Financing the decarbonization of hard-to-abate sectors: Trends, issues, and ways forward

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Fatih Yilmaz, Senior Fellow

King Abdullah Petroleum Studies and Research Center, Riyadh, Saudi Arabi

Abstract

The decarbonization of hard-to-abate sectors, such as steel, cement, petrochemicals, and heavy transportation, is essential to achieving global net-zero targets and maintaining financial stability. Despite a significant increase in global transition investments, the funding directed toward critical technologies like carbon capture, utilization, and storage (CCUS) and clean hydrogen remains insufficient. These sectors face unique challenges, including high capital intensity and technological barriers, making conventional electrification strategies less applicable. Current investments in CCUS and clean hydrogen fall well below the levels required to meet climate targets, with government subsidies playing a key role in financing these projects. However, gaps remain, particularly in developing countries with limited public resources and private finance. Addressing these challenges requires a comprehensive approach that includes robust regulatory frameworks, innovative private financial instruments, and global coordination to scale up decarbonization efforts. This paper explores the investment trends, challenges, and opportunities in financing the transition of hard-to-abate sectors, offering policy recommendations to close the investment gap and ensure a successful global transition.

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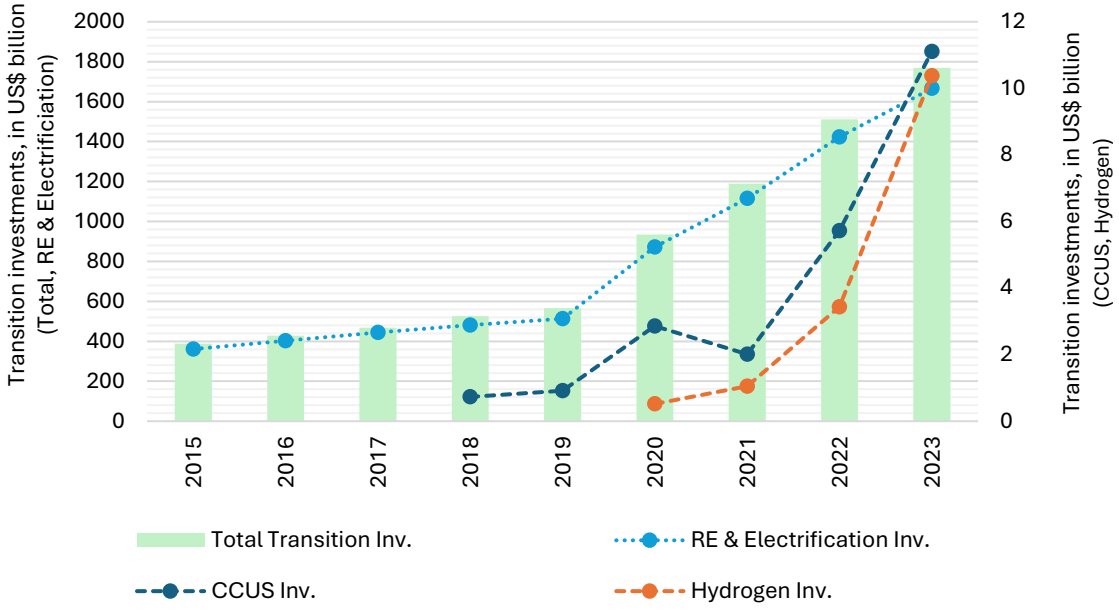
1. Introduction

Global transition investments have witnessed incredible growth and progress with the growing participation of private actors in recent years. The investment flows in clean technologies have increased significantly, particularly after the COVID era, reaching US$ 1.8 trillion in 2023, up from only half a trillion in 2019. While achieving a successful transition scenario aligned with the Paris Agreement goals requires a significant increase in current efforts (Yilmaz et al., 2023), an even greater challenge lies in securing financing for the decarbonization of hard-to-abate sectors. These sectors, such as steel, cement, petrochemicals and heavy transportation, face unique challenges due to their hard-to-abate nature with conventional electrification technologies, making the adoption of environmentally sustainable practices more complex. Consequently, their decarbonization strategies hinge on technologies such as carbon capture, utilization, and storage (CCUS) and clean hydrogen, which are capital-intensive and require substantial investments to scale up.

Despite the accelerating transition investment action, most of it disproportionately concentrated on renewable energy and electrification, constituting more than 90 % of the investment flows (Figure 1). While investments in technologies for hard-to-abate sectors, such as CCUS and clean hydrogen, have seen a remarkable increase during this period, the actual funding directed toward these two technologies remains minimal. For instance, in 2023, only US$10.4 billion was invested in clean hydrogen technologies and US$11.1 billion in CCUS technologies. Considering the actual investment needs of these technologies for a successful net-zero transition of the related sectors, which is multiple times higher, these figures remain significantly low to meet climate targets by 2050.

Decarbonization of hard-to-abate sectors is essential for financial stability due to their critical role in the global economy and the large size of capital stock. These sectors, such as heavy industry and transportation, are foundational to economic systems, providing direct or indirect inputs to almost any of the goods and services transacted in the markets. Moreover, the risk of stranded assets looms large as climate regulations tighten, threatening financial losses for businesses that fail to transition (McKinsey & Company, 2023; CFA Institute, 2023). Investor confidence is also at stake, with capital increasingly shifting toward sustainable investments, making effective decarbonization vital for maintaining access to financing. Nations that lead in transitioning hard-to-abate sectors will enhance their long-term economic competitiveness and resilience in emerging low-carbon markets (World Economic Forum, 2021).

Figure 1: Global annual transition investment flows in clean technologies, by total, renewables (RE) and electrification, CCUS and clean hydrogen breakdown, over time



Source: Author's construction from Bloomberg NEF.
Notes: "Total Clean" includes all clean technology investment flows, including renewable energy, electrified transport and heat, power grids and energy storage, clean industry, nuclear, clean shipping, CCUS, and clean hydrogen. "RE & Electrification" covers the sum of renewable energy, electrified transport and heat, power grids, and energy storage.

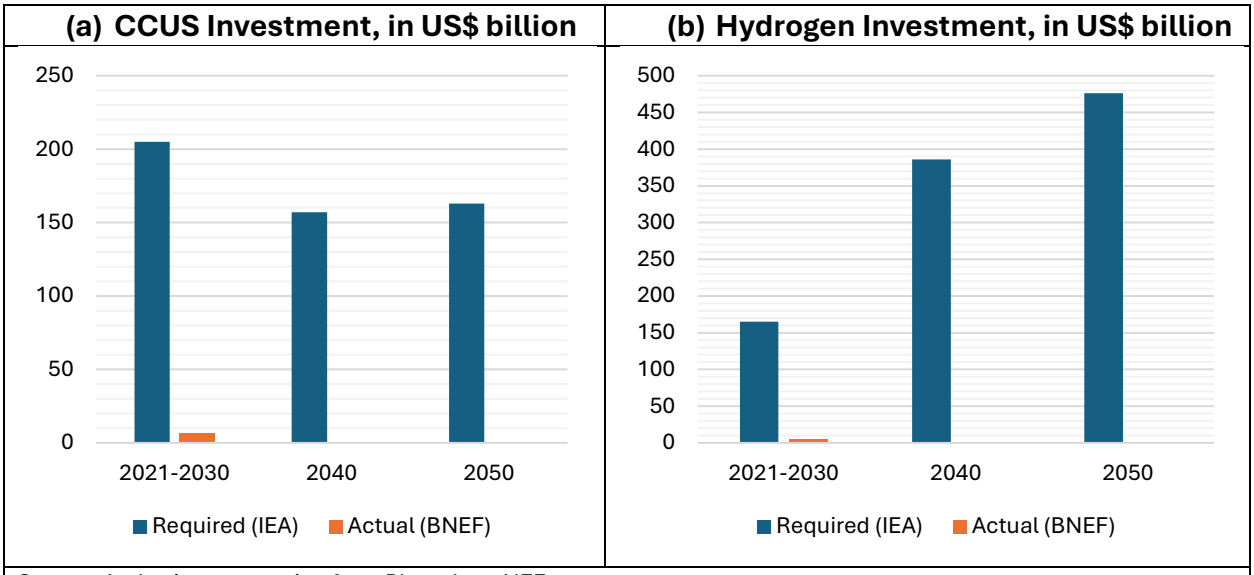
In this paper, we examine the current state of hard-to-abate sector decarbonization. We first summarize the current investment gaps in hard-to-abate sector technologies, namely CCUS and clean hydrogen, to align with net zero targets. We then review the current project outlook and global trends, discuss mainstream financing practices and issues, and finally, conclude with a policy discussion for ways forward.

2. Investment Gaps and Challenges

According to the International Energy Agency's (IEA) net-zero emissions (NZE) scenario (IEA, 2021), annual investments of US$205 billion in CCUS and US$165 billion in clean hydrogen are required between 2021 and 2050. Accordingly, only in the current decade until 2030, we need a total of US$2 trillion in investment in CCUS and US$1.6 trillion in clean hydrogen (Figure 2). The IEA's NZE scenario highlights that investment needs for these critical technologies will continue to grow over the next two decades, from 2031 to 2050, with clean hydrogen investment needs projected to reach nearly US$9 trillion. On the contrary, the average annual investment recorded is only US$6.3 billion for CCUS and US$5 billion for

clean hydrogen in the current decade. This stark disparity between required and actual investments underscores the significant gap that demands urgent attention.

Figure 2: Investment gaps in CCUS and clean hydrogen, over time

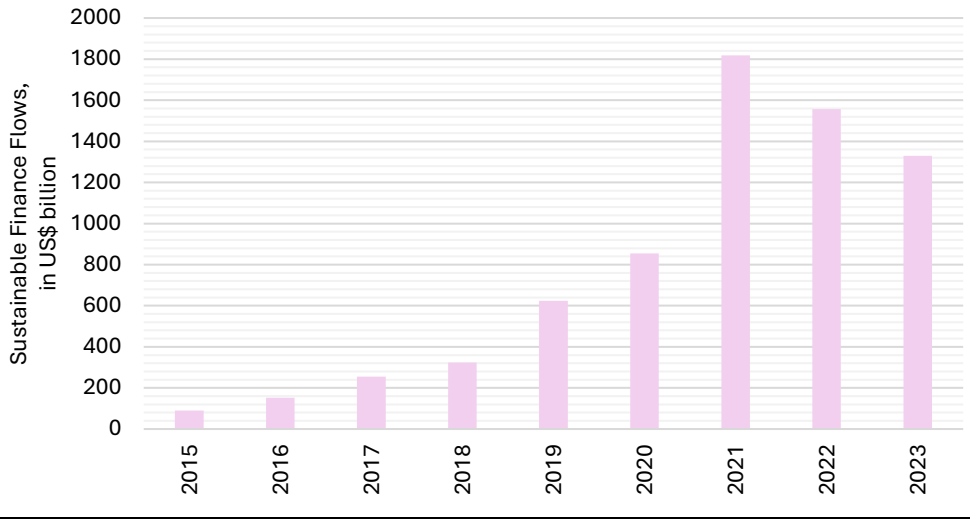


Source: Author's construction from Bloomberg NEF.
Notes: "Require" levels indicate annual investment needs based on the IEA net-zero emissions scenario, and "Actual" covers average investment into the technology in the current decade between 2021 and 2023.

CCUS and clean hydrogen technologies encounter significant challenges, including inadequate transportation and storage infrastructure, the absence of standards for measuring, reporting, and verifying (MRV), and an evolving regulatory landscape. Additionally, establishing a stable market for sequestered carbon and clean hydrogen remains critical. However, securing private finance is perhaps the most substantial obstacle for CCUS and clean hydrogen projects. As shown in Figure 3, the increasing trend of annual sustainable debt issuance, which represents the largest source of private financing for transition investment projects, closely parallels the rise in investments in renewable energy and electrification (as displayed in Figure 1). On the contrary, the recent spike in CCUS and hydrogen investments corresponds to the declining era of sustainable finance flows due to global monetary tightening after the COVID-19 pandemic. Consequently, the recent increase in these projects was mostly triggered by government subsidies in the form of off-take agreements and tax incentives. An example of the latter is the Inflation Reduction Act (IRA) in the United States, which provides a tax credit to businesses registered in the United States for each unit of carbon captured or hydrogen produced. Beyond these challenges, uncertainties and inadequate treatment of these technologies in current global Environmental, Social, and Governance (ESG) reporting frameworks, taxonomies, and rating

practices hinder efforts to scale up the necessary private finance (Global CCS Institute, 2020 and 2022).

Figure 3: Global sustainable finance flows, over time



Source: Author's construction from Bloomberg NEF.
Notes: "Sustainable Finance Flows" includes green, sustainable, sustainability-linked and transition bonds and loans. "RE & Electrification" covers the sum of renewable energy, electrified transport and heat, power grids, and energy storage.

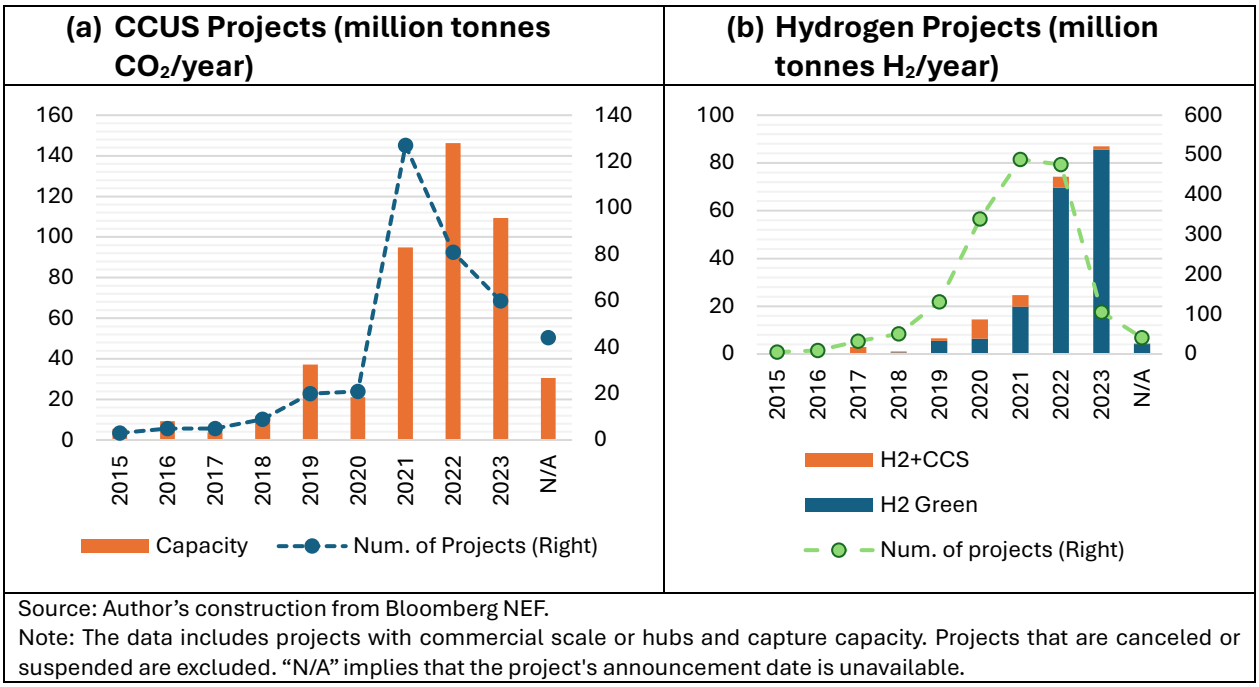
3. Current CCUS and Clean Hydrogen Projects Outlook

There has been a growing global interest in CCUS and clean hydrogen technologies in recent years. Project announcements have increased since 2022, especially following the release of generous subsidy programs in major countries, as discussed later. Furthermore, the announcement of the Carbon Border Adjustment Mechanism (CBAM) by the EU Commission in 2021 with a transitional phase, bringing additional carbon taxes, especially on hard-to-abate sector exports to the European Union (EU) markets from the rest of the world, also reiterated the importance of investing in the decarbonizing technologies for these sectors.

According to the project data shown in Figure 4, the number of announced projects and their capacities have increased significantly compared to pre-2019 levels, with continuous growth in subsequent years. For CCUS, the average project size has expanded considerably, with more recent projects concentrating on hubs with substantial capture and storage capacities. Similarly, there has been a notable increase in the size of clean hydrogen

projects, particularly those focusing on renewable energy as a source of energy, usually labeled as green hydrogen.

Figure 4: CCUS and clean hydrogen project trends, number of announced projects and their capacity over time



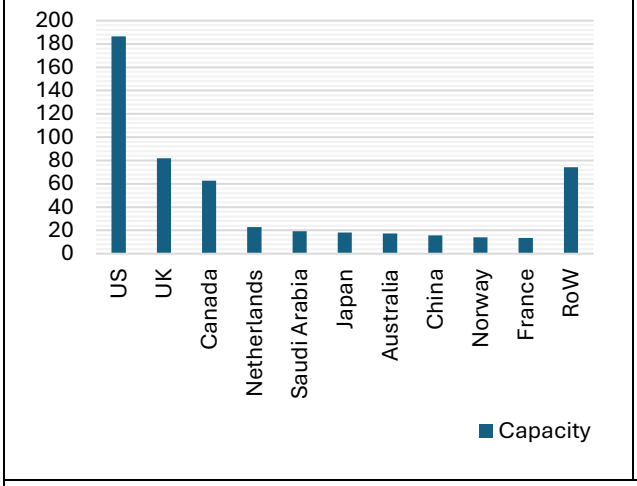
Source: Author's construction from Bloomberg NEF.
Note: The data includes projects with commercial scale or hubs and capture capacity. Projects that are canceled or suspended are excluded. "N/A" implies that the project's announcement date is unavailable.

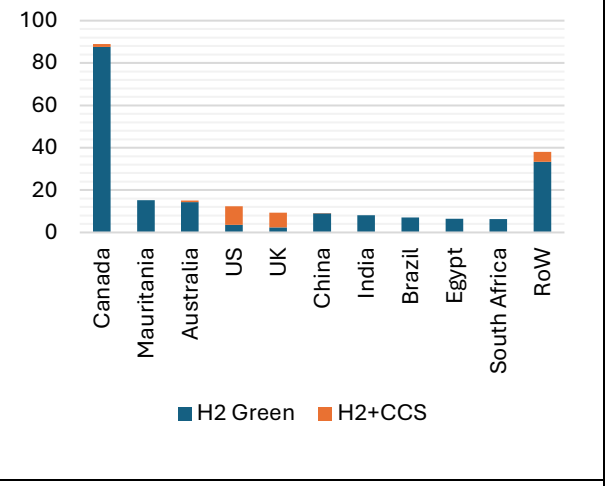
Some of the biggest subsidy programs from major developed countries include the United States Inflation Reduction Act (including 45Q and 45V credits), Canada's Investment Tax Credit program for hydrogen, and various hydrogen innovation programs from the EU, typically in the form of tax credits and grants. These government incentives represent the bulk of available external finance for these capital-intensive projects, leading to a concentration of CCUS and clean hydrogen projects in developed countries (Figure 5). For instance, about one-third of the global CCUS capacity currently under construction is located in the United States, with the United Kingdom and Canada accounting for another third. Similarly, approximately half of the announced clean hydrogen projects are situated in Canada (Figure 5b). Canada's hydrogen strategy emphasizes green hydrogen, while the United States and the United Kingdom have announced the largest blue hydrogen projects (i.e., relying on natural gas as a source of energy with CCUS) worldwide.

Although there have been project announcements in some developing countries, they are generally smaller in scale compared to their urgent decarbonization needs and the relatively more carbon-intensive nature of their economies (Yilmaz et al., 2022). Only Saudi Arabia and

China have announced sizable CCUS projects among developing nations, accounting for about 7 percent of the globally planned capacity. Developing countries are relatively more active in clean hydrogen projects than CCUS, with sizable announcements from Mauritania, China, India, Brazil, Egypt, and South Africa collectively representing about one-third of the global announced capacity. Unlike the government incentives prevalent in developed nations, state-owned enterprises (SOE) in developing countries are more active with their internal funds to finance these projects.

Figure 5. Total announced CCUS and clean hydrogen project capacities by location



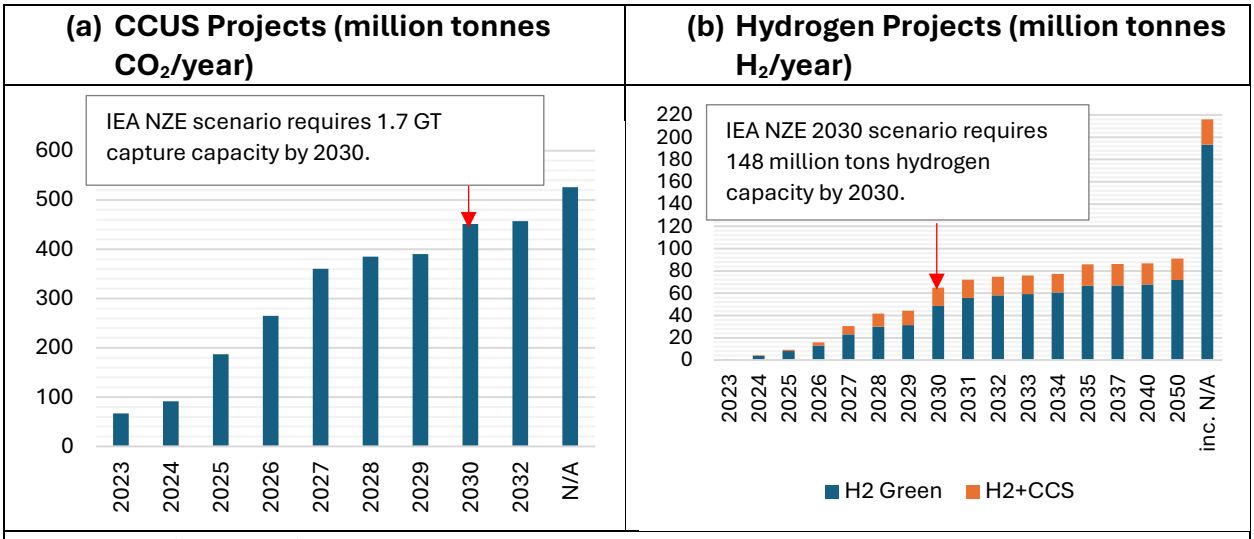


Source: Author's construction from Bloomberg NEF.
Note: The data includes projects with commercial scale or hubs and capture capacity. Projects that are canceled or suspended are excluded. "RoW" implies the rest of the world.

Despite the recent growth in hard-to-abate technology investments, the total announced capacity of the current projects remains significantly below the required levels. The project data indicates that commissioning all the announced CCUS and clean hydrogen projects will not suffice to meet the net-zero transition requirements projected by the IEA scenarios (Figure 6). For instance, the IEA's NZE scenario estimates a global need for 1.7 gigatons (Gt) of annual CO2 capture, utilization, and storage capacity by 2030, a target the currently planned projects fail to achieve. Even considering all current projects with known and unknown commissioning dates, the 2050 target of 7.6 Gt per annum remains unattainable. Similarly, the IEA NZE scenario anticipates an annual hydrogen production capacity of 148 million tonnes by 2030, which must expand to 520 million tonnes by 2050. Similarly, operationalizing all the current clean hydrogen projects by these dates will not be sufficient to meet even half of the stated targets. The disparity between the projected needs and actual

deployment underscores a significant gap that can only be addressed through substantial scaling up of efforts in the coming years and decades.

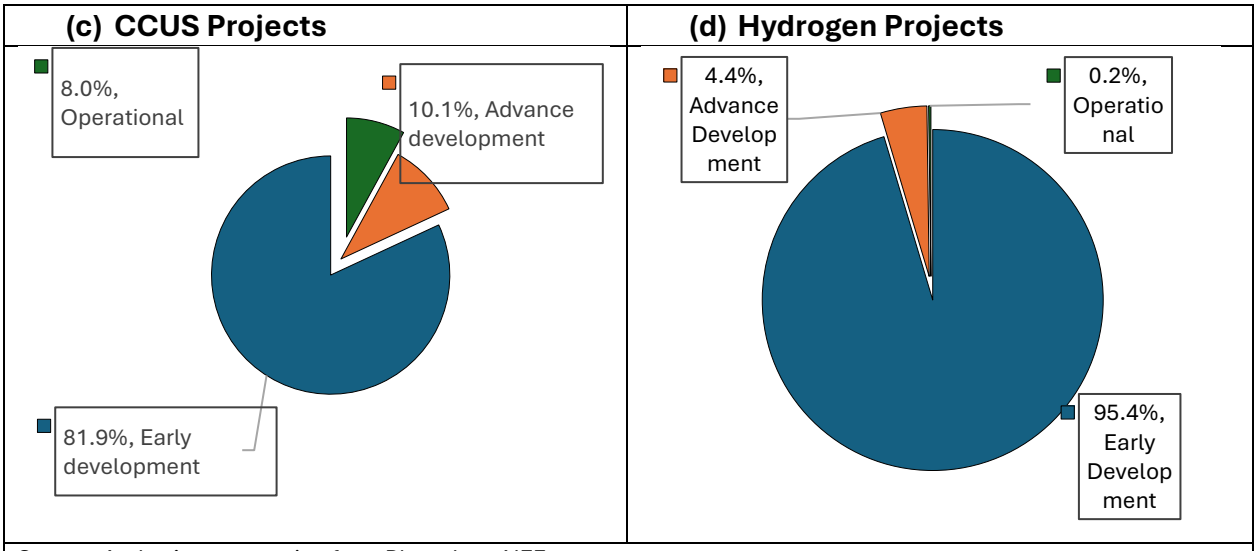
Figure 6. Cumulative CCUS and clean hydrogen announced capacity by commissioning year



Source: Author's construction from Bloomberg NEF.
Note: The data includes projects with commercial scale or hubs and capture capacity. Projects that are canceled or suspended are excluded. "N/A" implies that the project's commission date is not available.

It is important to note that only 8 percent of the current CCUS and less than one percent of the clean hydrogen projects are currently operational. Additionally, CCUS and clean hydrogen projects at the advanced development status constitute about 8 percent and 5 percent of globally announced capacity (Figure 7). Put differently, most of the current projects are in the very early development stages, which generally have not secured solid funding nor obtained the required permits. While funding has been the most critical concern in these projects, the lengthy government subsidy approval and provision processes, permitting time, and regulatory requirements further complicate the project development. Such difficulties, in addition to the long construction times, which may take several years, raise concerns about the project's economic viability and may even result in cancellations (S&P Global, 2023).

Figure 7. The current status of the announced CCUS and clean hydrogen projects



Source: Author's construction from Bloomberg NEF.
Note: The data includes projects with commercial scale or hubs and capture capacity. Projects that are canceled or suspended are excluded. Percentages are the shares of the total announced capacity. "Advance development" includes projects that are currently under construction, have obtained permits and/or secured finance. "Early development" covers planned and/or announced pipeline projects.

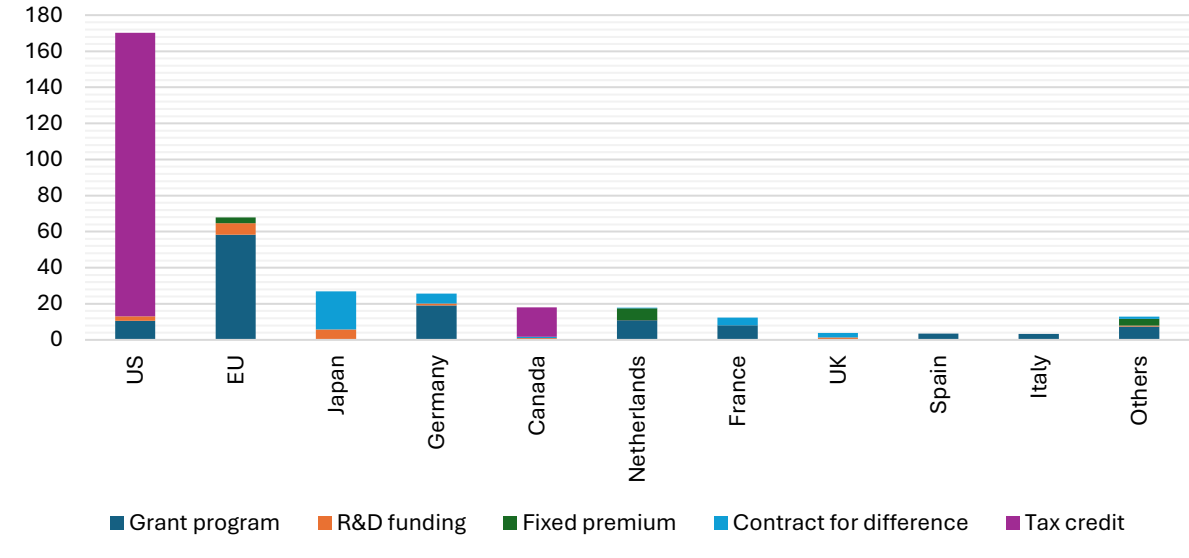
4. Current Financing Practices

As briefly discussed above, most CCUS and clean hydrogen projects are financed via government subsidies along with some support from corporate equity. For instance, Figure 8 presents government incentives for clean hydrogen's demand and supply development. Some of the incentives include CCUS projects, like the 45 Q of the US's IRA, and the CCUS component involved in blue hydrogen production along with other industrial applications. The incentives can take different forms, such as grants, R&D support, fixed premiums, contracts for differences, and tax credits. Grant programs and R&D funding are usually deployed to establish a robust demand for clean hydrogen and support clean hydrogen innovation. The fixed premium (i.e., a fixed price for a unit of output) and contract for difference (i.e., the lowest price for a unit of output) programs aim to ensure an acceptable and stable price for producers that can at least breakeven the marginal costs. Finally, investment tax credits directly aim to support project deployment.

According to the data in Figure 8, tax credit programs are particularly popular in the US (e.g., 45 V for hydrogen production and 45 Q for carbon capture and storage), estimated to reach a total budget of US$157 billion under the IRA, according to Bloomberg NEF. Similarly, Canada provides around US$16 billion in investment tax credits for hydrogen production and carbon capture and storage. The bulk of these credit programs target the supply side with

some incentives for the demand side, e.g., hydrogen fuel cell electric vehicles. On the contrary, the EU-level incentives, such as the EU Innovation Fund – targeting industry decarbonization – and individual European countries, such as Germany, tend to employ grants and other price-fixing policies.

Figure 8. Government incentives for clean hydrogen projects (in millions US$)

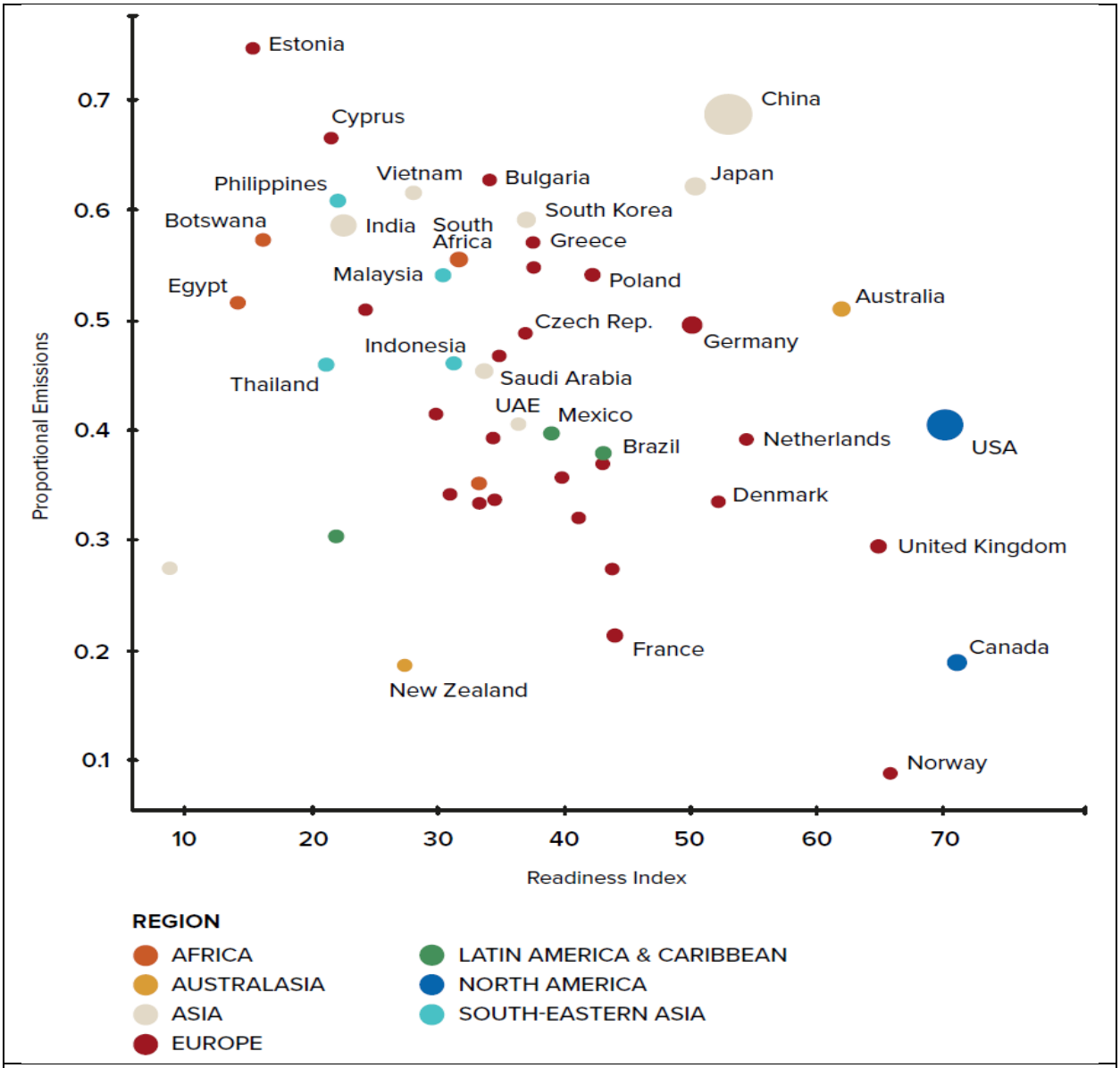


Source: Author's construction from Bloomberg NEF.

These incentives depend highly on countries' fiscal budget availability, which is certainly limited in developing countries. Accordingly, developing countries cannot provide any or as wide incentives to attract the deployment of these technologies. This is visually evident in the current deployment of CCUS and clean hydrogen projects worldwide, where penetration of the technologies, especially in middle- to low-income developing countries, is mostly missing. On the contrary, developing countries perhaps need these technologies more, given the dependence of their economies on hard-to-abate sectors, as described in the so-called environmental Kuznet's curve argument (Yilmaz et al., 2022). For instance, China and India produce more than half of the global steel (World Steel Association, 2023), producing nearly 60 percent of global cement production (MRC, 2024). Major petrochemical producers, including products like methanol, ethylene, and propylene, tend to be in developing Asia and the Middle East. Similarly, a significant portion of global oil and gas production occurs in developing countries. The larger appearance of hard-to-abate sectors in developing countries implies higher needs for CCUS and clean hydrogen deployment in these countries. This is summarized in Figure 9, which presents the CO_2 share of the hard-to-abate sectors against country readiness for CCUS deployment, based on the Global CCS

Institute's CCS Readiness Index[1]. The figure indicates that most developing countries reveal a high level of need for CCUS technology, although their readiness is significantly lacking.

Figure 9. Country-level needs for CCUS technology and their current readiness



Source: Rassool (2021)

Note: Countries' proportional emissions (representing their need for CCS in iron and steel manufacture, cement production, power generation from fossil fuels, and bioethanol production) are measured against their scores in the Global CCS Institute's Readiness Index. The higher the value of proportional emissions, the greater the need for CCS. The larger the size of each circle, the greater the country's overall emissions.

[1] See the link for further inference about the index: https://co2re.co/ccsreadiness

In developing countries, these projects are usually financed by either SOEs and sovereign wealth funds or company equities. For instance, Aramco is partially investing in the Jubail CCUS-hub project in Saudi Arabia, contributing to the company's blue hydrogen production. Saudi Arabia's Public Investment Fund heavily invests the Saudi NEOM Green Hydrogen Company's project. ADNOC, the United Arab Emirates' SOE, has invested in CCUS and blue hydrogen projects. Similarly, China National Offshore Oil Corporation has partnered with Shell and ExxonMobil to build the biggest CCS hub project in China, the Daya Bay project in Guangdong Province, and the Indian Oil Corporation has announced various clean hydrogen projects.

Overall, most developing countries face significant challenges in decarbonizing hard-to-abate sectors. Along with limited public resources, they struggle with inadequate private financing mechanisms and technical deficiencies. Consequently, one-sided approaches like the CBAM, which require the rapid adoption of decarbonization technologies for hard-to-abate sectors, without offering sufficient support (e.g., financing), could further hinder the transition efforts, particularly in the Global South.

5. Concluding Remarks with a Policy Context

Given the complexity of decarbonizing hard-to-abate sectors, a holistic approach is necessary to address their financing needs. Critical technical and market shortcomings must be tackled in parallel with ESG reporting, taxonomy, and rating practices to derisk projects and create a supportive environment for investors. This entails multi-faceted mechanisms that include establishing robust regulatory and legal frameworks, creating stable market opportunities, including carbon and hydrogen markets, and advancing inclusive ESG practices alongside innovative financial instruments all at once to pave the way forward.

Private capital is essential for achieving global net-zero goals, necessitating inclusive global practices, such as those ESG frameworks and standards developed by the International Sustainability Standards Board (ISSB) under the IFRS Foundation, alongside global banking regulations under the Basel Committee on Banking Supervision. The emerging global ESG standards under ISSB must address existing shortcomings by adopting an inclusive, flexible, and holistic approach to technologies relevant to heavy industries. Clear guidelines and standards will aid investors in navigating the complex landscape of heavy industry transitions, thereby enhancing confidence in financing for these projects.

Policymakers must adopt a more comprehensive vision that considers the benefits of successfully decarbonizing heavy industry. These sectors are integral parts of global supply chains, and disruptions in their transition to sustainability can have cascading effects on various parts of the global economy and the financial system. For instance, the asset portfolios of banks, insurance companies, and equity markets in the most advanced and emerging economies have significant exposure to these sectors. According to the European Central Bank's financial stability review (ECB, 2022), European banks have a loan exposure of around 60 percent to high-emitting firms, presumably located in hard-to-abate sectors. The review also states that despite ongoing sustainability efforts, the share of high-emitting firms' securities held by the European financial system is still above 30 percent. A potential disruption in asset values caused by a disorderly transition in these sectors can trigger the subsequent economic turmoil. Therefore, policymakers must carefully manage the transition, considering broader economic implications and implementing measures to prevent sudden financial shocks.

Unilateral actions risk causing unfair competition and sectoral distortions, particularly in the Global South. While ambitious climate action is critical to achieving Paris Agreement goals, uncoordinated policy implementations, such as the EU's CBAM, and technology-prioritized project financing, as seen in current ESG practices, may stigmatize hard-to-abate sectors and the relevant technologies in the ongoing energy transitions. Such stigmatization could impede global decarbonization efforts, especially in the Global South, and shift the focus away from a balanced net-zero agenda.

In conclusion, while challenges persist in financing for hard-to-abate sector transition, addressing these challenges presents an opportunity to drive meaningful change. Policymakers, financial institutions and the investor community, and the global standard-setters need to work collaboratively. A successful transition in hard-to-abate sectors will contribute to the net-zero goals and safeguard the stability of the global economy.

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