Carbon Capture and Utilization

Background

In 2022, the National Development Council (NDC) published the "Taiwan's Pathway to Net-Zero Emissions in 2050" mandating the integration of Carbon Capture, Utilization, and Storage (CCUS) technology into thermal power generation, with a target of achieving 20%-27% carbon-free electricity [1]. Subsequently, the 2025 "Carbon Reduction Action Plans by Six Major Sectors" established a CCUS Flagship Program. Because domestic Carbon Capture and Storage (CCS) technologies remain in the demonstration phase, immediate strategic priority is given to deploying Carbon Capture and Utilization (CCU). The program aims to reduce CO_2e emissions by 1.76 million tons per year by 2030 through converting CO_2 into industrial feedstocks and low-carbon products, thereby supporting the national decarbonization trajectory [2].

Global Outlook and Domestic Progress

(1) Global Outlook

The International Energy Agency's (IEA) "Tracking Clean Energy Progress 2023" report identifies synthetic fuels, chemicals, and building aggregates as the primary emerging CCU pathways [3].

A. Projected Capacity:

CCU deployment is projected to utilize approximately 15 million tons of CO_2 annually by 2030, with 8 million tons allocated to synthetic fuel production.

B. Policy Integration:

The European Commission has integrated synthetic fuels into regulatory frameworks, such as the "FuelEU Maritime Initiative" and "ReFuelEU Aviation Initiative", mandating the use of low-carbon marine fuels and Sustainable Aviation Fuels (SAF), including e-fuels and biofuels [4, 5, 6].

(2) Domestic Progress

Current domestic initiatives focus predominantly on the conversion of CO_2 into chemical products, materials or high-purity CO_2.

A. Chang-Chun Petrochemical Co., Ltd. reduces captured CO_2 to CO for acetic acid production. In 2024, approximately 61,000 tons of the 82,000 tons of captured CO_2 were reused through CCU applications [7, 8].

B. China Steel Corporation operates a "Co-production of Steel and Petrochemicals" pilot plant to convert CO_2 into CO for downstream chemical production. The facility with the Industrial Technology Research Institute (ITRI) synthesizes methanol from purified CO_2 and hydrogen, achieving an annual reduction of 4,900 tons [9, 10].

C. Oriental Union Chemical Corporation captures high-purity CO_2, selling it for industrial and food-grade use while also converting it into ethylene carbonate (EC). This combined effort results in an annual reduction of approximately 100,000 tons [11].

D. CHIMEI Corporation targets the commercial production of polycarbonate (PC) by 2029, with a projected annual reduction of 178,500 tons at full capacity [12].

Unlike chemical applications, there has been no significant domestic investment in low-carbon fuel production to date.

(3) Challenges of Developing Domestic CCU

The development of Taiwan's CCU industry faces significant barriers across technical, regulatory, and market dimensions:

A. Technical & Resource Constraints:

High technology costs and the limited availability of green hydrogen remain primary bottlenecks, severely constraining the advancement of high-value CCU pathways. These challenges are further compounded by inconsistencies in system boundary definitions and a lack of standardized assessment tools, which impede the objective evaluation of life-cycle performance. Consequently, the CCU industry value chain remains underdeveloped, hindering large-scale commercial deployment and technology optimization.

B. Regulatory & Certification Deficiencies:

There is a notable deficiency in supporting frameworks, particularly regarding CCU-specific carbon crediting mechanisms and clear rules governing the use of e-fuels. Current certification schemes are insufficient to substantiate the low-carbon attributes of CCU products, while verification mechanisms remain unaligned with evolving industrial needs. Without a robust regulatory foundation to define and validate these products, mobilizing private-sector investment and ensuring long-term engagement remains difficult.

C. Economic & External Pressures:

Global decarbonization mandates, such as the EU's CBAM and SAF requirements, have intensified the pressure on Taiwan's chemical and aviation sectors. Despite these external drivers, the lack of adequate domestic economic incentives and viable commercial models limits the industry's ability to respond. Establishing integrated validation platforms and aligning with international standards like ISCC and CORSIA is essential to creating market demand and unlocking the commercial value of CCU [13].

Strategic Planning Framework

The strategic framework is executed through cross-agency collaboration between the National Science and Technology Council (NSTC) and the Ministry of Economic Affairs for CCU R&D and industrial implementation, with the Ministry of Environment (MOE) overseeing regulatory formulation. This strategic plan focuses on three major goals: (1) Industry-driven development of high-quality fuels, chemicals, and basic materials; (2) Cross-disciplinary industry-academic collaboration to build a CCU industry value chain; and (3) Accelerating industrial decarbonization and sustainability to co-create profitability. As shown in the figure below, these strategies aligning with four key strategies across four developmental sectors: economy, scientific R&D, society, and governance.

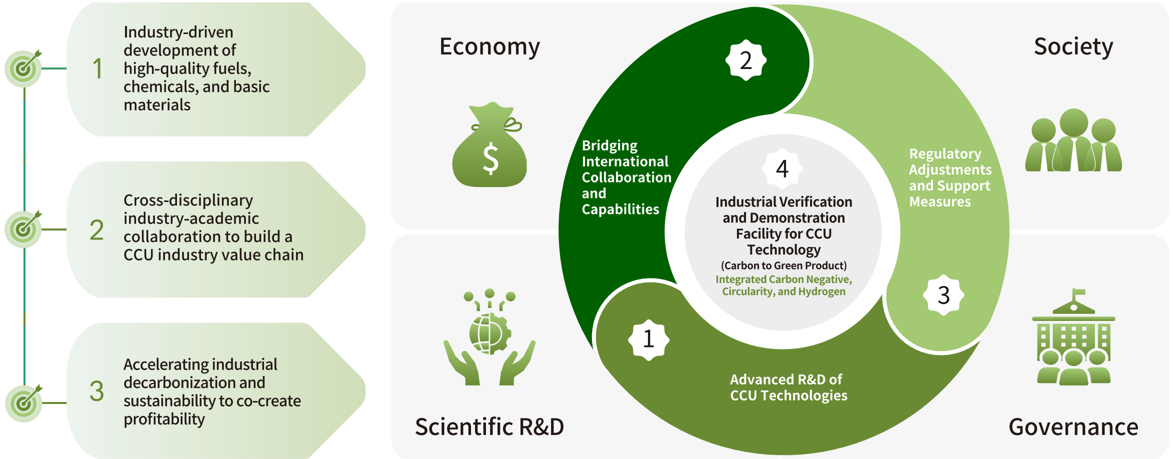

Figure 1 Strategic Plan for Carbon Capture and Utilization

Source: Taiwan Science and Technology Office for Net-zero Emission (T-STONE), (2024).

Implementation Strategies

Strategy 1: Advanced R&D of CCU Technologies

Development efforts will focus on cost-effective capture technologies and demonstrations, including chemical absorption, pressure swing adsorption/vacuum pressure swing adsorption, and membranes, while investing in Direct Air Capture (DAC) technologies.

Carbon utilization should prioritize low-carbon products aligned with industrial demand through four key pathways. First, direct use provides high-purity CO_2 for industrial and electronic applications. Second, bio-based pathways integrate biogas capture to produce SAF or green chemicals. Third, hydrogen-based utilization produces e-fuels and chemicals such as methanol and acetic acid. Finally, non-hydrogen-based pathways encompass mineral carbonation for construction materials, the production of high-value polymers (e.g., EC, PC, and PU), and advanced catalytic conversion into chemical feedstocks.

Strategy 2: Bridging International Collaboration and Capabilities

The strategy prioritizes collaborations with premier international R&D institutions (e.g., NETL and TNO) to accelerate technology readiness and validation. Co-developing CCU demonstration systems with international industry leaders reduces R&D costs and introduces proven project experience to the domestic market. Additionally, establishing matchmaking platforms and joint training programs or the establishment of CCU academies with global experts facilitates the adoption of international business models and accelerates CCU talent development.

Strategy 3: Regulatory Adjustments and Support Measures

To foster a robust market for CCU, the strategy focuses on establishing domestic standards for e-fuel and carbon-removal verification, ensuring alignment with IPCC methodologies and international requirements, such as ISCC and CORSIA [14, 15]. To mobilize private-sector engagement, the plan recommends integrating CCU products into green procurement and consumption regulations and drawing on international instruments, such as tax incentives and carbon pricing mechanisms [16]. Furthermore, the development of cap-and-trade–aligned carbon credit mechanisms, renewable fuel certificates, and low-carbon product certification schemes will be prioritized to substantiate environmental benefits.

Strategy 4: Industrial Verification and Demonstration Facility for CCU Technology

To validate business models and value chains, establishing a CCU verification and demonstration site is recommended. The site will integrate carbon sources—from industrial facilities, biogas plants, and DAC units—with renewable energy and hydrogen to assess the technical and economic feasibility of "Carbon-to-X" pathways. The resulting CCU products will be supplied to downstream industrial applications to foster market linkages. Furthermore, AI technologies will be introduced to enable integrated process management and life-cycle monitoring, providing a systematic data foundation to identify optimized application pathways and enhance industrial resilience.

Potential Benefits

To bridge the gap between current deployment and the 2030 target of 1.76 million tons of CO_2e reduction annually, the CCU Strategic Plan emphasizes an integrated validation of technical, economic, social, and environmental feasibility. By accelerating the implementation of CCU into industrial applications, the plan aims to cultivate a robust value chain and advance industrial net-zero goals. Given that domestic CCS is still in its demonstration phase, the proactive development of CCU represents a necessary and pragmatic pathway for Taiwan's near-term decarbonization.

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