International CCS Growth Driven by Article 6 of the Paris Agreement

Summary of IEAGHG Technical Report 2023-01 (IEA/CON/21/275)

I summarized key elements of an IEA report that assesses the status of and outlooks for international cooperation towards net zero emissions under Article 6 of the Paris Agreement. Approaches that could support the deployment of carbon capture and storage (CCS) are the particular focus of the report. Various models are proposed to suggest how Article 6 could apply to CCS through linked emissions trading systems, crediting systems, and alternative approaches. Collectively, these may lay the foundation for CCS to be upscaled to the estimated 2 000 facilities necessary by 2050.

Realizing the Opportunities of Carbon Capture and Storage (CCS)

Carbon Capture and Storage (CCS) involves capturing carbon dioxide (CO_2) emissions from industrial processes and power plants, transporting them to storage sites, and securely storing them underground. The primary goal is to mitigate climate change by reducing greenhouse gas emissions.

Measurement, Monitoring, and Verification (MMV) are crucial components of CCS projects to ensure their effectiveness, safety, and compliance with regulations. Through the principles of MMV, stakeholders can be confident that the CCS system is reducing greenhouse gas emissions, is operating safely and effectively, and that any issues or anomalies are promptly addressed.

Geophysical subsurface characterization and monitoring in CCS and MMV projects has matured greatly, and many CCS projects are underway globally to identify suitable storage reservoirs. However, the availability of technology-driven solutions to enable and manage CCS projects is insufficient to tangibly affect global CO_2 emissions at the level desired by common net zero goals. According to a 2020 white paper by the Global CCS Institute, the results from a range of scenario models shows that CCS has an important role to play in meeting long-term targets, but that current rates of deployment are insufficient. For example, in the IEA Sustainable Development Scenario (SDS), which is consistent with meeting the goals of the Paris Agreement, over 2 000 CCS facilities would need to be in operation by 2050, requiring a build rate of 70-100 facilities per year. This compares to an average build rate over the past decade of one facility per year.

The Paris Agreement is a legally binding international treaty to limit global warming to well below 2°C and pursuing efforts to limit it to 1.5°C, whilst aiming to strengthen each country's ability to deal with the impacts of climate change and as a support mechanism to achieve national goals. Article 6 of the Paris Agreement is an enabler that will help countries cooperate to meet global emissions reductions targets by: using international carbon markets; allowing transfers of emission reductions between countries; and providing a framework for greenhouse gas emissions to be balanced globally. Several relevant models are correspondingly considered below to support the wide-scale deployment of CCS in economically viable ways.

The Paris Agreement and CCS

Under The Kyoto Protocol, an international treaty which extended the 1992 United Nations Framework Convention on Climate Change, the emphasis of climate action was firmly on *emission reductions*. The Paris Agreement, however, requires that Parties seek "to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century", thereby embedding the concept of *net zero* into global climate change mitigation approaches.

Aspects of net zero offsetting discussed in the past include the pathways to net zero emissions, the importance of carbon dioxide removal (CDR) in balancing residual emissions, and the political and regulatory risks involved with pursuing CO_2 removals to meet net zero goals.

In respect of The Paris Agreement, the types of NDC (nationally determined contributions) targets so far communicated by many developing countries are based on reducing GHG intensity or reductions against a

'business as usual' scenario, either of which can allow for absolute emissions to rise over time. In a nutshell, existing emission reduction units are essentially counting "avoided emissions" (**Figure 1**).

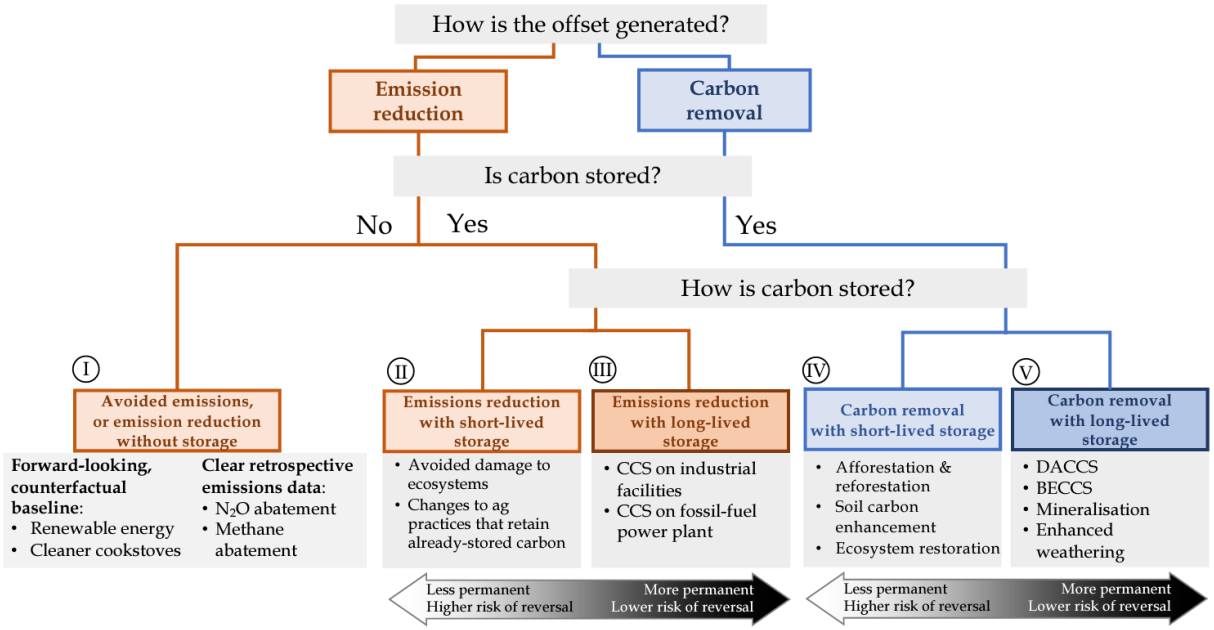

Figure 1. Taxonomy of Carbon Offsets. From Allen et al. (2020), The Oxford principles for net zero aligned carbon offsetting, Figure 1.

Report Navigation

"Integrating CCS in international cooperation and carbon markets under Article 6 of the Paris Agreement", by the IEA (International Energy Agency) Greenhouse Gas R&D Programme, discusses several potential approaches for incorporating CCS into international cooperation under Article 6 of the Paris Agreement.

Of relevance, The Paris Agreement requires each country to establish Nationally Determined Contributions (NDCs) toward mitigation targets. CCS could correspondingly be incorporated in NDCs as a mitigation measure—particularly through international cooperation on CCS. Under Article 6, mitigation outcomes transferred internationally between countries are referred to as Internationally Transferred Mitigation Outcomes (ITMOs).

CCS projects could be implemented via crediting approaches under Article 6, similar to how the Clean Development Mechanism worked under the Kyoto Protocol. This could drive investment in low-cost, early opportunity CCS projects.

The study starts with a comprehensive snapshot of the Article 6 rules, the types of markets and mechanisms that could evolve, and the units that could be traded. With respect to the key recommendations, Section 3 (pages 27-32) provides a concise introduction to the three models proposed, including consideration of linked carbon markets and trading of carbon reduction/removal units (CRRUs: p. 29), voluntary corporate use of carbon storage units (CSUs) for supply-side offsetting (p. 30), and country-led supply-side offsetting and "CCS clubs" using CSUs (p. 31).

Section 4.1 (pages 34-36) evaluates the potential effectiveness of each model in delivering geological CO_2 storage and provides estimates of potential CSU demand under Models 2 and 3.

Section 5 (pages 51-52) concludes by contrasting the models' implications for CCS deployment under Article 6 of The Paris Agreement. The uncertainty around Model 1's effectiveness for CCS is noted, while Models 2 and 3 using CSUs could provide more targeted incentives for permanent geological storage.

Three Models for Improved CCS Development

With reference to the comparative summary of the three models in **Table 1** below, Model 1 provides a representation of the mainstream climate policy approach of today. Models 2 and 3 are novel concepts that base cooperation around carbon storage and the producers and suppliers of fossil carbon but remain someway from actual implementation.

- **Model 1**: Linked carbon pricing policies between countries.
  - → This model is based on the trading of emission reduction and/or removal units (CRRUs).
- **Model 2**: Supply-side offsetting based on voluntary pledges by major independent energy companies (e.g., net zero or other types of commitments to carbon storage), potentially bolstered by national carbon storage obligation schemes in some countries. i.e., Voluntary (or partially regulated) system of storage targets for fossil fuel producers.
  - → Carbon storage units (CSUs) are used to drive bottom-up actions by corporations and countries for supporting CCS deployment. The relevance to Article 6 in a voluntary corporate context is limited, although voluntary actions could be supported by domestic regulations in supportive countries. The latter evolution could lead to international trades of CSUs with a resultant need to incorporate storage targets in NDCs (e.g., by countries implementing CSO/CTBOs (carbon storage obligation/carbon takeback obligation) or similar measures.
- **Model 3**: Supply-side offsetting based on country pledges to support geological carbon storage, potentially starting as results-based finance, before transitioning to other types of cooperation built upon the adoption of storage targets in nationally determined contributions (NDCs). The approach is also underpinned by CSUs.
  - → A multilateral "CCS club" of parties to the Paris Agreement. This model is based on a select group of likeminded countries with a common interest in fossil fuel production and CCS adopting CSUs to cooperate on plurilateral basis.

	MODEL 1 **Linked carbon markets**	MODEL 2 **Voluntary system of storage targets for fossil fuel producers**	MODEL 3 **Multilateral "CCS club" of Parties to the Paris Agreement**
UNIT TYPES	▶ Allowances (tCO_2e) ▶ Credited emission reductions or removals (tCO_2e)	▶ CSUs (tCO_2) measuring carbon stored in geological reservoirs	▶ CSUs (tCO_2) measuring carbon stored in geological reservoirs
MARKET TYPE/ MECHANISM	▶ Globally linked carbon market ▶ Fungible units between countries/systems ▶ Credits and allowances are fungible	▶ Quota system for offsetting carbon content of fossil fuels produced from geosphere, established either:[1] ○ Voluntarily by fossil fuel producing corporations ○ Mandated for fossil fuel suppliers under national carbon storage obligation (CSO/CTBO) policy ▶ Tradable CSUs used for compliance purposes	▶ Quota system based on offsetting carbon content of fossil fuels produced from geosphere, established through a national carbon storage pledge[1] ▶ Tradable CSUs used for compliance purposes
TARGET METRIC	▶ tCO_2e/yr emitted	▶ tCO_2/yr produced in fossil fuels [2]	▶ tCO_2/yr produced in fossil fuels
COMPLIANCE POINT	▶ Facility emissions (under ETS cap) ▶ Corporate emissions (for voluntary targets against corporate scope 1, 2 and/or 3 GHG emissions)	▶ Corporate inventory of CO_2 in produced fossil fuels ▶ Target ratchets over time vs. compliance metric, e.g.: 2020s (5-10%); 2030s (15-30%); 2040+ (60-100%) [1]	▶ National inventory of CO_2 in produced fossil fuels ▶ Target ratchets over time vs. compliance point, e.g.: 2020s (5-10%); 2030s (15-30%); 2040+ (60-100%) [1]
UNIT SELLERS	▶ Facility operators in national ETSs ▶ Developers (and/or intermediaries) under crediting programmes (emission reduction/removal activities)	▶ Geological storage site operators	▶ Geological storage site operators
CREDITED ACTIVITIES	▶ Emissions reduction, emissions avoidance, sink conservation; carbon removals (CRRUs)	▶ Geological storage (CSUs)	▶ Geological storage (CSUs)
SOURCE OF UNITS	▶ Compliance registries (e.g. via allocation process; through Article 6.4 mechanism) ▶ Voluntary registries (e.g Verra, Gold Standard etc)	▶ Registry dedicated to MRV/origination of CSUs ○ Voluntary ○ National (under CSO/CTBO)	▶ Registry dedicated to MRV/origination of CSUs, operated by the CCS club, either through UN or private system
UNIT BUYERS	▶ Corporations acquire units through market ▶ Acquired units surrendered to governments	▶ Fossil fuel producers/suppliers	▶ National governments (direct CSU procurement) ▶ Fossil fuel producers/suppliers, where govts. devolve CSU acquisition through national CSO/CTBO policy
USE OF UNITS	▶ Corporations surrender to government to demonstrate compliance with caps ▶ Government retires surrendered units to demonstrate compliance with NDC targets/caps ▶ Corporations retire units as offsets against corporate GHG inventory	▶ Corporations retire CSUs in registry to demonstrate compliance against target metric	▶ Govts. retire CSUs in registry to demonstrate compliance against target metric

Table 1. [1]Size of offsetting quota determined based on SAFE-Carbon rate described by Allen et al. (2009), The case for mandatory sequestration?. [2]In Model 2, carbon extraction can be proxied as embodied carbon or corporate Scope 1 and Scope 3 emissions (emissions from operations excluding bought-in energy and emissions from combustion of sold products, respectively). From p.33 of IEAGHG Technical Report 2023-01.

National and Global Initiatives to Raise the Level of Ambition for CCS

It remains uncertain whether technology-neutral market-based mechanisms can deliver significant amounts of permanent geological storage of CO_2 (Model 1). Experiences suggest that they are poorly suited in supporting deployment of higher cost climate change mitigation technologies such as CCS without the use of supplementary measures. Despite the assumption that carbon prices will rise over time and offer greater stability that may encourage investment in CCS, high levels of uncertainty persist. Carbon markets could however lead to some near-term deployment of lower-cost CCS projects (such as those involving CO_2 utilization or high purity CO_2 sources, for example) but crediting of such activities could pose some environmental integrity risks. Integrity concerns could be addressed with certain adjustments, but the effectiveness could be limited if the NDC is not particularly ambitious.

As noted above, CSUs are proposed as a new tradable unit representing tons of CO_2 geologically stored. CSU-based policies under Models 2 or 3, based on the use of storage targets or quotas, could provide a supplementary mechanism to ensure that more mitigation options include the geological storage of CO_2.

For example, CSUs could be used in supply-side offsetting systems that place storage obligations on fossil fuel producers. The IEAGHG report correspondingly examines how CSUs and CRRUs from CCS could potentially be transferred as ITMOs. CCS could also generate tradeable units in the form of CRRUs that represent tons of CO_2 emissions reduced or removed from the atmosphere, and CRRUs could be traded between countries to help meet NDC targets.

By creating two units (CRRUs and CSUs) and two points of compliance (carbon emissions and carbon production), trades in CSUs can act as a supplement to carbon price signals in the conventional carbon market. **Figure 2** provides a schematic illustration of the dual focus upon demand-side and supply-side considerations.

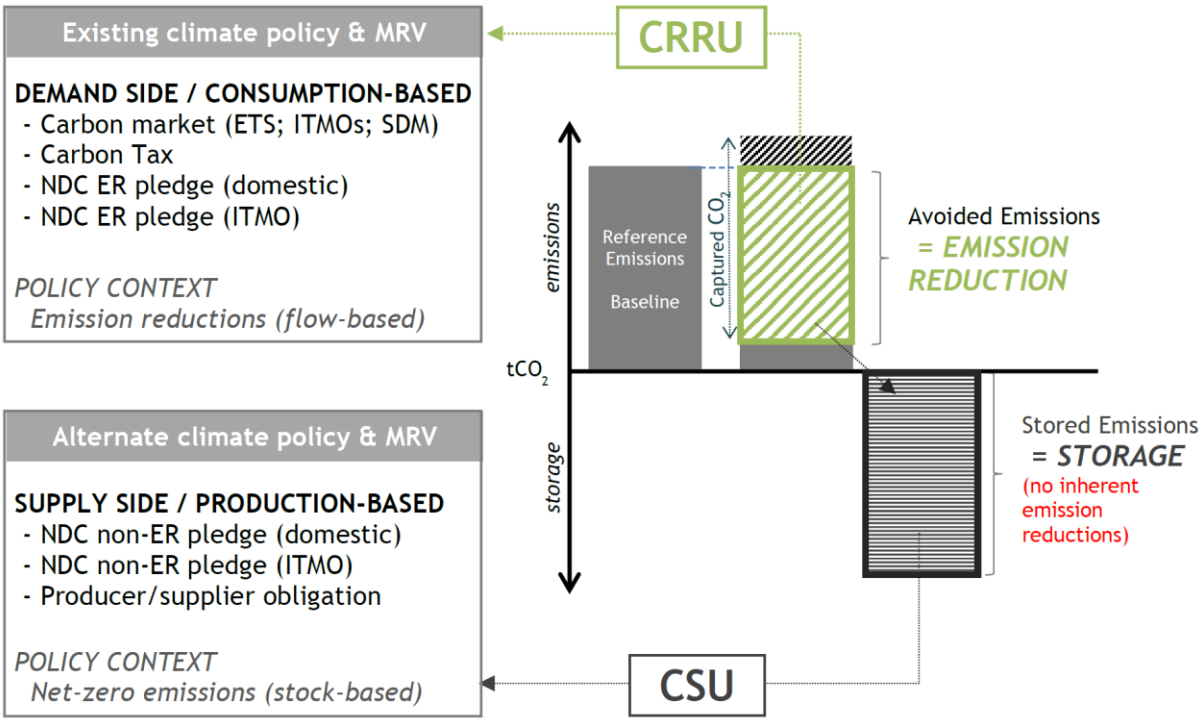

Figure 2. Relationship between emissions reduction and carbon storage. From IEAGHG Technical Report 2023-01, Figure 3-1.

Key: CRRU = Carbon Reduction/Removal Unit; CSU = Carbon Storage Unit; ETS = Emissions trading scheme; ITMO = Internationally Transferred Mitigation Outcome; SDM = Sustainable Development Mechanism under Article 6.4 of the Paris Agreement; MRV = Measurement, Reporting and Verification, ER = Emission reduction.

Figure 3 compares the scale of potential CSU demand under the corporate-led (Model 2) and country-led (Model 3) supply-side offsetting models. Under Model 2, fossil fuel exporters could adopt novel NDCs based on achieving "net zero in the geosphere" using CSUs to offset exported carbon through domestic CCS and carbon removal. Private sector energy companies could use CSUs to voluntarily offset their carbon production footprint and

demonstrate net zero supply-side emissions. Attention could also be given to the development of more robust MMV/MRV standards and registries specifically for certifying permanent geological CO_2 storage.

Under Model 3, CSUs could also underpin "CCS clubs" where groups of countries cooperate on achieving storage targets and financing CCS, starting outside Article 6 but potentially transitioning into the Paris framework.

The evaluation within the report indicated that a top-down, country-led approach (Model 3) could be more effective in enhancing geological storage because the scope of the obligation would extend into national energy companies as opposed to only major independent countries (Model 2). Gaining agreement to adopt storage targets across multiple countries under Model 3 is likely to be challenging but Model 2, bolstered by a few pioneering countries implementing supporting policies, may be more practical for implementation. An approach built on CSUs could also help to provide additional financing for CCS and a pathway towards technological removals and at a national level, adoption of complementary storage targets can also help to enhance progression in NDCs.

Countries considering carbon takeback obligations/carbon storage obligations could undertake detailed design studies to inform implementation, such as determining point of compliance and managing imports. Governments could provide targeted incentives for early CCS projects to help build capacity, experience, and confidence in geological storage. Multilateral platforms like the Clean Energy Ministerial, a partnership of the world's key economies working together to accelerate the global clean energy transition, could be utilized to initiate government dialogues on supply-side offsetting approaches and "CCS clubs".

It is important to note that the volumes of CSU demand represent the global total, of which only a portion may ultimately be traded alongside oil and gas, and that in both Model 2 and Model 3, the source of CO_2 is immaterial to the policy approach. Overall, Models 2 and 3 are believed to offer a coherent pathway to support technological CO_2 removals, building off from CCS deployment approaches.

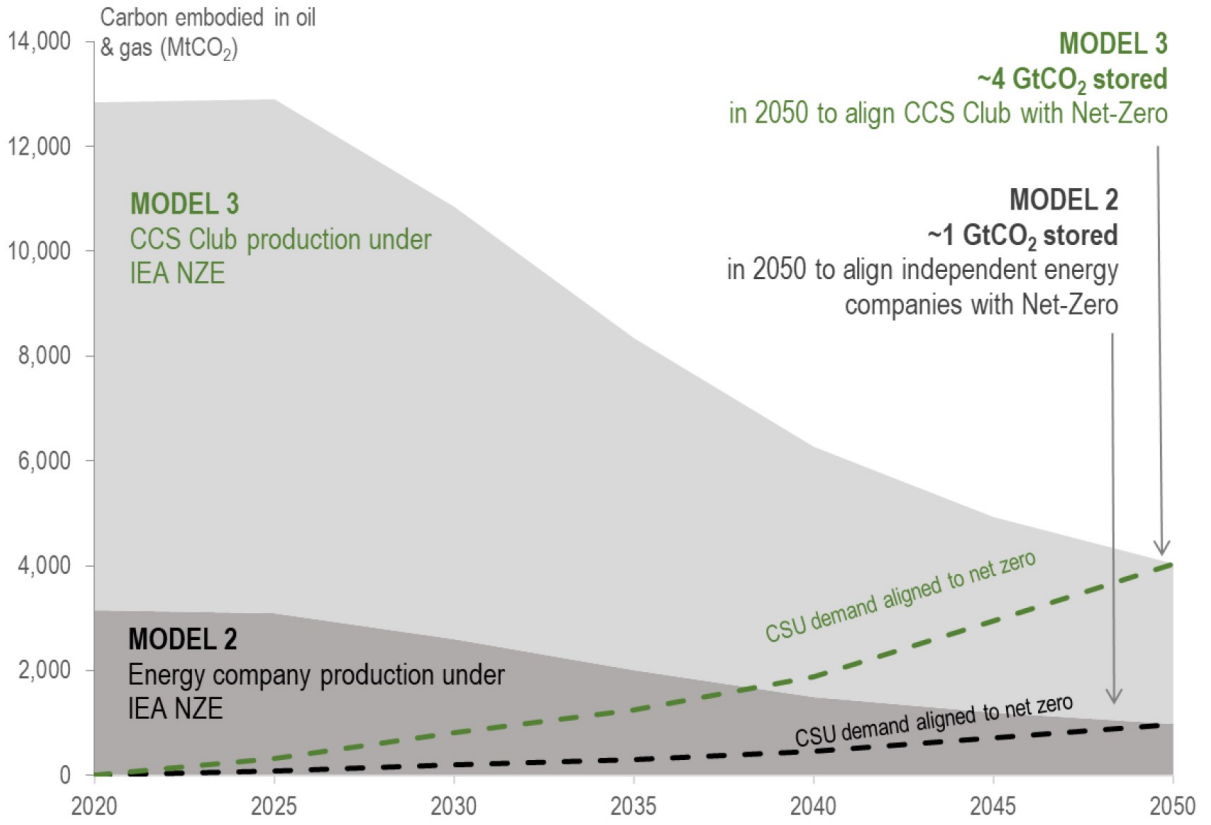

Figure 3. Potential CSU demand (tCO_2 stored) in Models 2 and 3 over the years 2020-2050. From IEAGHG Technical Report 2023-01, Figure 3-1.

Summary

Article 6 of the Paris Agreement facilitates international cooperation to achieve global emissions reduction targets using international carbon markets. This framework allows for emission transfers between countries, ensuring a global balance in greenhouse gas emissions. Carbon Capture and Storage (CCS) is a pivotal technology for substantial and prolonged reduction in atmospheric CO_2, and its integration into the Paris Agreement can be achieved through various mechanisms including emissions trading, governmental transfers, and CCS-specific approaches. Three central models for integrating CCS under Article 6 are proposed: linked carbon pricing policies, a voluntary system of storage targets for fossil fuel producers, and a multilateral "CCS club." While technology-neutral market mechanisms might not efficiently promote CCS, policies based on Carbon Storage Units (CSUs) can bolster its inclusion in more mitigation strategies. Though the future of a CSU mechanism is still uncertain, all proposed models contribute to the enhancement of CCS in global climate strategy.

Further Reading

- Allen, M.R., Frame, D.J., and Mason, C.F. (2009). The case for mandatory sequestration? Nature Geoscience, 2, 813-814.
  → This paper proposed the concept of supply-side offsetting and "SAFE-Carbon" that underpins the idea of using carbon storage units (CSUs) to incentivize geological storage.
- Allen, M.R., K. Axelsson, B. Caldecott, T. Hale, C. Hepburn, C. Hickey, E. Mitchell-Larson, Y. Malhi, F. Otto, N. Seddon, and S. Smith, 2020. The Oxford principles for net zero aligned carbon offsetting. Oxford Net Zero.
  → Some observers have suggested that net zero requires offsetting strategies to be increasingly geared towards removals rather than emission reductions or avoided emissions. The authors furthermore propose that offsetting needs to be focused on long-lived storage, primarily geological storage.
- IPCC (2018). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.
  → Highlights the significant role and scale of CCS envisaged in pathways aligned with the Paris Agreement's 1.5°C goal.
- IEA (2021). Net Zero by 2050.
  → Shows the extensive use of CCS anticipated under IEA's net zero roadmap, projecting around 7 GtCO2 stored by 2050.
- UNFCCC (2018). Guidance on cooperative approaches referred to in Article 6, paragraph 2, of the Paris Agreement. CMA.2.
  → Provides the agreed guidance and rules for international cooperation under Article 6 of the Paris Agreement.
- Zakkour, P.D. and Heidug, W. (2019). A mechanism for CCS in the post-Paris era: Piloting results-based finance and supply side policy under Article 6. King Abdullah Petroleum Studies and Research Center discussion paper.
  → This paper develops the concept of using CSUs and "CCS clubs" under Article 6, providing an important basis for the models evaluated in the report.