2021 THOUGHT LEADERSHIP

UNLOCKING PRIVATE FINANCE TO SUPPORT CCS INVESTMENTS

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CONTENTS

KEY MESSAGES

The need for CCS

Carbon capture and storage (CCS) comprises a group of technologies that prevent carbon dioxide (CO_2) from being released into the atmosphere. The capture of CO_2 from gas streams is not new. CO_2 capture technologies based on chemical solvents (amines) were first commercially deployed in the 1930s to separate CO_2 and other acid gases from methane in natural gas production. The first commercial CCS facility commenced operation in 1972 at the Val Verde Natural Gas Plant in west Texas USA. This facility is still operating as the Terrell gas processing facility. CO_2 captured from natural gas processing at Terrel is transported via a pipeline to oil fields where it is injected for Enhanced Oil Recovery (EOR). The first use of CCS purely for climate mitigation was at the Sleipner natural gas processing facility in the North Sea. This facility has permanently stored about 0.9 million tonnes of CO_2 every year since 1996.

As the world's emissions have continued to rise and the global carbon budget diminishes, climate experts have increasingly cited the use of CCS in their scenario models whereupon the technology is used to permanently store CO_2 in geological formations.

One of these models is the International Energy Agency's Sustainable Development Scenario (IEA-SDS) which is aligned with the goals of the Paris Agreement. It starts with the United Nations Sustainable Development Goals and then works back to set out what would be needed to deliver these goals in a realistic and cost-effective way. The IEA-SDS requires 15% of the world's emissions reductions to be achieved using CCS.

Private investments are needed to meet CCS capital requirements

The need for CCS in the IEA-SDS translates to an estimated 70-100 CCS facilities built per annum, for which we estimate the total capital requirement to be between US$655 bn and US$1280 bn. To achieve this, the private sector must be incentivised to invest in CCS because the capital requirement far outstrips what governments are willing to pay in the timeframe required. This means most of the funding for CCS is to come from debt, capital markets, and other sources such as sovereign wealth funds, which currently do not directly fund CCS at a meaningful scale.

Governments can create an enabling environment for investments in CCS

Thus far, the 28 commercial CCS facilities around the world have mostly been financed on the books of state-owned enterprises and large corporations (through corporate finance), and, in most cases, these projects have relied on the commercial value of CO_2. What is clear is that if there is a business case for CCS, the private sector will invest in and deliver CCS projects.

However, for CCS to be deployed at scale, governments can support the deployment of CCS in two ways. Firstly, they can create climate-based policies to provide a reliable source of revenue for CCS projects. These policies may take the form of various mechanisms, so long as they place a sufficient value on CO_2 to create a business case for CCS investments. Secondly, smaller emitters with more constrained balance sheets cannot invest in CCS through the corporate finance model. Instead, they will require support to enable their

investments through project finance. To enable project finance, governments can mandate specialist financiers such as multilateral agencies (MLAs) and credit export agencies (ECAs) to support CCS investments. Support from these specialist financiers will allow the participation of commercial lenders in CCS projects as they can fund the most high-risk areas of projects.

Sustainable finance can benefit CCS deployment

As CCS deployment accelerates, sustainable finance has an important role to play, whether through innovative lending instruments such as sustainability linked loans (SLL's) or through capital markets, for example, bond markets. SLL's have proved particularly popular, despite their recent emergence, whilst green bonds have supported the deployment of other sustainable infrastructure projects such as offshore wind and solar farms. Issuances of green bonds have accelerated over the past decade and yields of green bonds are now often less than conventional debt. As new standards emerge to include CCS within the taxonomy of green and sustainable bonds, it is essential that large capital flows find their way to CCS projects.

Potential for climate finance to support CCS deployment in developing countries

For CCS to achieve widescale deployment, however, deployment will also be necessary in developing countries, where there are relatively few facilities. The risks that beset CCS investments in developed nations are compounded in developing countries. Climate finance must play an important role in helping countries to create an enabling environment for CCS projects.

Firstly, vertical funds such as the Green Climate Fund and their agencies can provide concessional financing to support the capital needed to fund pilot projects that serve the purpose of derisking investments. Vertical funds can also support the development of policy mechanisms that place a value on CO_2 to create a business case for investing in CCS.

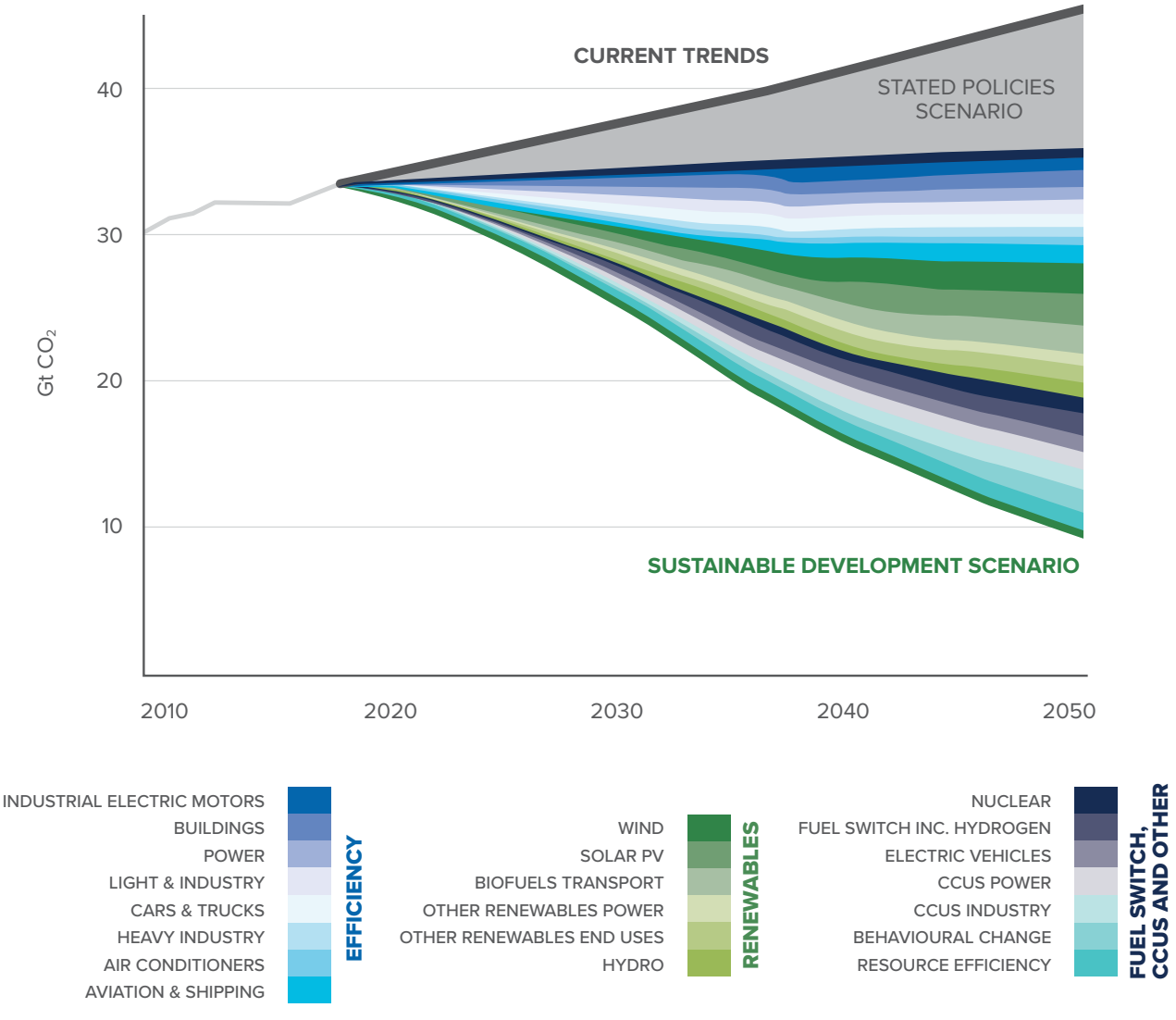
Secondly, international carbon markets are also a means through which CCS projects in developing countries can generate revenue. As international climate negotiations get underway at COP 26, the developments surrounding Article 6 of the Paris Agreement will help to ensure CCS projects in developing countries can generate revenue through carbon crediting mechanisms.

1.0 CCS IS NEEDED AT SCALE

Climate change is often referred to as the greatest challenge of our time. To avoid the irreversible effects of climate change, global average temperatures should remain within 2 degrees Celsius above pre-industrial levels. The Paris Agreement is a landmark achievement for the world as it legally binds 196 countries to a common goal of limiting global warming to well below 2 degrees, preferably to 1.5 degrees Celsius compared to pre-industrial levels. Achieving this requires countries to peak their emissions as soon as possible to aim for climate neutrality (referred to as net-zero emissions) in the second half of this century.

There are many scenario models that have been developed to define the actions that will be needed over the coming years. One such scenario is the International Energy Agency's Sustainable Development Scenario (IEA-SDS), which estimates that global annual emissions must come down from around 33 $GTCO_2$ today to 10 $GTCO_2$ in 2050. Figure 1 compares the effects of the world's existing policies (Stated Policies Scenario) with those of the IEA-SDS, describing the wide range of mitigation technologies and each of their required contributions.

Figure 1 The IEA's Sustainable Development Scenario (International Energy Agency, 2020)

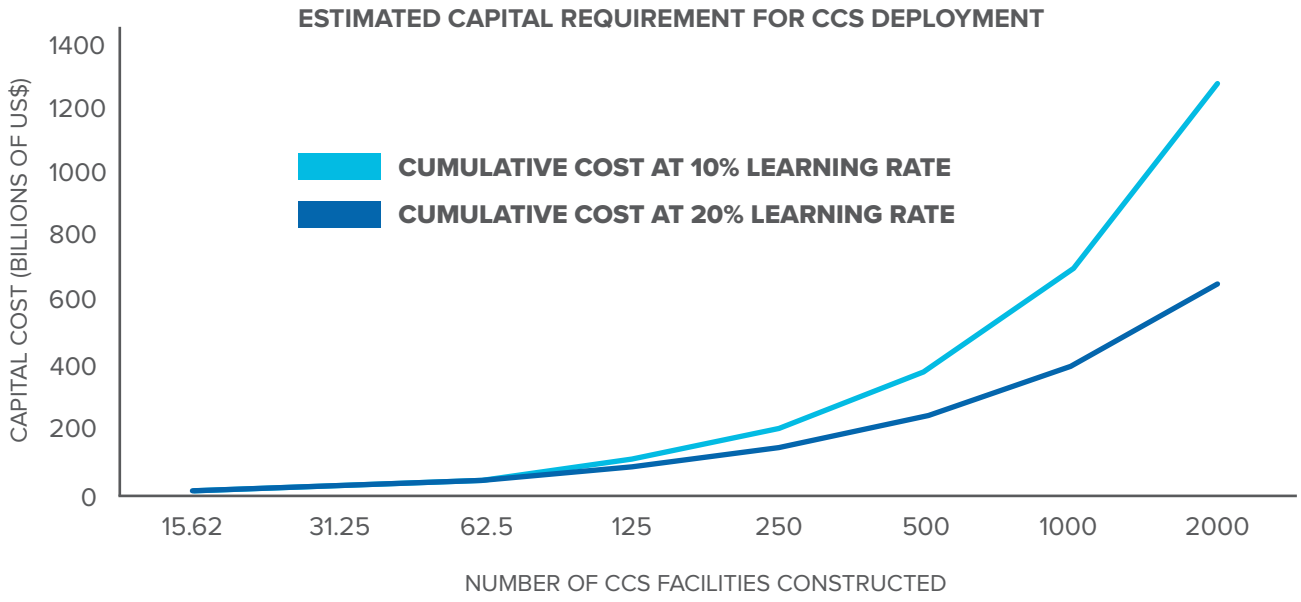


For its part, Carbon Capture and Storage (CCS) is required to mitigate emissions across hard to abate sectors, including firm power generation as well as in the manufacturing and chemicals industries, amounting to 15% or 5.6 GT CO_2 per year.

Approximately two thousand commercial CCS facilities constructed between now and 2050 will be required to meet the IEA-SDS, approximately one hundred times more than are currently in operation. For this to happen, the build rate of CCS facilities must be ramped up: from 28 facilities constructed over the past forty years to around 70 to 100 new facilities built each year.

The capital requirement for the deployment of CCS at this scale is vast, but costs are anticipated to come down over time through deployment. Estimates for the CCS learning rate vary depending on various factors including location, and the sector within which the technology is being applied. Experts estimate that costs can come down by 10% to 25% for every doubling of capacity installed (Rubin, Davison and Herzog, 2015), which gives rise to a total cumulative capital requirement that we estimate to be between US$ 655 bn and US$ 1280 bn (Figure 2). In either scenario, this has drastic implications for how CCS projects are financed.

Figure 2 Estimated costs for deploying CCS to meet emissions targets of the IEA-SDS. For each doubling of global CCS capacity, a reduction in cost, due to the learning rate, is achieved. These two scenarios estimate the overall cost for both a 20% and 10% learning rate.



2.0 THE COST OF WIDESCALE DEPLOYMENT REQUIRES PRIVATE INVESTMENT IN CCS

CCS facilities are large-scale, capital intensive infrastructure projects, requiring capital in the order of hundreds of millions, or sometimes billions of US dollars. During the early stages of CCS deployment, financial support from governments is necessary to mobilise private capital for CCS projects. In order to deploy CCS at the scale required by the IEA-SDS, most capital will have to come from the private sector with some support from government via special financiers (see Chapter 4).

Unlike other mitigation technologies, CCS does not generate revenue since it does not produce a product such as electricity. The only means by which a positive return on investment in CCS is achieved is when the service provided by CCS (CO_2 emissions abatement) is monetised. This requires that the value placed on the CO_2 captured, transported and stored exceeds the cost of CCS. The value on CO_2 can be explicit, such as a carbon tax, or implicit, such as a licence to operate. In the absence of this value, investors will not invest.

As we shall see in Chapter 4, investments have been enabled through public policy incentives that place a sufficient value on CO_2. These have often been supplemented by the sale of CO_2 under an offtake agreement. When revenue generated through either of these sources is insufficient, the only way to maintain an acceptable return on investment is by reducing the capital required from investors. As a result, several CCS projects have relied significantly on capital grants to reach a positive financial investment decision (FID).

However, the capital required to achieve widescale deployment massively outstrips what governments are willing to provide in the timeframe required. By contrast, there are trillions of dollars currently locked up in the private sector across financial markets, capital markets as well as other sources of funding such as sovereign wealth funds. Private funding can come from a wide range of investors, especially banks, as they are experts in funding infrastructure projects. Unlocking this liquidity will require governments to develop ambitious policy incentives that enable viable business models for CCS projects.

3.0 BARRIERS TO PRIVATE INVESTMENT IN CCS

To understand government's role in creating an enabling policy for CCS, it is first important to determine the key barriers to investment in CCS. In a similar manner to other large-scale climate mitigation projects, the development and operation of CCS projects engenders risks that, if not properly managed, create barriers to investment.

CCS investment risks can be broadly categorised into two broad groups:

- **General project or mitigable risks, being those that are mitigated through learning by doing.** As more CCS facilities have been constructed, project developers have learned how to manage these risks.
- **Hard-to-reduce risks**, which are the risks that cannot be mitigated in the same way by private sector actors and should, therefore, be addressed by government which is best suited to manage them.

For the purposes of this paper, it is important to note that if hard-to-reduce risks are not properly managed, CCS projects are unlikely to reach a positive FID. The Global CCS Institute has previously identified the following hard-to-reduce risks (Zapantis, Townsend and Rassool, 2019):

- **Revenue risk arising from an insufficient value on CO_2 emissions**
  For a potential capture plant developer, the main impediment to investment is often the lack of a clear and compelling CO_2 price signal that places a sufficient value on emissions reductions. Without this, there is no incentive to incur the costs of constructing and operating the capture facility.
- **Cross-chain risk arising from the interdependency of the CCS value chain**
  CCS projects require the coordination of several activities, often with multiple investment decisions, and each with long lead times. Taking decisions to develop each element of the CCS value chain exposes various risks associated with relative timing and capacity management. This interdependency continues during the operational phase. One component of the CCS value chain's failure may affect others' costs and revenues and prevent the value chain from performing as a whole.
- **Long-term storage liability risk**
  While the risk of leakage from geological storage is diminishingly small, it is not zero. This presents a significant risk to CCS project owners if they remain liable for the risk of leakage over an indefinite period since the value of this contingent liability is very likely to increase with time (e.g. as carbon prices rise).

For CCS projects to become investible, public policy plays an essential role in managing hard-to-reduce risks. To this end, there have been several ways governments can and have responded to each of them. Table 1 provides examples of the types of policy responses that governments can consider.

Table 1 Potential policy responses to overcome hard-to-reduce risks

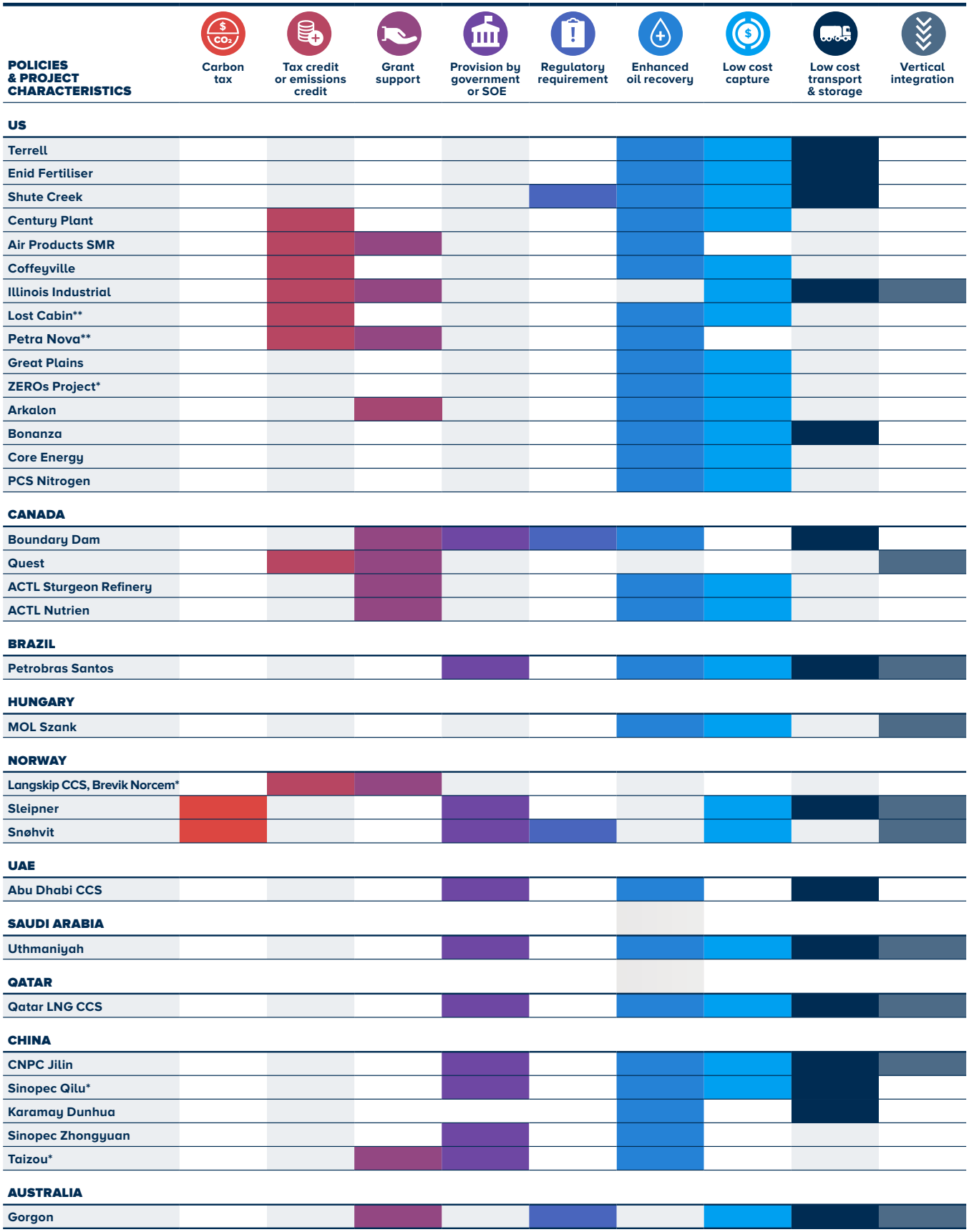
HARD-TO-REDUCE RISK	EXAMPLES OF POTENTIAL POLICY RESPONSE
Insufficient value on CO_2 emissions	Introduce a value on CO_2 emissions reductions through a carbon tax, tax credit, emissions trading scheme, CCS obligation, emissions performance standard, or government procurement standards. A robust policy mechanism that places a sufficient value on CO_2 will support investments in capture facilities that can then pass on a share of the benefit to transportation and storage providers.
Interdependency of the CCS value chain	Provide capital support to enable the development of shared CO_2 transport and storage networks, focusing on integrated hubs and clusters where economies of scale can reduce unit costs and a diversified source of emissions can reduce the risk of CO_2 transport and storage asset stranding. Governments may initially own the T&S infrastructure. As more emitters connect to the network the interdependency risk will be reduced. Government may then choose to sell the infrastructure to the private sector for a profit.
Long term storage liability	Legal and regulatory frameworks may place limits on private investors' exposure to any long-term storage liabilities. This can be achieved by transferring these liabilities to the state after a specified period of post-closure, and subject to acceptable performance of the storage facility. Jurisdictions may specify a minimum number of years for which operators will have to continue post-closure monitoring of a site. Another way long-term storage liability can be managed is through a risk capping mechanism. This would allow the private sector operator to take responsibility for risks incurred below a cap, whilst the government would take responsibility for all additional risks above that cap. The value of the cap could be a function of the balance of public and private equity in the storage operation, with higher private equity translating to a higher cap.

While the policy mechanisms that governments may choose can vary significantly, they all achieve the same objective: to create a business case for investing in CCS. To help examine this, Figure 3 provides information on the current fleet of commercial CCS facilities in operation or construction[1]. Understanding the key trends during these early stages of deployment provides some insight into what has worked in terms of policies and the nature of CCS investments.

FOR CCS PROJECTS TO BECOME INVESTIBLE, PUBLIC POLICY PLAYS AN ESSENTIAL ROLE IN MANAGING HARD-TO-REDUCE RISKS.

[1] CCS facilities in operation or construction as of April 2021

Figure 3 The location of commercial CCS facilities in operation, project characteristics and enabling policies.



*In construction

**Operation suspended.

Figure 3 shows that investments have been incentivised through a range of mechanisms. While each specific mechanism may differ, the following features are common in CCS projects:

- **CCS deployment has occurred chiefly across low-cost capture opportunities.** These are opportunities, such as natural gas processing, where the separation of CO_2 gas from methane is standard industry practice. This substantially reduces projects' capital requirement since the capture facility's costliest component is pre-existing. This limits the additional cost of CCS to compression, transport and storage.
- **Most of the world's CCS facilities rely upon revenue generated from the sale of CO_2 for enhanced oil recovery (EOR) purposes.** This is because, in the absence of a policy mechanism that places a sufficient value on the capture, transportation and storage of CO_2, practices such as EOR can provide a reliable stream of revenue to CCS projects. This occurs most frequently by selling CO_2 gas to a third-party off-taker, whereby the value of CO_2 is indexed to the oil price. This practice predates the use of CCS for climate considerations, with the first facility having been built in the United States in the 1970s. This helps to explain why the United States is now the country with the most CCS activity since the use of CO_2 for EOR started there.
- **Most CCS facilities have been developed on the books of large corporations or state-owned enterprises (SOEs).** These emitters have tended to have deep knowledge of the technologies and practices that underpin CCS, primarily because of their knowledge of the oil and gas sector. It follows that they are more comfortable with CCS project risks than other emitters and are large enough to absorb the costs of these risks if they materialise.

The combination of low-cost opportunities, enabling policy measures, the sale of CO_2, and corporate investments, has given rise to the current fleet of CCS projects. However, these circumstances cannot support deployment at the accelerated rate required to meet climate objectives because:

- The opportunities for commercial sale of CO_2 will be limited and cannot absorb the scale of emissions that will need to be captured and stored through CCS. Further, there are logistical barriers to selling CO_2 since not all large emitters are within proximity of those seeking to offtake CO_2.
- Meeting climate targets requires the application of CCS to a broad range of industries, not just the lowest cost opportunities.
- Most of the world's companies that have a high need for CCS to reduce their emissions will not be in a financial position to fund CCS projects through their balance sheets.

To overcome these challenges, new projects will have to come from a more diverse group of emitters. In turn, their investments in CCS will be driven primarily by climate-based policies as opposed to the commercial value of CO_2. For this to happen, policy frameworks should include measures to enable project finance. The importance of project finance to CCS deployment is discussed further in the following chapter.

4.0 PROJECT FINANCE INCREASES PRIVATE INVESTMENT IN CCS

This section describes the role of different financing structures to deliver widescale CCS deployment.

As discussed in the previous chapter, funding for many of the world's commercial CCS facilities has been channelled through large corporations and state-owned enterprises. Projects developed in this way are funded directly by the corporation and have not required the approval of commercial financiers to achieve positive FID. This form of structuring is known as corporate finance, and its prevalence across CCS projects underlines the importance of policy and financial derisking if the technology is to be deployed rapidly and at scale. Currently, CCS projects are perceived to be too high-risk to be funded using alternative means.

Corporate finance

The corporate finance model involves a single corporation that develops the project and finances all of its costs. The corporation may choose to implement the project through a subsidiary, which would then be consolidated into the corporate's financial accounts. Since it has full ownership of the subsidiary, the corporation reaps all the benefits of the project. Still, it is also exposed to all of the risks and liabilities, which can be significant should the project not perform as expected. Such an arrangement makes it possible to raise debt at the corporate level, with the lenders having recourse to all of the corporate's assets in the event the project should not perform. This significantly reduces the interest rate applied to debt, making the latter relatively cheaper. Also, since the project management is internalised, this makes the entire corporate finance process attractive in terms of cost of capital and speed of implementation. Not all companies however, are large enough to develop projects in this manner. So, while corporate finance is efficient, it cannot deliver the volume of investments required to meet the number of CCS projects proposed under the the IEA-SDS.

Project finance

An alternative, and perhaps more scalable funding model, is project finance. It allows multiple equity investors to participate in a single project, and unlike corporate finance, the financiers have no recourse to the assets of project owners. Debt provided through project finance is referred to as non-recourse debt, and it is for this reason that this form of debt is charged at higher interest rates than corporate debt.

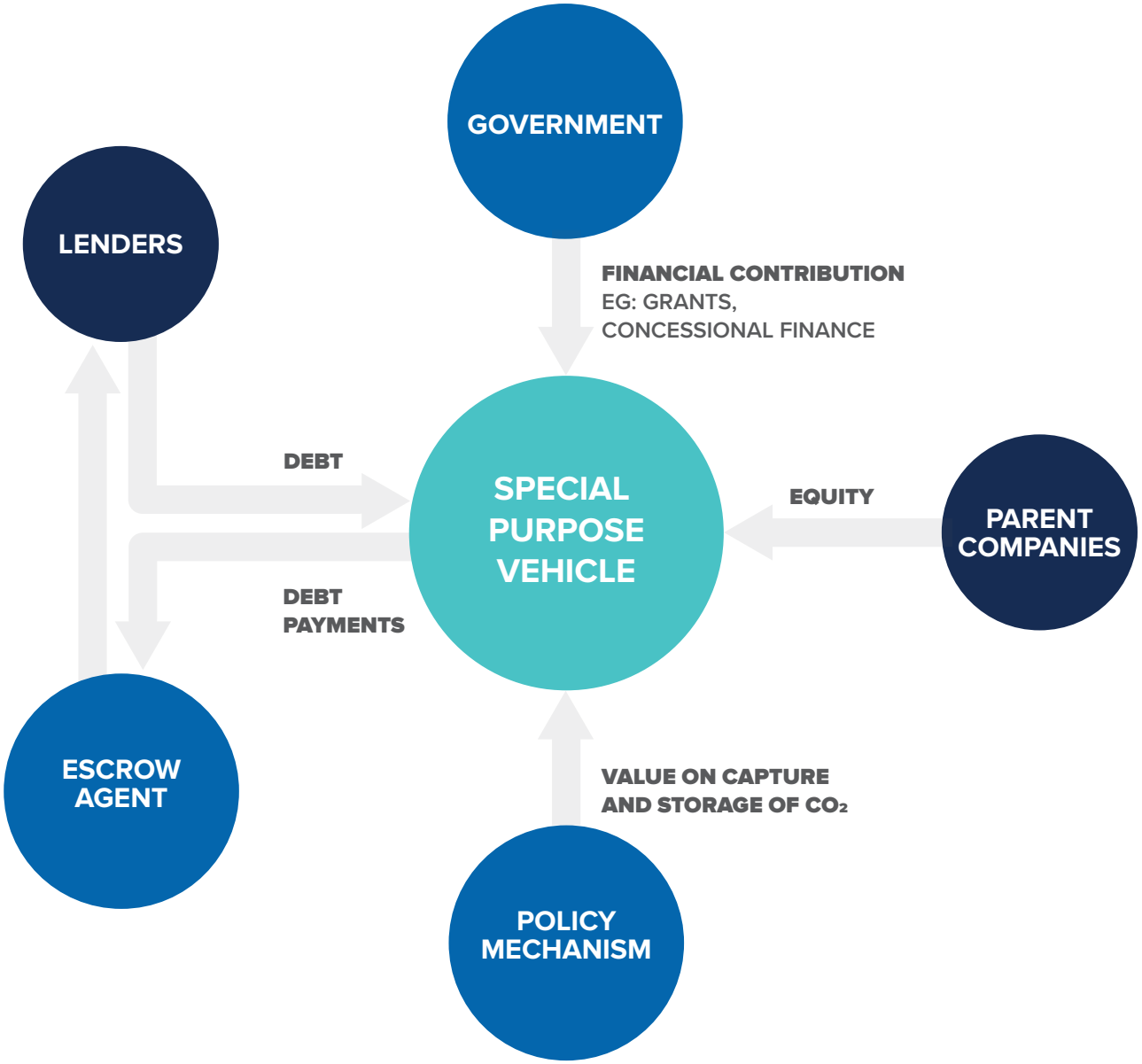
Under project finance, the project is set up through a standalone company, known as a special purpose vehicle (SPV), with each investor having an equity stake. Capital for the project is raised based on future cashflows, so both equity and debt investors are exposed to any uncertainty in the project's performance, thereby increasing the investment risk and subsequently the cost of debt.

The ratio of debt to equity – also known as the gearing – in project finance can vary significantly and will be dependent on the project specifics, availability of capital and risk profile of the project owners. Some projects may have a very high gearing of up to 85% debt, whilst others will be much lower, at around 50% debt. Each project is unique, and its gearing can depend on a wide range of variables, from the amount of equity available to the number and nature of risks and how they are managed. Since debt raised for project finance is secured entirely based on future cashflows, a lot of analysis is required before these types of projects can secure funding.

Large companies, such as utilities, will find that corporate finance suits their needs better than project finance. This is because large corporations have two distinct advantages: their ability to use cash flows from other operating activities and use their general creditworthiness to borrow money to fund projects.

Smaller companies which do not have the large balance sheets of corporations will find the project finance structure to be the more attractive and accessible option for funding CCS projects. Key to their participation in the project finance model will be their capacity to partner up with other investors. Project owners will need to form consortia to raise equity, whereas lenders will come together to provide syndicated project loans on the debt side. Figure 4 provides a simplified illustration of how a CCS project could be structured through project finance.

Figure 4 Illustrative example of how a project finance structure used to enable a CCS investment



Conditions for lending

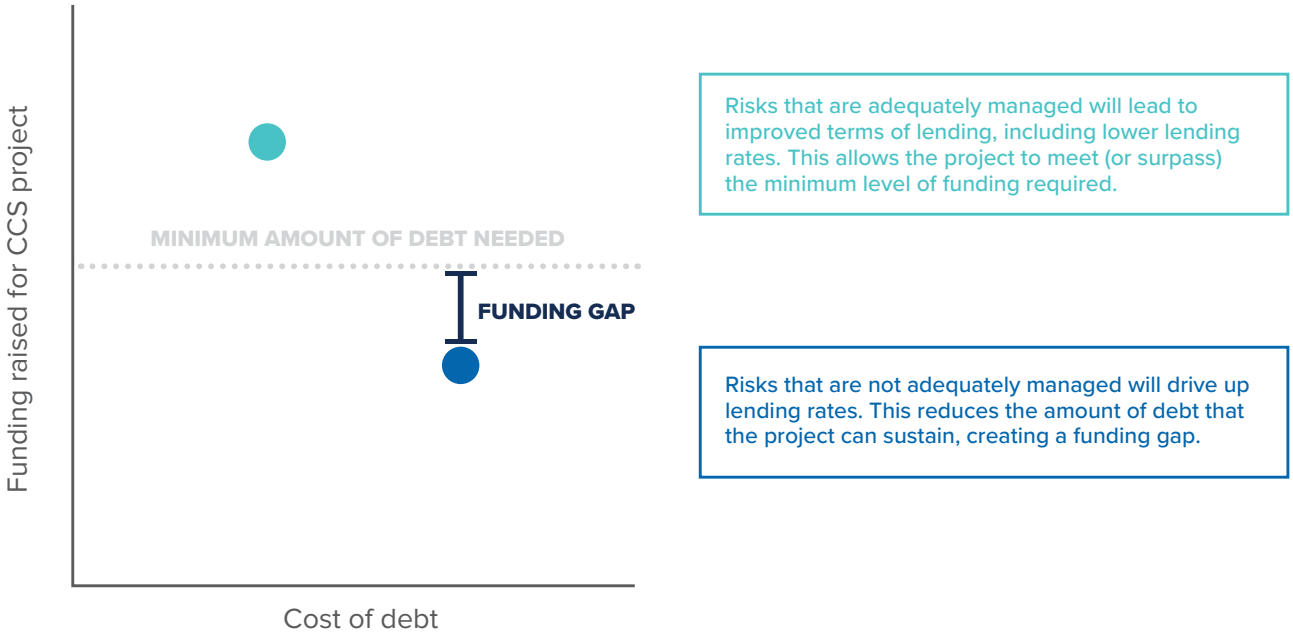
Since non-recourse debt commands higher lending rates, project costs will be sensitive to the proportion of debt in the capital structure of such projects. This is further compounded by any hard-to-reduce risks, which project developers cannot effectively mitigate.. If not properly managed, these risks will drive up the lending rates further, leading to high financing costs. This can significantly impact the amount of debt financing that CCS projects can raise.

Banks will require that CCS projects generate enough revenue to service their debts i.e., the revenue generated by the project is greater than all project costs, including the amount of principal repayment and interest due for each billing period. A measure of this is the debt-service coverage ratio (DSCR)[2], which lenders will set a minimum target for. This effectively limits the amount of debt that can be applied to a project. In cases when the revenues are too low in comparison to the cost of debt, this leads to a funding gap (Figure 5).

To close the funding gap, general projects risks should be allocated to the parties that are best placed to manage them. During the early stages of deployment, when general project risks are at their highest, CCS projects will have to rely on specialist financiers who can provide insurance for risks, loan guarantees and direct funding for components of CCS projects that commercial banks will otherwise charge at a premium or not fund at all.

Where a funding gap remains, this implies there are residual risks, at which stage it will be necessary for government to intervene. Whilst the private sector investors in the project are driven by expectations of a financial return, government can be driven by investments that deliver a public good. In this case, the public good is the mitigation of emissions through CCS. For this reason, government can take a financial loss by funding the component of the project where residual risks remain, thereby making the project economically viable. This closes the funding gap and enables the development of the project, which then goes on to de-risk investments in projects that follow.

Figure 5 Project risks can influence the amount of debt that is made available to CCS projects, and if not sufficiently well managed this leads to a funding gap



[2] DSCR is equal to the net operating income divided by the total debt service. The net operating income is the total revenue generated minus certain operating expenses not including taxes and interest payments.

Lenders and financial instruments

There are a host of different financiers that can support CCS projects. There are three types of financiers that, for the purposes of this paper, shall be referred to as specialist financiers: National Export Credit Agencies (ECAs), Multilateral Agencies (MLAs) and Developmental Financial Institutions (DFIs). Some of the main differences between specialist financiers and commercial banks are highlighted in Table 2.

Table 2 Specialist financiers and commercial banks' areas of financing

FINANCING TYPE OR SOURCE	EXAMPLES OF FINANCIAL INSTITUTIONS	ROLE	EXAMPLES OF SPECIALIST AREAS OF FINANCING
Commercial Banks	HSBC, Wells Fargo. BNP Paribas	Experts at pricing term debt to projects. Commercial banks are sensitive to risks.	
Export Credit Agencies (ECAs)	NEXI, UK Export Finance	ECAs provide risk guarantee to cover a significant proportion of a transaction. They also provide improved terms and conditions.	
Multilateral Agencies (MLAs) and Development Financial Institutions (DFIs)	World Bank Group, Asian Development Bank, Inter-American Development Bank, UK Infrastructure Bank[3] and the European Investment Bank.	Term debt providers that promote sustainable economic and social development in low-income member countries.	
Developmental Financial Institutions (DFIs)	FMO (Netherlands), DEG (Germany), Proparco (France), UK Infrastructure Bank[3] and OPIC (USA).	DFIs are owned by singular governments and are tasked with promoting sustainable economic and social development	

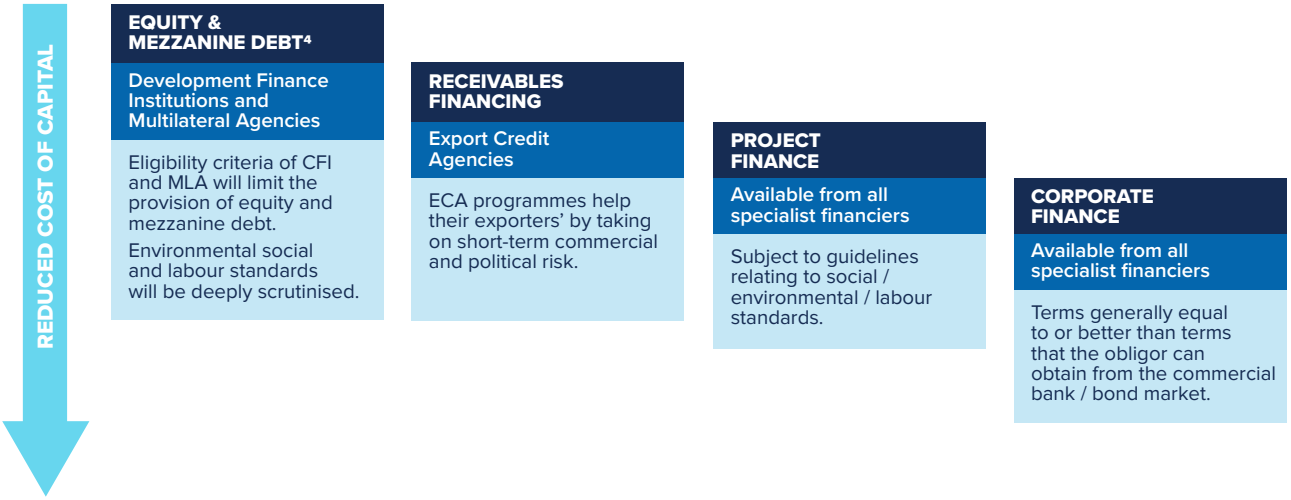
KEY

- EQUITY
- LONG-TERM DEBT
- MEDIUM-TERM DEBT
- POLITICAL OR COMMERCIAL RISK INSURANCE
- GUARANTEES
- CONCESSIONAL FINANCING

These specialist financiers are driven more so by countries' policy goals rather than conventional market forces. They are prepared to accept a much lower risk-weighted return on capital than other lenders. They have the capacity to help close the funding gap described in Figure 5, and will, therefore, have an essential role to play in the development of CCS projects. Figure 6 provides an overview of the different types of funding offered by each of the specialist financiers. For example, DFIs and MLAs will often provide the most expensive forms of capital (equity and mezzanine debt[4]) but at far lower rates than is available from commercial lenders.

[3] While the UK Infrastructure Bank is not strictly a DFI, it serves a similar purpose within the UK. The UKIB is to co-invest alongside the private sector and act as a cornerstone investor on key infrastructure projects including CCS investments

Figure 6 The different funding instruments and structures offered by specialist financiers



ECAs are government institutions or private companies operating on behalf of governments, providing finance to support national exporters competing for overseas sales. Project proponents will be able to partner up with CCS technology providers from a country where a suitable ECA is able to lend their support, such as in the form of loan guarantees and direct funding.

MLAs and DFIs are specialists at funding projects in relatively new sectors or high-risk environments, specifically those that are aligned with their development goals. Their objectives, experiences and diplomatic leverage often enable them to provide cover for risks in countries and projects that would otherwise struggle to access funding. One of the most prominent funders in large-scale climate infrastructure projects, is an MLA – the European Investment Bank (EIB). It has often played a key role by committing large amounts of debt to projects such as offshore wind during its early stages of deployment.

As the CCS sector evolves, investors will become more comfortable with general project risks, so the participation of financiers will diversify. At this stage, commercial lenders will play a more prominent role than during the early stages of deployment. Over time, commercial banks will gain confidence, becoming increasingly more important contributors of non-recourse debt for project finance.

It is important to note, however, that not all derisking occurs over long timescales. Like all large-scale infrastructure projects, CCS projects will have a varying risk profile across the different phases of development, construction and operation. Once a project is commissioned, its risk profile falls because risks are highest during the construction phase and lower during operation. This drop in the risk profile of a project can lead to the refinancing of a project's debt with more favourable terms of lending being applied. This, therefore, opens the door to private lenders who may not participate in the construction of the project, but will be attracted to the lower risk and lower returns nature of the operational phase.

As rates of CCS deployment increase, it is expected that a significant proportion of private funding will be raised from the private sector, for example, through the issuance of green bonds (see Chapter 5). Bond issuances can either be delivered at corporate or project level. For corporates, they serve to finance portfolios of CCS projects. For individual projects, these tend to raise financing from bond issuances through SPVs as part of a non-recourse, project finance structure.

[4] Mezzanine debt is a form of subordinate debt that bridges the gap between conventional debt and equity finance. It is more expensive than senior debt, which tends to be secured and is more likely to be paid back in the event of bankruptcy

5.0 ACCELERATING THE USE OF SUSTAINABILITY LINKED LOANS AND GREEN BONDS FOR CCS INVESTMENTS

Environmental, Social and Governance (ESG) criteria have emerged as an important factor in investors' behaviour. Lenders have responded to the need for improved ESG ratings by creating specialised forms of debt that link back to sustainability so that borrowers are incentivised to develop sustainable projects. A recent innovation in corporate finance has been sustainability-linked loans (SLL). In this arrangement, a borrower can use the proceeds for any purpose but is incentivised to raise the ESG performance of the project being funded. This is because an in-built pricing mechanism means that the loan is cheaper (lower lending rate) if the borrower achieves certain ESG-related targets. By the same token, if the borrower underperforms, the lending rate increases. Issuances of SLLs have grown rapidly in the past couple of years, with most of the issuances coming from the US (40%) and European region (39%) (HSBC, 2020). SLLs present emitters with a potentially attractive form of debt financing for CCS projects.

Banks and corporates will initially be an important source of CCS finance. Still, the scale of the necessary investment may easily exceed both their capabilities, notwithstanding the financial implications of COVID-19 that have yet to take hold. Bond markets[5], which can either be an alternative or supplement to debt and corporate finance, and have some of the largest flows of liquidity, may play a pivotal role in helping CCS meet its capital requirement for mass deployment. Bonds are also potentially more cost-effective than project finance since, often times, the interest cost of the latter is higher than the yield for investment-grade project bonds (Kaminker, 2015).

In recent years, green bonds have contributed significantly to the deployment of other mitigation technologies such as wind and solar. Green bonds are long term debt instruments that are specifically designed to fund environmentally friendly projects. A project or company that issues a green bond will use the proceeds to finance activities that fall within what green bond standards classify as 'green'. Climate change mitigation technologies are usually accepted as such, but there are exceptions.

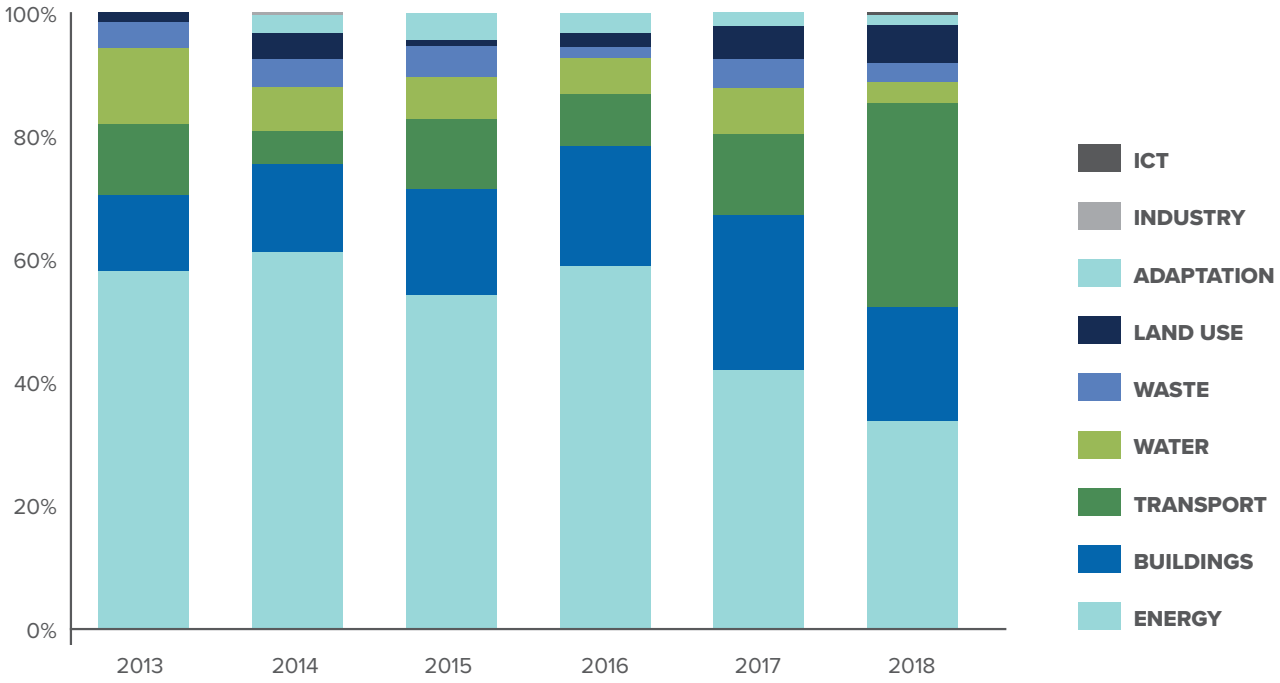
Green bonds can be issued by governments, banks, municipalities or corporations, but will first have to meet certain criteria prior to issuance. At a high level, the bond ensures that proceeds go to "green" assets (The Climate Bonds Initiative, 2018), which precludes some applications of CCS, for example, in coal fired power plants[6]. Bonds can also go on to obtain green labelling,

[5] Bonds are a form of debt that companies, governments or municipalities can raise. The borrower issues a bond with clear terms of the loan and interest payments as well as a maturity (when the loan amount or the principal will be paid back). The yield to maturity (YTM) of a bond is the total return on a bond if the lender holds onto it for the entirety of its lifetime and is a useful way of comparing the value of bonds. Bonds can be traded from one party to another and the income on bonds are generally taxable.

which becomes an option if projects comply with the ICMA Green Bond Principles or the LMA Green Loan Principles. While conventional bonds are taxable, green bonds come with tax incentives such as tax credits and tax exemptions. This feature of green bonds makes them particularly attractive to investors.

Over the past ten years or so, the market for green bonds has been growing rapidly. Global issuance surpassed US$250 billion in 2019, equivalent to approximately 3.5% of total global bond issuance (Ehlers, Mojon and Packer, 2020). Climate mitigation energy investments received most of the allocations (Figure 7).

Figure 7 The energy sector has received the most allocations of green bonds in Europe but its share is falling (The Climate Bonds Initiative, 2018).



Green bonds originally gained popularity because they offered financial institutions the opportunity to invest in environmentally friendly projects and companies. Initially, companies would make these investments for a slightly lower return as a means of demonstrating they were contributing towards the environment. Over time, these returns improved[7]. Today, climate related investments are regularly outperforming their counterparts (Westminster Forum, 2019).

However, there are now more powerful drivers that are increasing demand and growth in green bonds. The latest forecast from the United Nations Principles for Responsible Investment (Fulton, 2021) anticipates that, among other things, there will be:

- **A four-fold increase in economies with carbon pricing schemes covering emissions in power and industry by 2030**, from 20% of CO_2 emissions in 2020 to all major economies and over 75% of CO_2 emissions by 2030 - while Carbon Border Adjustments Mechanisms (CBAMs) will increasingly feature:
- **Rapid acceleration in international coal phase outs**, including most coal intensive markets
- **All major industrial economies including the US, Germany, Japan and China will require all new industrial capex,** led by steel and cement, to be low-carbon by 2040, through a combination of emissions performance standards and carbon pricing.

[6] Although coal fired power plants with CCS do not qualify for green bonds this does not imply that they are not technically viable mitigation options.

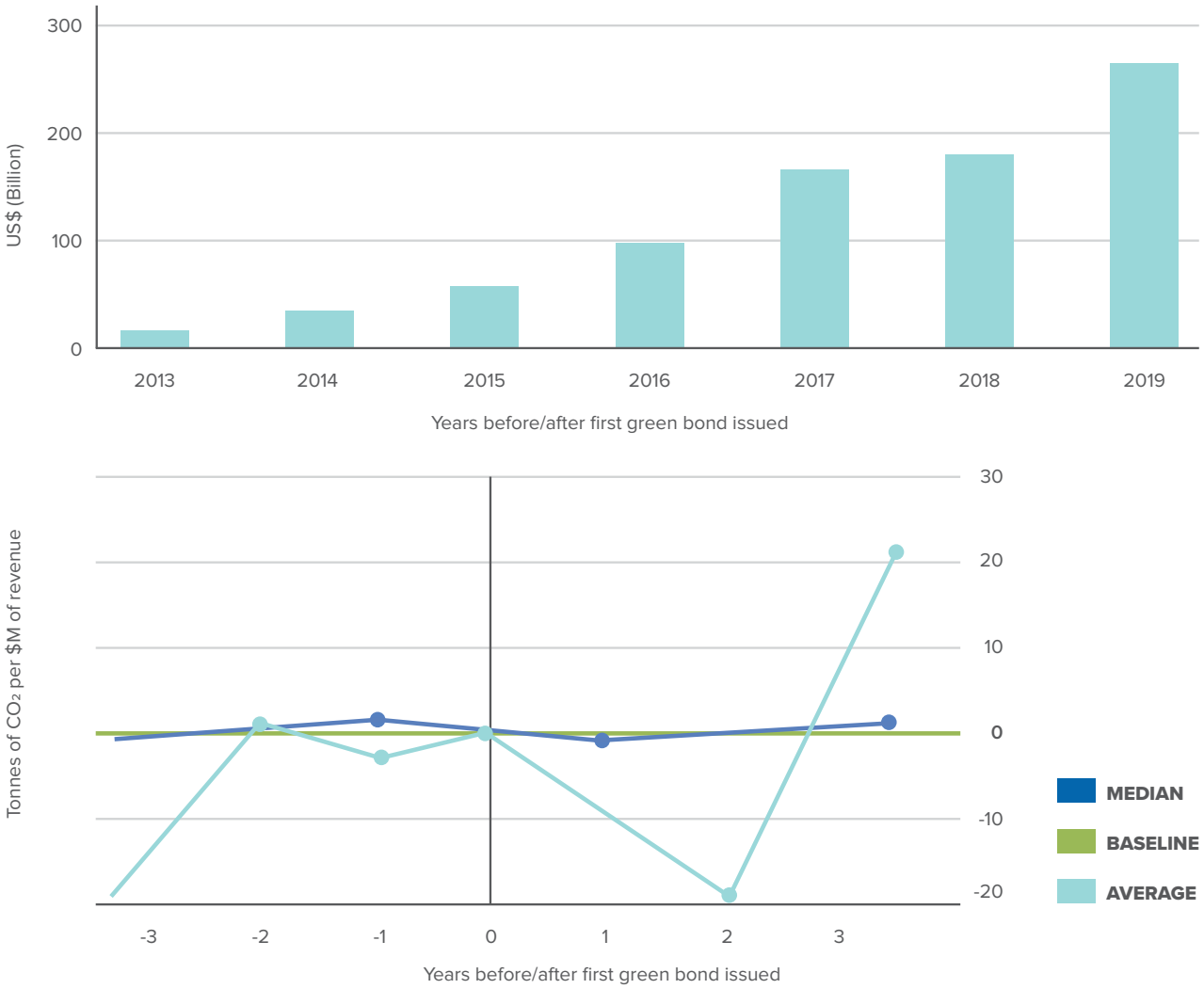
[7] Returns improved because the cost of physical renewable energy assets fell as their deployment increased, similar to how it is anticipated the cost of CCS will fall with deployment.

These developments will all occur as a result of the management of climate risks[8]. Although climate risks comprise physical and transition risks, it is the latter that financial institutions are most exposed to. This is because, while a given physical manifestation of climate change may not affect a corporate bond's value, policy action to promote the transition towards a low-carbon economy could spark a fundamental reassessment (Carney, 2015). For example, the adoption by some countries of a deadline for coal phase out, results in coal burning assets being rendered 'stranded'.

The emergence of transition risks has led to increased demand for green bonds. Yet, while green bonds have been highly effective at supporting renewable energy and energy efficiency projects, there is evidence they have had little impact on the emissions intensity of their issuers (Figure 8). By contrast, companies operating in the hard to abate sectors (called brown companies), have been reluctant to issue green bonds in fear of being accused of greenwashing (The Economist, 2021).

For green bonds to have more impact, they must be applied to low-carbon projects within hard to abate sectors. One of the most recent developments to enable this has been the EU taxonomy for sustainable investments, which now qualifies CCS investments as sustainable, easing the path towards financing CCS from capital markets within the EU. The EU taxonomy for sustainable investments recognises certain applications of CCS, all modes of CO_2 transport infrastructure and permanent CO_2 storage as sustainable activities. It is expected that bond issuances across these sectors will grow over the next decade because financial institutions are increasingly cognisant of impending transition risks as these pose a major threat to their portfolios.

Figure 8 Green bond issuance over the past decade has risen dramatically but not had a significant impact on the carbon intensity of 200 large issuers (The Economist, 2021). This has occurred chiefly because the issuers were relatively green to begin with i.e., they produce relatively low emissions per unit of revenue.

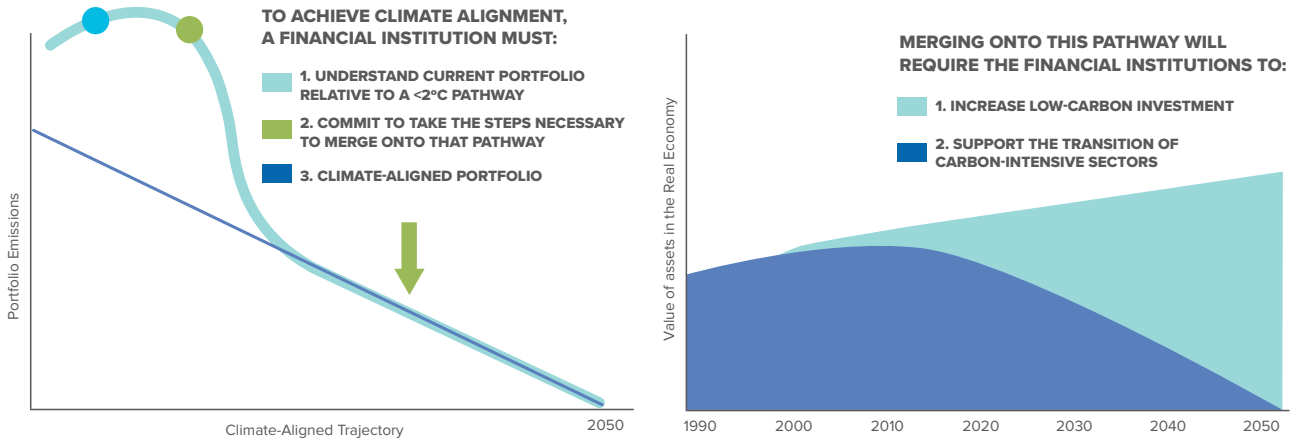


[8] Climate risks comprise physical risks (such as fires, floods, draughts and sea-level rise) and transition risks. Transition risks emerge from the policy responses from governments to fight climate change.

6.0 CLIMATE RELATED FINANCIAL DISCLOSURES WILL HELP DRIVE INVESTMENTS IN CCS

An ever-growing number of climate pledges from financial institutions has been occurring. Since 2017, financial institutions representing at least US$17.2tn have pledged to become climate-aligned[9] (Bloomberg, 2019). For a financial institution to achieve climate alignment it must cover all of its operational emissions as well as the emissions of its lending and investment portfolio (Figure 9). While financial institutions will find it more straightforward to address their operation's emissions, there are barriers to decarbonising their portfolio's emissions.

Figure 9 Charts showing what is required to achieve climate-alignment and what the implications are for high-carbon assets (LaMonaca et al., 2020).



Part of the challenge is assessing transition risks themselves. Financial institutions have often tended to assess their exposure by identifying emissions across their portfolio, which requires reporting by the emitters themselves, a voluntary process called carbon disclosure. In some parts of the world, the process of climate-related disclosure is becoming more frequent and may soon be mandatory. For example, one of the key catalysts in advancing the understanding of climate risks has been the Task Force on Climate-related Financial Disclosures (TCFD).

The TCFD sets clear guidelines (Table 3) and recommendations to help businesses disclose climate-related financial information, which has led to an increased effort by companies to disclose their emissions.

[9] To align their portfolio emissions with the temperature goals of the Paris Agreement.

Table 3 High level summary of the TCFD's guidance on disclosure for various organisations (Task Force on Climate Related Financial Disclosure, 2021)

ORGANISATION	TCFD GUIDANCE
Banks	• Banks should consider characterising their climate-related risks in the context of traditional banking industry risk categories such as credit risk, market risk, liquidity risk, and operational risk. • Banks should also consider describing any risk classification frameworks used (e.g., the Enhanced Disclosure Task Force's framework for defining "Top and Emerging Risks").

Insurance companies	• Insurance companies should describe the processes for identifying and assessing climate-related risks on re-/insurance portfolios by geography, business division, or product segments, including the following risks:
	  • physical risks from changing frequencies and intensities of weather-related perils,
	  • transition risks resulting from a reduction in insurable interest due to a decline in value, changing energy costs, or implementation of carbon regulation, and
	  • liability risks that could intensify due to a possible increase in litigation.

Asset owners	• Asset owners should describe, where appropriate, engagement activity with investee companies to encourage better disclosure and practices related to climate-related risks to improve data availability and asset owners' ability to assess climate-related risks. • Asset owners should describe how they consider the positioning of their total portfolio with respect to the transition to a lower-carbon energy supply, production, and use. This could include explaining how asset owners actively manage their portfolios' positioning in relation to this transition
Asset managers	• Asset managers should describe, where appropriate, engagement activity with investee companies to encourage better disclosure and practices related to climate-related risks in order to improve data availability and asset managers' ability to assess climate-related risks. • Asset managers should also describe how they identify and assess material climate-related risks for each product or investment strategy. This might include a description of the resources and tools used in the process • Asset managers should describe how they manage material climate-related risks for each product or investment strategy. • Asset managers should also describe how each product or investment strategy might be affected by the transition to a lower-carbon economy.

In doing so, this provides a clear indication to financial institutions to which extent their portfolios are exposed to transition risks and in which sectors. In turn, they have choices to make in terms of taking action to reduce their exposure: they can divest away from brown companies and projects, engage with them, or choose a combined strategy.

The practice of divestment, however, simply transfers climate risks from one investor onto another. It does not necessarily help to bring the global portfolio closer towards climate alignment. To achieve climate alignment at this level, institutions will have to engage their customers to honour the commitments made to their shareholders.

For some investors, climate risk is best managed by active engagement with businesses. This has been the case for both Norway's US$1tn Government Pension Fund Global and Japan's US$1.36tn Government Pension Investment Fund (GPIF). Both have decided against exiting fossil fuel investments and have instead favoured engaging with companies on climate change.

The COVID-19 crisis has triggered governments into developing a response to mitigate the pandemic's economic ramifications. To meet the dual challenge of economic recovery and emissions reductions, several governments and industry groups have proposed economic recovery packages that include the development of new, climate friendly infrastructure. For example, the Canadian government is making it a requirement for large corporations that apply for government loans to publish annual climate disclosure reports as well as reports that link to wider environmental sustainability goals (Havercroft, 2020).

Through this approach, key sectors that underpin the global economy – sectors such as steel, cement, oil and gas, and electricity – that are not currently on a pathway towards the goals of the Paris Agreement, can be supported as they seek to transition towards low-carbon emissions. This is important for CCS because it is one of the few technologies that can be applied to decarbonise these sectors.

7.0 FINANCING CCS IN DEVELOPING COUNTRIES

CCS will have to be deployed in all regions of the world, in order to meet the emissions reductions defined in the IEA-SDS. This means developing countries have an important role to play in CCS deployment. Developing countries represent high risk environments for investments in CCS, which further extend the funding gap discussed in Chapter 4. It is the role of climate finance to help close such funding gaps.

Given the long lead times associated with developing CCS projects, success in deploying CCS to meet the IEA-SDS emissions targets will depend on the steps taken between now and 2030. In developed countries, policy derisking and commercial deployment of CCS has already begun to occur but has yet to attract significant levels of private financing through project finance and, crucially, from capital markets and sovereign wealth funds through green bonds. By 2030, a rapidly growing demand for CCS projects must emerge from capital markets and sovereign wealth funds as this will indicate that the technology is on course for widescale deployment.

In anticipation of learning by doing benefits that arise from deployment in developed countries, developing countries may take steps to improve their level of CCS readiness. This can be achieved through policy derisking.

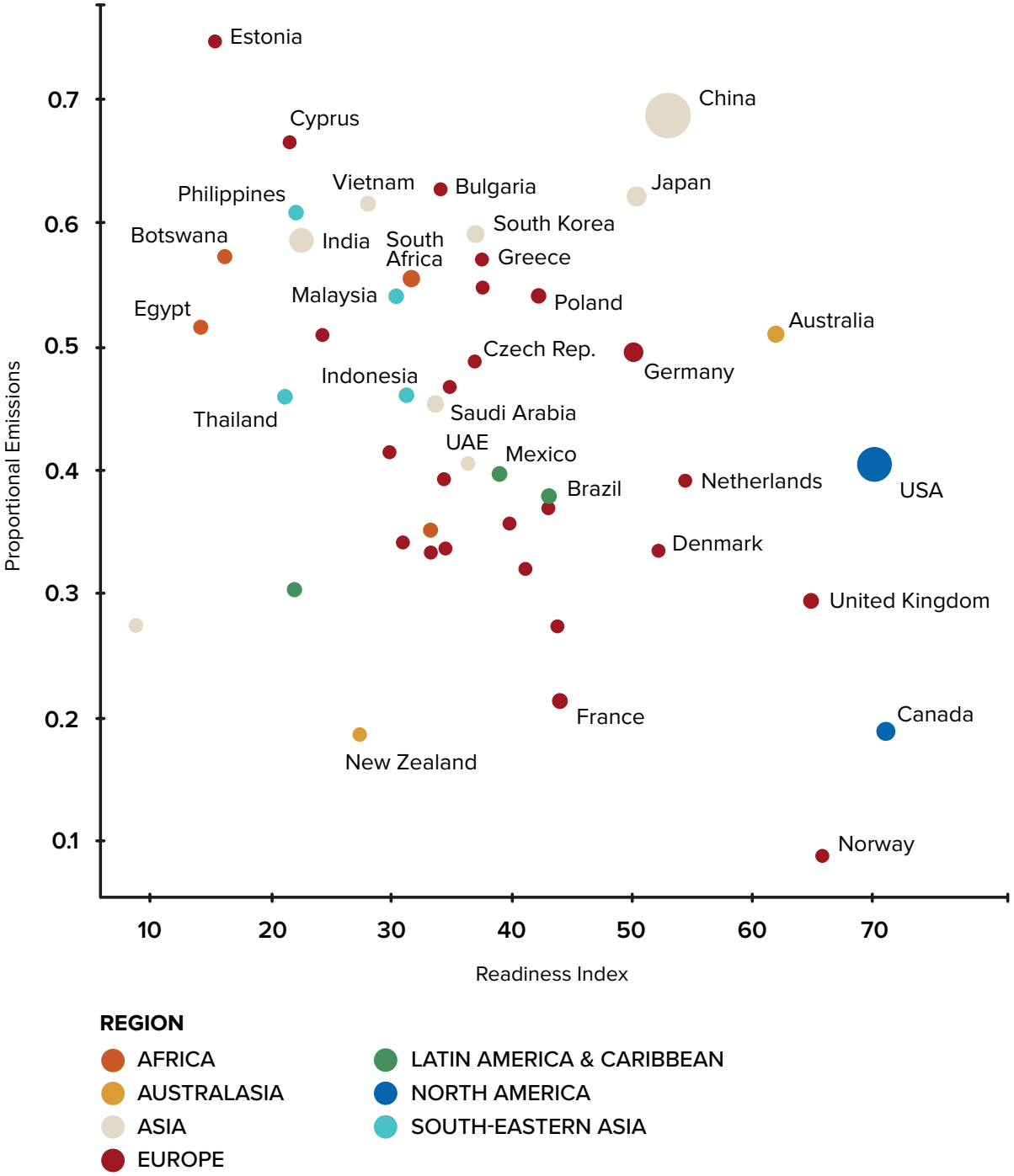
At the same time as they adopt enabling policies for CCS deployment, however, developing countries must also implement demonstration CCS projects that will help to reduce risks for future investments. Funding these projects is, therefore, a key consideration for developing countries that have a high need for CCS in key industries. Climate finance can play a critical role in this regard.

The lack of CCS in developing countries

While several developed countries have taken steps to improve their enabling environment for CCS (see next section), developing countries lag far behind. One measure of this performance is to compare countries' general need for CCS with their level of CCS readiness.

Figure 10 shows a recent analysis by the Global CCS Institute, whereby countries' CO_2 emissions from sectors where CCS can be applied are measured against their level of readiness for CCS deployment.

Figure 10 Countries' proportional emissions[10] (representing their need for CCS in iron and steel manufacture, cement production, power generation from fossil fuels, and bioethanol production) is 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 a country's overall emissions.



While the data in Figure 10 does not represent all of the sectors where CCS can be applied, it is an indicator of the need for CCS in sectors where the technology can play a key role. Further, Figure 10 also shows the extent to which governments are responding through policy action. Developing countries, particularly those in Asia and SE Asia, are falling behind in terms of their response to a clear need for CCS deployment in these sectors. By contrast, developed countries with similar or sometimes lower need for CCS are further ahead in their level of readiness. Notwithstanding this, some developing countries have explicitly or implicitly included CCS as a technology required to meet their Nationally Determined Contributions (NDC) under the Paris Agreement (Table 4).

[10] The sum of a country's CO_2 emissions from key sectors where CCS can be applied, divided by that country's total emissions.

Table 4 CCS in countries' NDCs

	INDC	1ST NDC	1ST NDC UPDATE	2ND NDC
Australia	–	✗	✓	
Bahrain	–	✓		
China	✓	✓		
Egypt	–	✓		
Iran	✓			
Iraq	✓			
Malawi	✓	✓		
Mongolia	✗	✗	✓	
Norway	–	✓	✓	
Saudi Arabia	✓	✓		
South Africa	✓	✓		
UAE	–	✓		✓
United States	✗	✓		

KEY

✓ **NDC MENTIONS CCS** ✗ **NDC DOES NOT MENTION CCS** – **NOT AVAILABLE**

The United Nations Framework Convention on Climate Change (UNFCCC or "the Convention") recognises that countries' contribution to climate change and their capacity to prevent (and cope with) its consequences varies significantly. Climate finance is an area of international development that facilitates the provision of financial resources (from developed countries) to assist developing countries in implementing the Convention. The UNFCCC's Financial Mechanism administers these funds to developing countries. Climate finance can be broadly divided into non-market and market-based mechanisms.

Non-market-based mechanisms

The UNFCCC has several funds which serve the purpose of climate finance, but its two most prominent are the Global Environment Facility (GEF) and the Green Climate Fund (GCF). Both funds separately pool financial resources from donor countries and administer them to developing countries, usually through third parties.

The GEF

The Global Environment Facility (GEF) provides grant funding for relatively small projects. These projects vary in size, with full-sized (the largest type) projects ranging from $1M to $15M. The use of GEF funds tends to be restricted to activities that increase countries' capacity to deploy technologies, such as the development of policies, technical studies and small pilot projects. In comparison to the cost of a commercial CCS project, the sums involved are small.

Because of its limited funding capacity, the support that the GEF can lend to CCS deployment is in the development of legal, regulatory and policy frameworks to improve countries' level of CCS readiness. To date, there haven't been any CCS projects that have been approved by the GEF.

The GCF

The GCF is a financial mechanism of the UNFCCC and is a dedicated financing vehicle for developing countries. Since the approval of the first project funding in 2015, the GCF has made rapid strides in building a portfolio of more than 100 projects.

The GCF operates at a much larger scale than the GEF and has the capacity for delivering large-scale infrastructure projects, including CCS, through several financial instruments, including grants, loan guarantees, concessional loans and equity investments. By partnering with private sector investors, the GCF enables a blended finance approach, combining different sources of capital to reduce risk, making otherwise unaffordable efforts viable.

Given the volume of financing (in the order of tens to hundreds of millions of US dollars) and the array of financial instruments at its disposal, the GCF has the potential to significantly accelerate the rate of deployment of CCS in developing countries.

While the GCF can help projects meet their capital requirement, it does not make provision for overcoming the entirety of the revenue risk associated with all types of CCS projects. The GCF recently approved its first project with a reliance on carbon markets, which can provide much-needed revenue for CCS projects so long as they do not conflict with the GCF's eligibility criteria.

Market-based mechanisms

In most developing countries, there are few existing government-led policies that place a sufficient value on CO_2. There are, however, a group of initiatives that have been successfully used for mitigation projects in developing countries that give insight into potential incentives for CCS investments. These are known as carbon crediting mechanisms.

Carbon Crediting

Carbon crediting – a form of carbon pricing – serves the broader function of carbon offsetting, whereby carbon credits are used to offset equivalent amounts of emissions either locally or elsewhere in the world. In the context of climate finance, crediting schemes are used to finance the development of mitigation projects in developing countries, and the credits they generate are then used to offset emissions in more industrialised countries.

The most notable example of a crediting scheme is the UNFCCC Clean Development Mechanism (CDM) and was developed under the Kyoto Protocol in 1997. The design of the CDM was based on developing countries participating on a voluntary basis since they did not have emissions targets. Through it, developing countries hosted low-carbon projects (developed by entities from either the public or private sector) to obtain credits, called certified emissions reductions[11] (CERs), in return. CERs were then transferred to developed countries to meet their targets.

The CDM created a price signal for emissions, providing sufficient incentive for investments in projects that would otherwise not have occurred. While CCS was an eligible technology under the CDM, the price of CERs was never high enough to enable CCS projects[12]. Despite this, the inclusion of CCS in the CDM points to the importance of CCS even at a time when the technology was less common, and the carbon budget was significantly higher.

A rapidly growing area of carbon crediting is that of voluntary carbon markets (VCMs). As the emissions mitigation options to address climate risks (discussed in Chapter 6) are exhausted, businesses and financial organisations will eventually be left with residual emissions. These can only be tackled through carbon dioxide removals, which can be achieved through nature-based solutions as well as technological solutions such as CCS. VCMs offer a pathway to invest in carbon removals.

VCMs operate in a similar way to the CDM, whereby a baseline[13] and credit approach allows investors to purchase (and subsequently surrender) credits to offset their emissions. Three of the prominent VCMs are the Gold Standard, Verified Carbon Standard, as well as the CDM itself. In recent times, demand for credible offsets has surged. Between 2007 and 2019, around 612 million carbon credits were issued from baseline-and-crediting programmes that targeted mainly VCMs, including 142 million in 2019 alone (Doda et al., 2021).

[11] One CER represents one tonne of CO_2 avoided or mitigated.

[12] Methodologies were developed to account for the emissions reductions from two CCS applications: Egypt (BP) and Mexico (Petronas).

[13] Methodologies are designed to establish a baseline that is used to determine a targeted carbon intensity level for units of material produced. Producers earn credits when units of material are produced at a lower emissions intensity than that which is set by the baseline, otherwise they must surrender credits if their emissions intensity is higher than the baseline.

Carbon removal is relevant to some forms of CCS, most notably bioenergy with carbon capture and storage (BECCS). Biogenic CO_2 can be produced through fuel processing (for example CO_2 from fermentation to produce bioethanol) and from fuel use (CO_2 from direct combustion of biofuel). The value of BECCS to investors is that it offers the benefit of permanent removal of carbon dioxide from the atmosphere. By contrast, nature-based solutions such as afforestation – which can be lower cost – do not have the same level of permanence.

The most cost-effective application of BECCS is when it is used in fuel processing. For example, when applied to bioethanol fermentation, very high CO_2 concentrations can be reached, leading to lower costs. We estimate the amortised cost of capture of bioethanol with CCS to range from US$1/t$CO_2$ to US$10/t$CO_2$, whilst VCM credits most relevant to BECCS are anticipated to be priced between US$5/t$CO_2$ and US$20/t$CO_2$ (TSVCM, 2021). This implies that under the right conditions, CCS projects can be supported in developing countries through voluntary markets.

In comparison to BECCS, DACs projects are today less cost-effective forms of removal. DACs, however, is anticipated to play an important role in the future, especially as low-carbon electricity becomes more widespread and demand for CO_2 removals increases. An indication of this is the emerging demand for DACs projects in developed countries.

Aside from the need for a legal and policy framework to support such a CCS project in a developing country, CCS projects will firstly have to be legitimised by way of a methodology before they can generate credits for sale in VCMs. Currently, there are no approved methodologies for CCS to allow for this.

Article 6 of the Paris Agreement

Carbon crediting can also form the basis of an international carbon market, which is being enabled through Article 6 of the Paris Agreement. Article 6 comprises three approaches for cooperation between Parties:

- cooperative approaches
- a new mechanism to promote mitigation and sustainable development
- and a framework for non-market approaches

The framework that is set to be defined under Article 6 is an outstanding issue for negotiations at the UNFCCC, which may be resolved later this year at the Conference of Parties (COP 26). Article 6 provides a framework for two distinct approaches to market-based mechanisms and one approach for non-market-based mechanisms. Table 5 provides a summary of these, as described in the text of the Paris Agreement.

Table 5 Mechanisms under Article 6 of the Paris Agreement (Tamme and Scowcroft, 2020)

ARTICLE	DESCRIPTION
Article 6.2	Allows countries to strike bilateral and voluntary agreements to trade units (Internationally Transferred Mitigation Outcomes – ITMOs). It establishes an accounting framework that also applies to Article 6.4.
Article 6.4	This creates a centralised governance system for countries and the private sector to trade emissions reductions anywhere in the world. This system is due to replace the CDM. The system will be supervised by a specifically established UN Supervisory Body, which tends to mean a heavy layer of administration to operate under it (article 6.2 should be easier to use).
Article 6.8	This develops a framework for cooperation between countries to reduce emissions outside market mechanisms, such as aid, financing adaptation, using taxes to deliver emission reductions. In the current draft texts, it is a work program, not an accounting framework like 6.2 or a mechanism like 6.4.

Making use of market-based mechanisms is a choice that individual countries will have to make. Some countries have already specified the use of international cooperation as part of their NDC commitments (Figure 11).

[14] The higher the concentration of CO_2 in a flue gas, the lower the cost of capture.

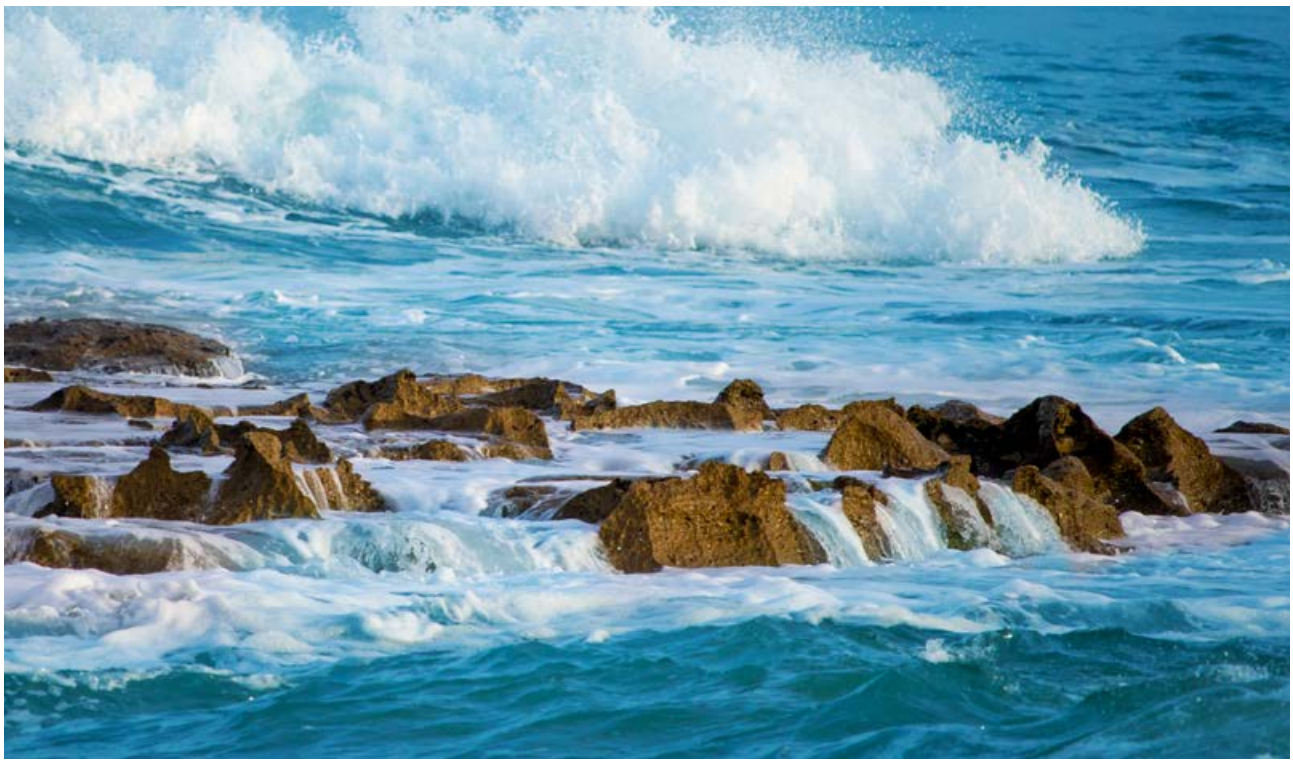
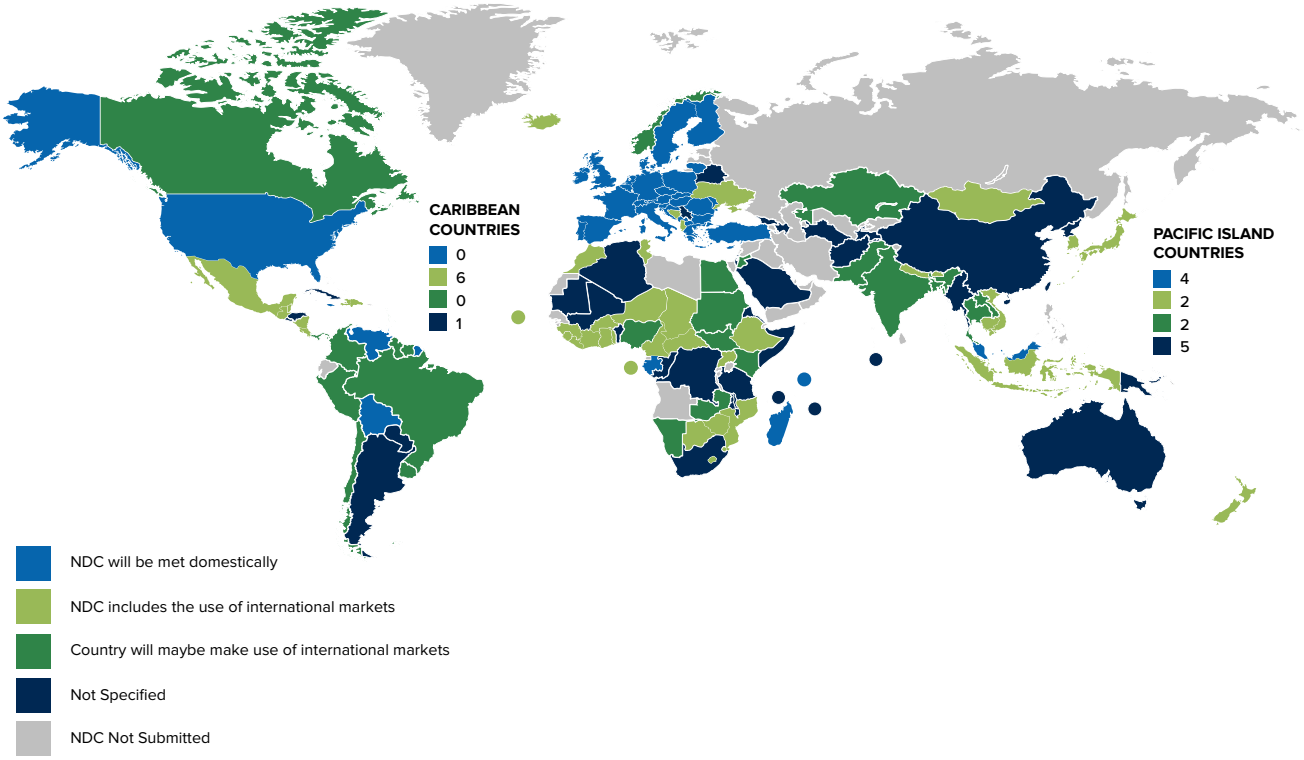
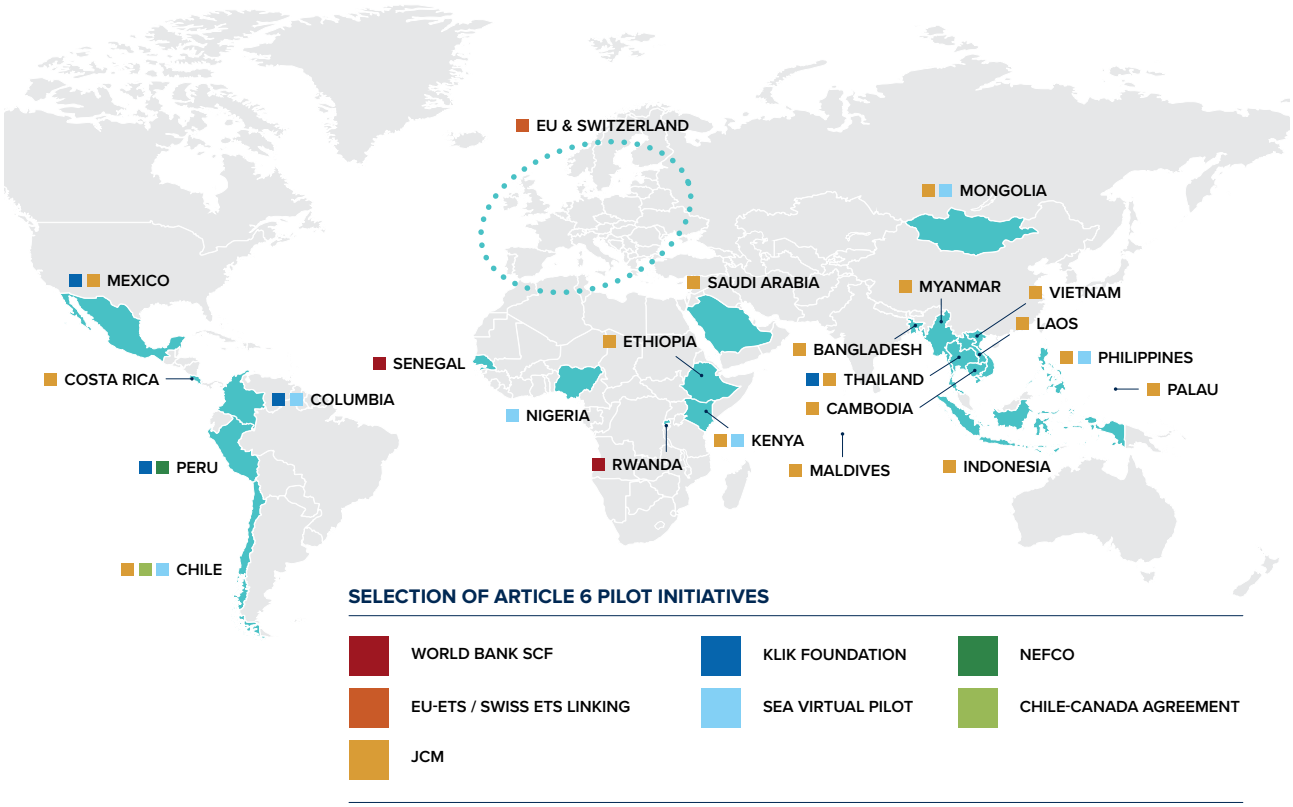


Figure 11 Market friendly NDCs (International Emissions Trading Association, 2018)



The extent to which Article 6 will enable CCS in developing countries is as yet unknown. But there are several pilot initiatives already underway that are testing and experimenting with the concepts of international market mechanisms emerging from the climate negotiations. The lessons learned from these can help to inform discussions surrounding Article 6. Figure 12 provides an overview of the different mechanisms and where projects are being piloted using them. (Figure 12).

Figure 12 Article 6 pilot initiatives (Greiner et al., 2019)



To date, none of these pilot initiatives, which include other forms of carbon crediting through, for example bilateral arrangements, have yet to support the development of a CCS project. For this to happen, significant support from other areas of climate finance will be required to place a sufficient value on CO_2 to enable the first pilot projects in developing countries. This will likely have to come from the GCF combined with each country's CCS-specific policies.

If CCS projects are deployed through climate finance, the important lessons learned, for policy derisking as well as learning by doing, will then have to be shared with climate negotiators as well as the next wave of projects. The developments at COP 26 – specifically in relation to Article 6 –will indicate to which extent CCS deployment in developing countries will come to rely on market-based mechanisms to enable pilot projects over the next decade.

8.0 CONCLUSIONS

CCS is currently at a critical stage in its deployment. Given the long lead times associated with developing CCS projects, the steps taken between now and 2030 will determine whether CCS technology will be deployed at the scale necessary to meet the climate challenge. A critical step towards achieving this is for enabling policies to be implemented between now and 2030. These policies are key to attracting private sector investments, which will have to occur at a rate of tens of billions of US dollars a year, driven by enabling policies. These policies will lead to significant transition risks, and it is through them that incentives to drive private investments in CCS will occur. At the same time, other government-led initiatives to support and enable these investments should also be prioritised.

The role of specialist financiers will be crucial in supporting emitters that are unable to fund their CCS investments on their balance sheets. Governments can mandate specialist financiers to support investors through project finance. Further, transition risks play the role of triggering engagement from the financial sector. To this end, it is also within the remit of governments to support the development of financial standards that recognise the eligibility of CCS investments as green or sustainable. This will not only lead to better terms of finance for CCS projects but will first make it far easier for financial institutions to engage with brown companies in their portfolio and for issuers to benefit from the huge potential of the green bond market.

While CCS deployment advances in developed countries, actions to support early deployment in developing countries will have to increase dramatically over the coming years. Climate finance has supported numerous mitigation technologies around the world, helping to create enabling environments for their deployment at scale. If CCS is to be deployed in developing countries, where CO_2 emissions are growing most rapidly, a concerted effort is needed to ensure that developing countries are well supported when increasing their level of CCS readiness. Further, CCS investments will greatly benefit from support across both non-market as well as market-based mechanisms such as the Green Climate Fund and what is to emerge from Article 6 of the Paris Agreement at COP 26.

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