2020 THOUGHT LEADERSHIP

SCALING UP THE CCS MARKET TO DELIVER NET-ZERO EMISSIONS

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EXECUTIVE SUMMARY

Understanding how the carbon capture and storage (CCS) market is likely to develop over the coming years is of interest to a wide range of stakeholders. It can help inform the timing and design of policies introduced by governments, the scale of the market for potential investors, and the challenges associated with meeting long-term climate targets.

This report aims to inform the discussion on these topics by providing an overview of the near-term and longer-term developments in the CCS market. It reviews the current CCS facility pipeline, and how that could change in the next few years given project lead-in times. It then considers how this compares to projections of the number of CCS facilities needed to meet long-term climate goals. Throughout the report the number of CCS facilities deployed is used as a proxy for the size of the CCS market.

The current CCS facility pipeline provides a relatively robust indicator of the CCS market in the next few years, particularly given it takes around 6-8 years for projects to progress through the full development cycle. There are currently 51 large-scale CCS facilities in the CCS facility pipeline, with 19 in operation, 4 under construction, 10 in advanced development and 18 in early development. Most of the large-scale facilities in operation are in North America, with the remainder in Norway, China, Brazil, Saudi Arabia, Australia and the UAE. The projects tend to be concentrated in industries where the unit cost of capturing CO_2 is low, such as natural gas processing, fertiliser and ethanol production.

As with other large infrastructure projects, not all of the projects currently in the CCS pipeline will make it to operation. For example, just under half of the CCS projects announced since 2010 are no longer in the CCS facility pipeline. While this may be striking at first, comparing it to LNG projects, which could be a close analogue, shows CCS project survival rates are not uniquely low. In addition, initial evidence suggests CCS project survival rates have improved over time and as projects have moved through the development cycle. Nevertheless, the exit of some projects emphasises the need for a healthy project pipeline to support a given number of operational facilities in the future.

There are positive signs that the development and deployment of CCS is gathering momentum, with several projects expected to enter the pipeline in the coming years. In the United States, the time-limited 45Q tax credit and recent changes to the Low Carbon Fuel Standard (LCFS) in California, provide incentives that should lead to further CCS projects being added to the pipeline. In Europe, Canada and Australia, and also the United States, the emergence of hubs and clusters supported by public-private partnerships could be the source of further project announcements in the near-term.

Estimating the longer-term developments, for example to 2050, is more challenging. As the window for projects to be designed, constructed and commissioned extends over time, and the anticipated rise in carbon prices and CO_2 regulation takes effect, the validity of the current CCS facility pipeline and current country policy assessments decline. One option for longer-term estimates is to focus instead on the rate of CCS deployment needed, as provided by results from various scenario models, rather than the amount projected.

Assessing 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.

A pertinent question that follows from this is whether this rate of construction can be achieved. A review of infrastructure analogues suggests that it is achievable, but it will require a monumental shift in policy, particularly if we are to stay on track with a 1.5°C pathway. The longer these policy changes are delayed, the less likely that CCS will reach the deployment rates required and, ultimately, that long-term climate goals will be met.

1.0 INTRODUCTION

Understanding how the CCS market is likely to develop over the coming years is of interest to a wide range of stakeholders. It can help inform:

- the timing and design of policies introduced by governments;
- the location of deployment opportunities for emitters that can build on other planned projects;
- the scale of the market for potential investors; and
- the broader challenges associated with meeting long-term climate targets.

The purpose of this report is to inform the discussion on these topics by providing an overview of the near-term and longer-term developments in the CCS market. The market in this context is measured principally in terms of the number of CCS projects in development, construction and operation, as an indicator of CCS activity.

Rather than attempt to provide a single projection of how the market will develop in the future, the report sets out the parameters that will define the boundaries within which the market will develop. These parameters are explored at a global level, but a regional breakdown is also provided where available.

The report is structured as follows. Section 2 summarises the current CCS facility pipeline which, given the lead-time of projects, provides a reasonable indication of the deployment of CCS projects for at least the next five years. Section 3 assesses potential entry into and exit from the pipeline, considering the countries with enabling environments to support CCS and the survival rate of projects in the pipeline. Section 4 provides an overview of the rate of CCS deployment needed to remain on track with international climate change commitments, and how this compares to current levels of activity. Section 5 concludes, bringing together the various strands of analysis to characterise the anticipated near-term and longer-term development in the market.

2.0 THE CURRENT CCS FACILITY PIPELINE

The Institute has closely monitored CCS project activity across the world over the past ten years. Developments in the CCS facility pipeline are published annually in the Institute's Global Status of CCS report, with the latest version released in December 2019 (1).

There are currently 51 large-scale CCS facilities at various stages of development. These projects are distributed across conventional project development pipeline stages, with 19 in operation, 4 in construction, 10 in advanced development using a dedicated Front-End Engineering Design (FEED) approach, and 18 in early development. There are also 39 pilot and demonstration-scale CCS facilities and 9 CCS technology centres globally (Figure 1).

Most of the large-scale facilities in operation are in North America, where a combination of supportive policy, industry knowhow, established CCS legislation and revenue opportunities from enhanced oil recovery have encouraged investment in CCS. The US is also the location of the majority of projects in advanced development, with several of the projects benefitting from funding for FEED studies from the US government and the extension to the 45Q tax credit. The remaining facilities are in China, the Republic of Korea, Brazil, Europe, the Middle East and Australia.

Collectively, the 19 large-scale CCS facilities in operation have the capacity to capture and permanently store 39 million tonnes of CO_2 every year. The total capture capacity of all 51 large-scale facilities in the pipeline is 98 million tonnes of CO_2 per year.

While a large number, this is significantly less than the number of CCS facilities deployed in most credible pathways to achieve net-zero emissions by the middle of the century (see Section 4).

Figure 1: Number of CCS facilities by scale, location and phase of development as of December 2019

	LARGE SCALE FACILITIES				PILOT AND TEST CENTRES	
	OPERATING	IN CONSTRUCTION	ADVANCED DEPLOYMENT	EARLY DEVELOPMENT	PILOT AND DEMONSTRATION	TEST CENTRES
AUSTRALIA	1		1	1	2	2
BRAZIL	1				1	
CANADA	2	2			3	2
CHINA	1	2		5	3	1
NORWAY	2		1		2	1
REPUBLIC OF KOREA					2	
SAUDI ARABIA	1					
THE NETHERLANDS				2	1	
UNITED ARAB EMIRATES	1		1			
UNITED KINGDOM				6	3	1
UNITED STATES	10		7	3	10	2
REST OF WORLD					12	
TOTAL	19	4	10	18	39	9


Photo Credit: CarbonNet. Drilling Rig at Pelican site, Victoria

In terms of the underlying industrial activities for which operational CCS facilities are reducing CO_2 emissions, activity levels are a good reflection of the current distribution of the unit costs of CCS. Most CCS activity has occurred in industrial processes with the lowest cost of CCS on a "$ per tonne of CO_2 avoided" basis. For example, 10 of the 19 operating facilities are in natural gas processing, two are in fertiliser production and one is in ethanol production, all of which have costs of less than $25/t$CO_2$ for a typical plant (2). The remaining projects are in hydrogen production, synthetic natural gas production, iron and steel production, and power generation.

All of the large-scale facilities in operation rely on pipelines to transport CO_2 from emissions sources to storage sites, supported by a network of over 6,500km of CO_2 pipelines globally (3). Some CO_2 pipeline networks in the US, the location of most CO_2 pipelines, also transport CO_2 from natural sources to oil fields for enhanced oil recovery. CO_2 transport by ship has not yet been implemented for CCS, but CO_2 shipping has been common practice for more than three decades for the food and drink industry. Moreover, several projects, such as the Northern Lights project in Norway and Korea CCS project in the Republic of Korea, plan to use shipping as a means of transport.

3.0 THE FUTURE PROSPECTS FOR CCS DEPLOYMENT

The CCS facility pipeline provides a snapshot of the current projects in operation and under development. As the window for projects to be designed, constructed and commissioned extends over time, and the anticipated rise in carbon prices and CO_2 regulation takes effect, many commentators anticipate the CCS pipeline will expand significantly.

Estimating the anticipated growth in the CCS pipeline is challenging for a variety of reasons. However, there are several parameters that can inform our understanding of the timing and geographic distribution of future deployment. These parameters set the boundaries within which the future developments in the market can be described and include:

- the lead-in time for new CCS projects;
- the anticipated entry of new projects into the CCS pipeline; and
- the survival rate of projects currently in the CCS pipeline.

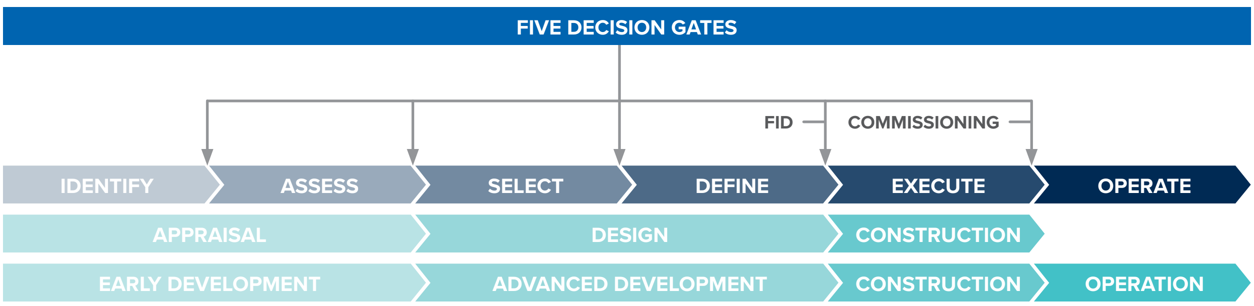
The following sections provide an overview of the information available for each of these areas and describe the implications for the evolution of the CCS pipeline.

3.1 The lead-in time for new CCS projects

As with other large infrastructure projects, a CCS facility follows a phased process with decision gates that determine, and guide, the development journey (Figure 2). After a project is identified, the concept design is evolved, and this forms the basis of the FEED study. Assuming support continues and all the necessary permits and financial agreements are secured, the Final Investment Decision (FID) is taken and construction begins. The project is then commissioned and ultimately progresses into operation.

The process of moving from concept to operation takes time. Evidence from the Institute's CCS facility database shows the construction of CCS projects that entered operation in the last decade took 3-4 years on average. While there is less visibility of the time taken for the earlier stages of development, there are some projects where this information is available. For example, the Boundary Dam and Quest CCS projects took four years to progress from being identified to entering construction, and Petra Nova took three years (4) (5) (6) (7). Taking this into account, a reasonable assumption would be that it takes 6-8 years on average for new CCS projects to progress through the full development cycle.

Figure 2: A typical project development process



The significance of this lead-in time is that it places a ceiling on the near-term deployment of CCS and in which countries this is likely to occur. For example, if the average lead-in time for projects is 6-8 years, then it won't be until 2026-2028 that projects entering the pipeline in 2020 would be expected to enter operation. By virtue, the number of projects entering operation before this date would be limited to the 32 under development or in construction globally in the current CCS pipeline.

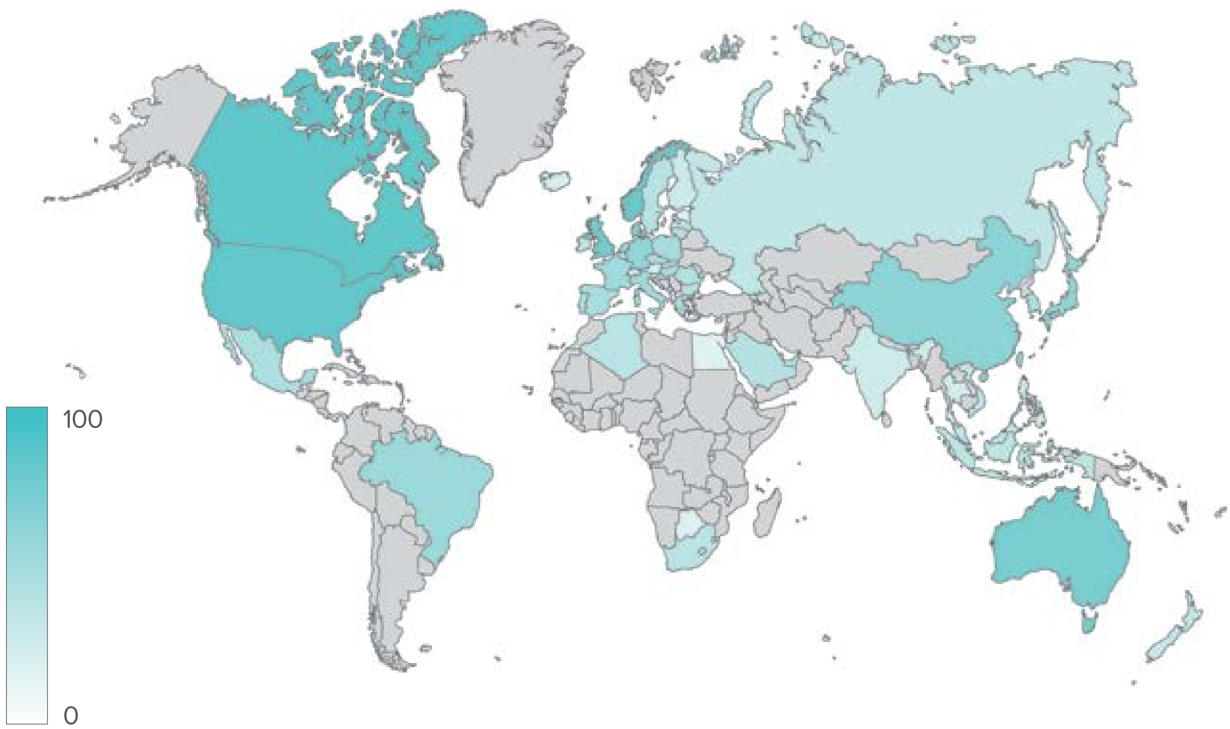
In practice, the lead-in time for CCS projects will vary by project type and location, and with time. As with other large capital projects, the construction phases would be expected to shorten as the pool of CCS facilities in operation increases. This is due to both the impact of learning-by-doing and the increasing availability of transport and storage infrastructure to which capture projects can be more quickly connected. Nevertheless, for most of the current set of projects in the pipeline the historic lead-in times are likely to provide a reasonable guide to the time taken to complete the full development cycle.

3.2 Entry of new projects into the CCS pipeline

The scaling up of deployment will only be achieved if there is a clear commercial case to invest in CCS. Critical to this is the enabling environment in individual countries, in terms of the presence of supportive policy frameworks, comprehensive legal and regulatory frameworks, and detailed and targeted storage assessments. The countries most advanced in these areas are more likely to be the countries where the next wave of CCS projects are announced.

The Institute tracks developments in the enabling environment through its policy, legal and regulatory, and storage indicators. These indicators are combined to create the Institute's CCS Readiness Index, which describes the readiness of each country to support the scale-up of CCS deployment. The Index examines over 50 countries using 70 discrete criteria and enables a comparative assessment of countries globally (Figure 3).

Figure 3: CCS Readiness Indicator (2018)



The Index shows five clear leaders that are well advanced along the path to CCS readiness - Australia, Canada, Norway, the United Kingdom and the United States. These five nations have taken significant steps to reduce domestic barriers to CCS. It is no surprise that they account for 70% of all CCS projects in operation, construction or under development globally.

In the United States, the time-limited 45Q tax credit and recent changes to the Low Carbon Fuel Standard (LCFS) in California, provide incentives that should lead to further CCS projects being added to the pipeline. To qualify for the 45Q tax credit, projects need to enter construction by 1 January 2024, placing greater emphasis on US projects to be identified in the next few years. Project developers are currently awaiting formal guidance on 45Q from the Internal Revenue Service, after which more project announcements are expected.[1] Industry sources say that more than two dozen facilities could potentially be announced once the Internal Revenue Service finalises the guidance.

In Europe, Canada and Australia, and also the United States, the emergence of CCS hubs and clusters supported by public-private partnerships could be the source of further project announcements in the near-term. Many of the hubs proposed, including Northern Lights in Norway, Net Zero Teesside in the UK, and the Alberta Carbon Trunk Line in Canada, have initial anchor projects with plans to expand over time.

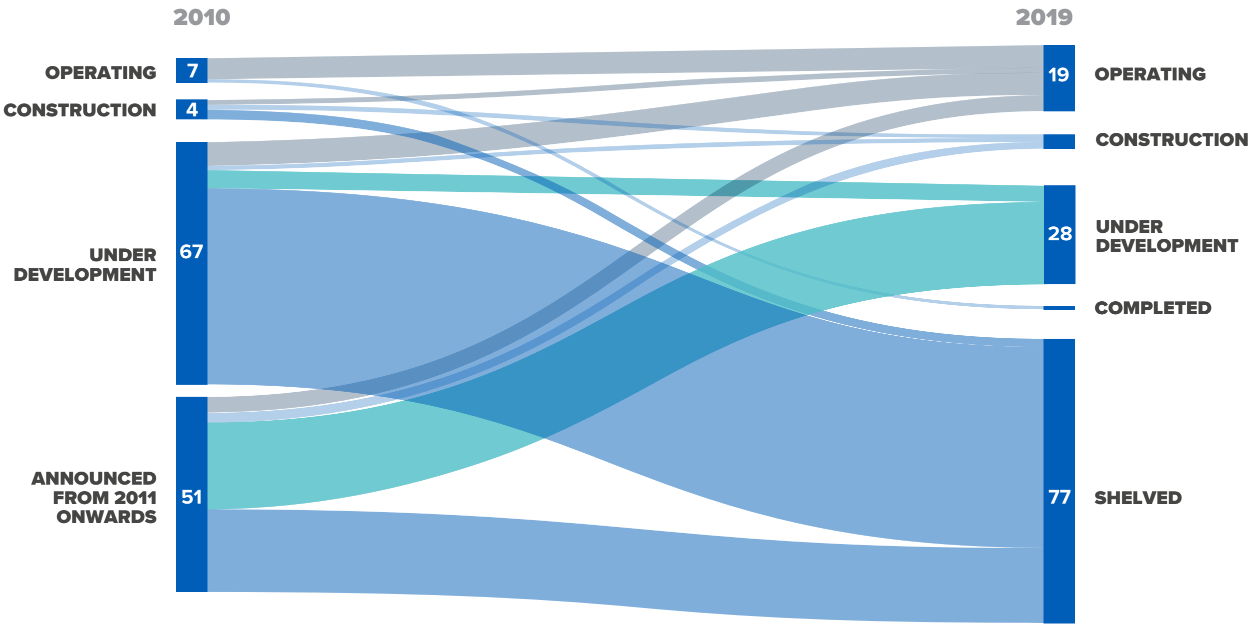
Hubs and clusters have the benefit of economies of scale, helping to lower costs, and reduce the commercial risks of deployment. They also potentially shorten the development cycle for projects, as new capture projects can be more quickly connected to storage sites.

3.3 The survival rate of projects currently in the CCS pipeline

Like other large infrastructure projects, it is inevitable that some CCS projects that are identified will not progress to operation. This could be for a variety of reasons, for example due to changes in market conditions, policy changes, the inability to secure the correct permits, or financial constraints. The survival or failure rate of projects ultimately determines the size the CCS pipeline would need to be to support a given number of operational projects in the future.

Evidence from the Institute's CCS facility database provides several insights into the survival rates of CCS projects over the past decade (Figure 4). The overall trend over the period has been a decline in the size of the project pipeline, with a net outflow of three projects per year. Of the 71 projects in construction or under development at the start of the period, and the 51 projects announced since then, only 45 (37%) remain in the pipeline today.

Figure 4: Changes in the large-scale CCS facility pipeline 2010-19



[1] As of February 2020.

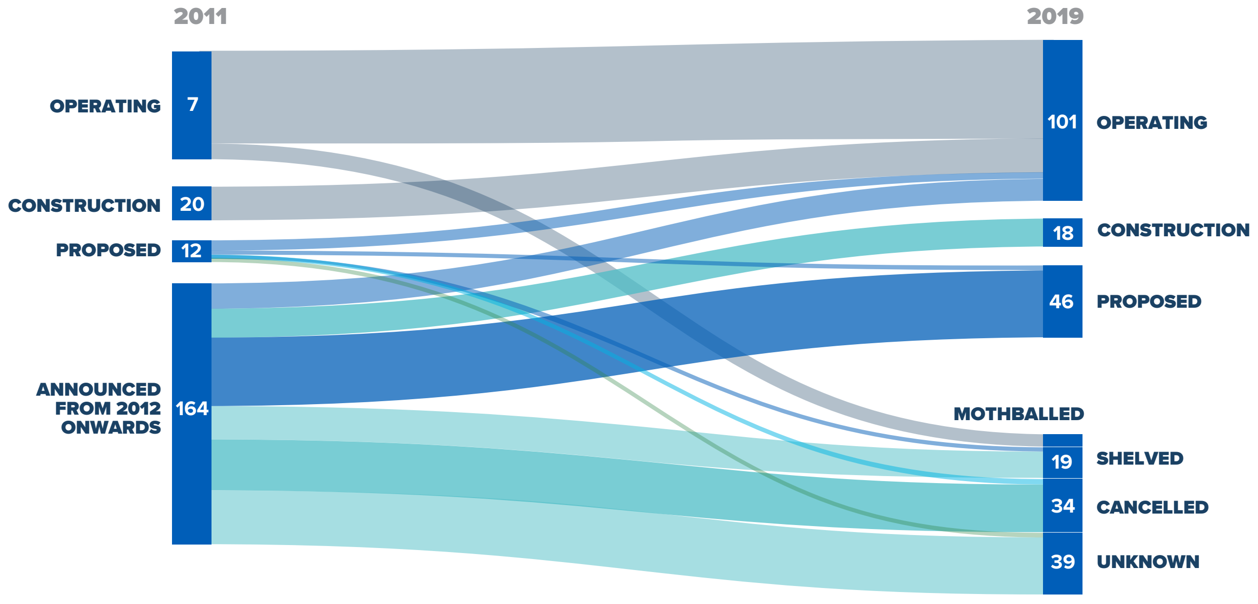
However, the overall trends in survival rates disguise a more positive and improving story over time. In the past two years the number of projects added to the pipeline has exceeded the number of projects exiting the pipeline. Similarly, the survival rate of the projects announced since 2010 is higher than that of the projects in the development phases of the pipeline at the start of the period (59% compared to 21%). This increased momentum appears set to continue in 2020 as evidenced in Section 3.2.

The data also show an improvement in the survival rate as projects progress through the development cycle, and especially as they move from the development stages to construction. Just over 80% of the projects that have reached the construction stage of development at some point in time over the past ten years remain in the pipeline, either under construction or in operation. The projects that have not made this transition provide valuable lessons for other projects that will hopefully improve this survival rate further. In comparison, the survival rate for projects at the development stage is around 37%.

As well as considering the absolute numbers of CCS projects in development to assess future deployment prospects, there is value in considering analogues for comparable technologies. LNG and offshore wind are often used as two such technologies. Neither is a perfect parallel but, interpreted correctly, can prove insightful for CCS deployment projections. LNG facilities grew in numbers, mostly from the 1980s, and offshore wind projects from the 2010s, as their commercial case improved and unit costs reduced. The pathway followed by these technologies is comparable to the current needs for CCS.

The overall trend in survival rates for LNG projects is similar to CCS (Figure 5). For example, only 72 (44%) of the 164 LNG liquefaction plants announced since 2011 were still in the project pipeline in 2019. This is slightly lower than the survival rates for CCS projects announced over a similar period. The LNG project pipeline also shows a robust survival rate for projects that make it to the construction phase of development, with all projects under construction at the start of the period making it through to operation by 2019. The analogue between LNG and CCS can be taken further than just a simple comparison of survival rates, as shown in Box 1.

Figure 5: Changes in the global LNG liquefaction facility pipeline 2011-19 [2]



[2] Based on publicly available information on LNG projects collected from the International Gas Union annual LNG updates and Global Energy Monitor's LNG database.

PARALLELS BETWEEN LNG AND CCS PROJECTS

There are several parallels between LNG and CCS projects given the similarities in technologies and processes used for production, and the underlying drivers of the economics of projects. These parallels can provide further insights into the future development of CCS:

- The growth, and associated cost reductions, in provision of associated infrastructure has an influence on the development rate of underlying projects. For LNG, the fillip came from expansion in LNG shipping routes and trading. In CCS, the new interest in the independent provision of transport and storage could potentially be a capture project catalyst.
- The step-change in the growth of LNG facilities tended to cluster around a few major natural gas locations such as Qatar, Australia and Canada. Considering CO_2 emissions as the CCS comparator to natural gas supplies, the significant growth countries for future CCS facilities in the longer-term could perhaps be North America and China. These are regions with some of the highest scores in the Institute's CCS Requirement Indicator (18).
- LNG project activities tend to follow long-term trends in natural gas prices that ultimately determine their economic attractiveness. For CCS projects it should be long-term trends in the underlying carbon value – principally driven by regulation – that affect project growth rates. An interesting contrast with natural gas commodity price trends is that carbon values should only intensify and rise in future which provides reasons to believe that the survival rate of CCS projects over time should improve.

While less analogous to CCS projects than LNG, for example due to the smaller scale of projects, the experience of windfarms provides an interesting perspective. In the UK, 54% of onshore wind farms and 92% of offshore windfarms that have entered the planning stage were still in the pipeline, either under development or in operation, in 2019 (8). Unlike LNG and CCS projects, the primary reason for windfarm projects failing is the refusal of planning applications, particularly in the case of onshore windfarms. In a smaller number of cases, the applications have been withdrawn by the developer.

3.4 Summarising the implications for the near-term deployment of CCS

Recent developments in the CCS project pipeline and policy frameworks shows there is growing momentum in the CCS industry.

However, given the lead-in times associated with CCS projects, it will not be until the mid to late 2020s that any new projects that are added to the project pipeline make it through to operation. The lead-in time therefore places an effective cap on the number of facilities potentially in operation by this time at the 51 currently in operation, under construction, or under development.

The observed attrition of projects from the pipeline of CCS, LNG, onshore wind and offshore wind projects indicates the need for a healthy pipeline to support the scaling up of deployment. While the survival rates of CCS projects have improved in recent years, there remains room for improvement. The higher rates of survival for offshore windfarms, a technology which has shown a significant rate of growth over the past decade, could provide an indication of the survival rates needed or achievable for CCS.

4.0 LONGER-TERM DEVELOPMENT IN THE CCS MARKET

The longer-term deployment of CCS, for example up to the 2050s, is highly uncertain and difficult to predict. As the time available for new projects to be added to the pipeline increases, and policy and market conditions change, the validity of the current CCS pipeline and CCS readiness assessments decline. A different approach to that used to estimate the short-term developments in CCS is needed to estimate the longer-term deployment of CCS.

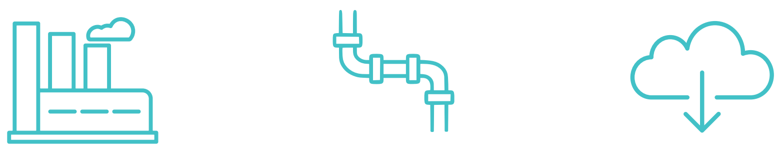
In the absence of detailed market data, a reasonable approach is to base long-term assessments on the rate of CCS deployment required to meet climate targets. Several credible scenario models have been developed that assess the trade-offs between climate and socio-economic systems and provide insights into the range of mitigation pathways that achieve long-term climate goals. The results often include a breakdown by mitigation technology, including estimates of the amount of CO_2 sequestered using CCS.

One scenario that is often referred to for estimates of the future deployment of CCS is the IEA's Sustainable Development Scenario (SDS).

The SDS describes the measures necessary to deliver a future where the United Nations energy related sustainable development goals for emissions, energy access and air quality are met. The scenario meets the conditions necessary to achieve the Paris Agreement, with a 66 per cent probability of limiting global temperature rise to 1.8 degrees Celsius without relying on large scale negative emissions.

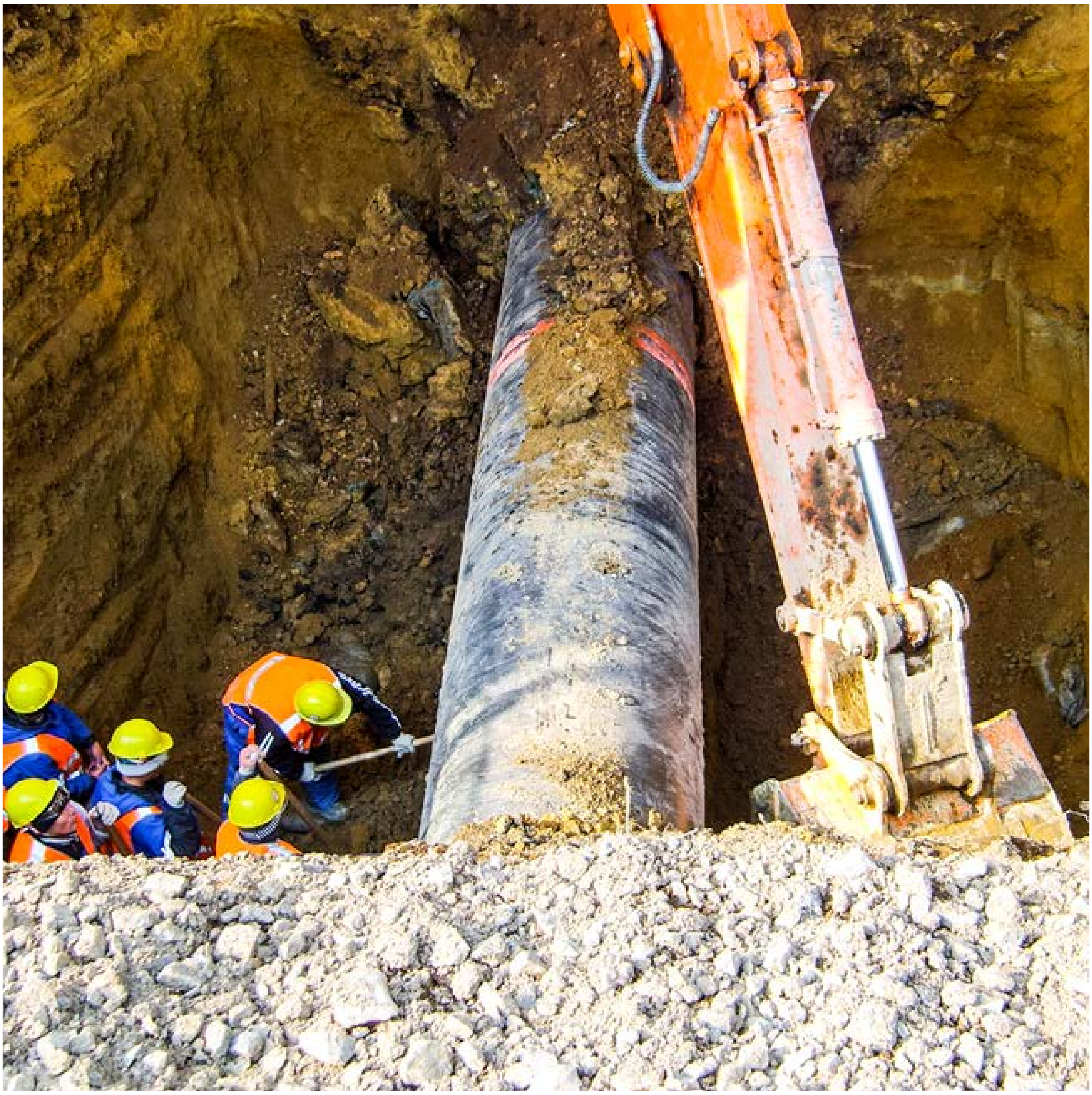
Under the IEA SDS, the amount of CO_2 captured and permanently stored globally is estimated to reach 0.8 $GtCO_2$/yr in 2030 and 2.8 $GtCO_2$/yr in 2050 (17). Achieving this level of deployment will require the number of capture facilities to increase a hundredfold, from 19 in operation at the end of 2019 to more than 2,000 in operation by 2050 (Figure 6). Reaching this scale will require 70-100 capture facilities to be built each year. These facilities would need to be supported by 200,000 km of pipeline by 2050, with an average pipeline build rate of 5,200-7,200 km per year. In addition, a total of 400 storage sites would be needed, with 10-30 being established each year.[3]

Figure 6: Total and annual build rates of CCS facilities in the IEA SDS



	CAPTURE FACILITIES	PIPELINES	STORAGE SITES
TOTAL IN 2050	MORE THAN 2,000	200,000 KM	400
ANNUAL BUILD RATE TO 2050	70 - 100	5,200 - 7,200 KM	10 - 30

[3] Global CCS Institute analysis, assuming the average facility captures one million tonnes of CO_2 per year, that the average pipeline length per facility is 80km, that 90% of facilities transport CO_2 using pipelines, and the average storage site is capable of storing 100 million tonnes of CO_2.



While CCS deployment in the IEA SDS is not available at a country-level, it is likely to be concentrated in those countries that have a high dependence on heavy industry and fossil fuels. The Institute's CCS Requirement Indicator identifies those countries that have a high dependence on fossil fuels and, therefore, will need to deploy CCS to meet their long-term climate targets (18). China, India, Indonesia, Russia and the United States are the five highest scoring countries under the CCS Requirement Indicator, followed by Australia, Canada and Germany. These countries provide the greatest opportunities in absolute terms to deploy CCS, subject to the introduction of supportive policy.

Several commentators have questioned how achievable the rapid build out of CCS would be in these scenarios given the relatively low level of CCS activity currently. This concern centres on whether there are any technical, commercial or resource constraints that are likely to limit the scaling up of CCS.

The main technologies that form CCS projects are generally well established and therefore the technical barriers to scaling-up deployment are relatively immaterial. On the other hand, it is well documented that there are significant commercial barriers for CCS, primarily due to the absence of a robust value on CO_2 emissions. What has been less fully explored is whether the physical resource exists to support the level of build out needed to meet the goals of the Paris Agreement.

One approach to assessing whether there are physical resource constraints is to compare the build out required for CCS to that achieved by similar infrastructure projects or analogues. A recent report by Shell for IEAGHG does this for scenarios consistent with a 2°C pathway and find the rates of deployment required remain within reach (9). The report identifies several relevant analogues, including:

- The number of CCGT plants built each year, which reached 60-120 from 1995 to 2010 (10).
- The number of coal-fired power plants built each year in China, which averaged around 100 per year from 2005 to 2015 (11).
- The length of natural gas pipelines built in the last decade (8,000km/yr) and at peak construction rate in the 2000s (9,200km/yr) (12).
- The rate of development of oil and gas fields, which averaged 350 per year from 2000-2010 (9).

Comparing these analogues to the build out rates required under the IEA SDS confirms that the build out rates are achievable. However, it will require a monumental shift in policy to address the commercial barriers to CCS deployment.

Other scenario models suggest the rate of deployment may need to be much higher or lower than in the IEA SDS. A review of the results from six Integrated Assessment Models (IAMs) across five different socioeconomic pathways shows a large range in CCS deployment.[4] For example, in scenarios that are consistent with limiting global temperature rises to 1.5°C, the mass of CO_2 sequestered using CCS is estimated to range from 5 $GtCO_2$/yr to 28 $GtCO_2$/yr in 2050, with an average across the scenarios of 11 $GtCO_2$/yr. Under a 2°C pathway, the range is 0.4 $GtCO_2$/yr to 30 $GtCO_2$/yr, with an average of 6 $GtCO_2$/yr.

The range in the results points to the need to consider the analysis of future deployment rates as illustrative rather than definitive. Differences in the assumptions around population, GDP and technological growth, and underlying differences in the CCS assumptions used in each model, can drive significantly different results. Estimates at the higher end of the range do not necessarily reflect less robustness of the underlying modelling. Instead, they are the result of the assumed high consumption of fossil fuels that in turn requires more CCS deployment to achieve climate goals.

An interesting observation from IAMs is that CCS deployment can be higher in lower ambition scenarios. This somewhat counterintuitive finding results from the carbon budget being more constrained under 1.5°C scenarios, limiting the space for residual emissions from fossil fuel consumption even with CCS (13). Scenarios consistent with 1.5°C on the other hand require greater deployment of negative emissions technology like bioenergy with CCS (BECCS). This indicates that climate ambition, along with differences in socio-economic developments, will have a large bearing on how the CCS market develops.

[4] The analysis uses the results for the five IPCC Shared Socioeconomic Pathways and from the AIM, GCAM, IMAGE, MESSAGE, REMIND and WITCH IAMs. Includes only scenarios for which climate constraints can be met given the underlying socio-economic assumptions, and that include the deployment of CCS.

5.0 CONCLUSION

Although it is not the main focus, the most important conclusion of this report is that current rates of CCS project development activities are insufficient to meet the needs for its deployment to keep the world on track for the goals of the Paris Agreement. That is not a surprise. What is more encouraging is the insight that the rates of deployment suggested in scenarios such as the IEA SDS remain achievable.

However, achieving the rate of CCS deployment in various scenarios will require a monumental policy effort. The report highlights the following areas where policymakers could facilitate the deployment of CCS:

- Maximising the number of CCS projects entering the development pipeline. This could be by means of regulation to underpin more robust carbon values, considering compelling and complementary tax incentives, or creating CO_2 transport and storage hubs to attract more local capture projects.
- Minimising the number of CCS projects exiting the development pipeline, especially in the critical, yet sensitive, pre-construction phase. This could be achieved by encouraging improved cross-learnings between projects, creating more support for CCS amongst the financing community, and encouraging closer interaction between capture customers and infrastructure providers.
- For all CCS policies, remaining sensitive to the relatively long gestation period for CCS projects and the disruptive impact that short-term political cycles can have on investor confidence and pipeline stability.

By its nature, this assessment of global CCS prospects is relatively high-level and sets broad boundaries around parameters and projections. Further work to refine and improve the results could be useful. That could focus on, for example:

- Reviewing country level commitments and assessments to understand what they commit to with respect to CCS deployment.
- Collecting information on other indicators of CCS activity rates in both the short and long term.
- More closely exploring individual aspects of the emerging markets for CO_2 and CCS, such as shipping, both inland as well as ocean, and independent hub and infrastructure development and operatorship.
- A deep review of deployment rate learnings from possible technology analogues. Possible LNG and offshore windfarm parallels were only touched on in this work. There could be scope for more value to CCS deployment rates from a “deep dive” on the experiences of these other technologies.

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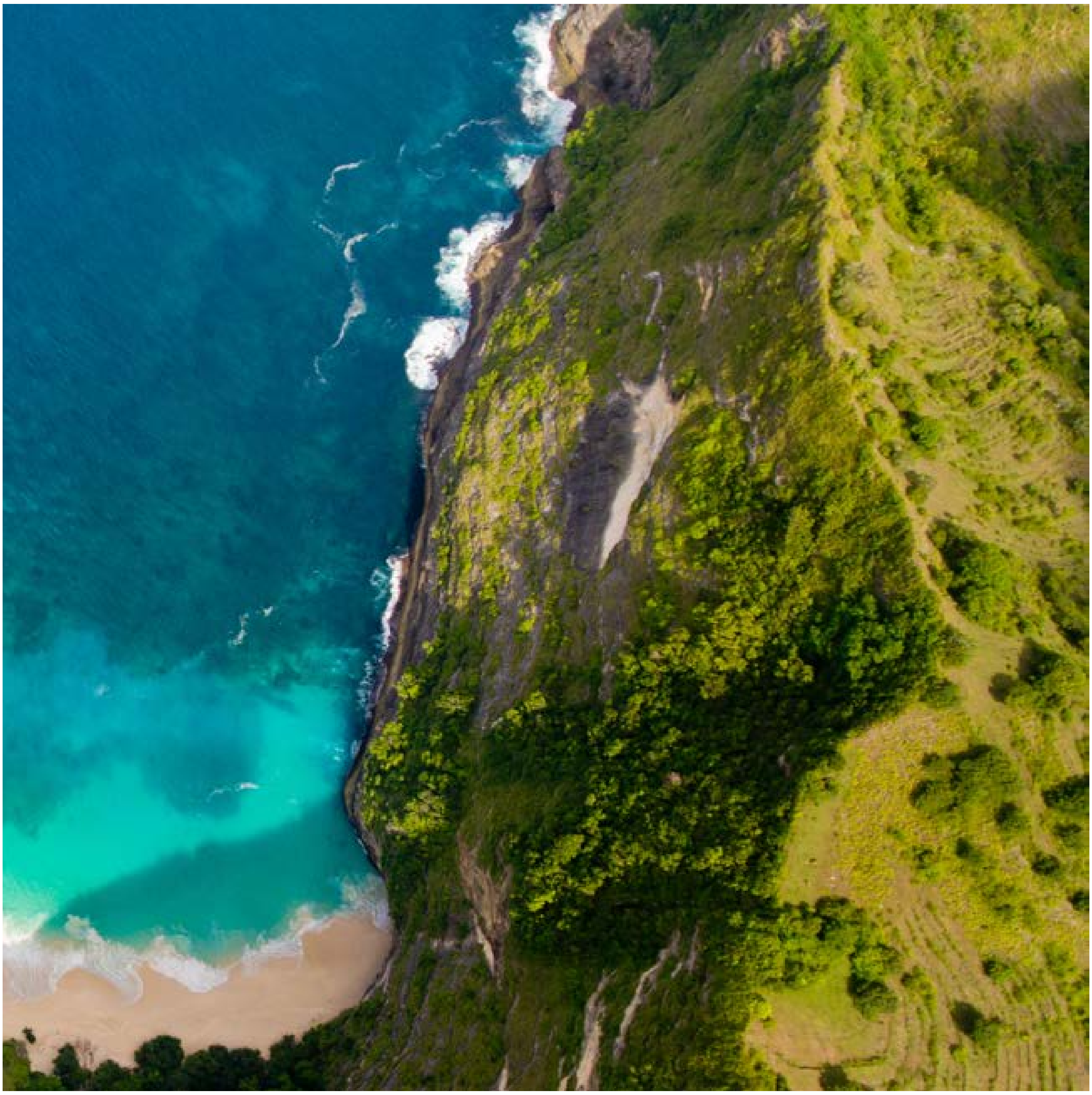

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