



## Foresight

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### **Exporting CCUS Technology**

An international business development strategy for Canadian carbon capture, utilization, and storage companies

*March 2021*



## About CMC Research Institutes

CMC Research Institutes is a national, not-for-profit organization providing emissions reduction solutions and support to Canadian industry. We strive to enhance the competitiveness of Canada's industries by accelerating the development and implementation of technologies that capture, utilize, store, and monitor greenhouse gases. We also provide evidence-based, advisory services including techno-economic and market assessments, as well as project planning.

## Foresight

## About Foresight Cleantech Accelerator Centre

Foresight accelerates the growth and impact of cleantech ecosystems across Canada. We have supported over 500 ventures in our Launch, Deliver and Grow programs, and more than 150 industry partners through our industry, capital, and export programs. Foresight's expertise has helped secure in excess of \$250 million in capital, \$200 million in revenues and has led to the creation of well over 5,000 high-paying jobs with an economic impact of over \$1 billion. Our domestic and international engagement includes collaboration with more than 2,000 stakeholders and partners. We have a strong history of strategy, ecosystem mapping, and partnership building that positions Canada as a global leader in cleantech innovation.

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## Acknowledgements

This publication was prepared by:  
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This report benefited from the inputs of John Loughhead, recently UK Department for Business Energy & Industrial Strategy; Eddy Chui, Natural Resources Canada; Ian Philp, Consulate General of Canada in New York; and Jason Switzer, Alberta Clean Technology Industry Alliance.

We would also like to thank Brett Henkel, Svante Inc.; Jeffrey Nichols, CarbonCure Technologies Inc.; Guy Gensey, Government of British Columbia; and Phil De Luna, National Research Council of Canada for their guidance. We also thank the global network of Canadian Trade Commissioners, industry representatives and other stakeholders who provided input.

## With thanks to our funding partner:

CanExport Associations Program through the  
Canadian Trade Commissioner Service

A decorative image at the bottom of the page showing a range of mountains under a hazy sky, with some clouds or mist in the valleys.

## A MESSAGE FROM STEPHEN LOUGHEED

President and CEO, CMC Research Institutes

Momentum to develop low carbon processes and technologies has accelerated since the International Panel on Climate Change released its 2015 report on the urgent need to reduce CO<sub>2</sub> emissions. Governments are putting low carbon targets in place and developing enabling policies and regulations. Industries are announcing net zero objectives and looking for ways to meet those targets. Investors are supporting new technologies that provide decarbonization pathways.

A global race is underway to develop solutions to reduce carbon emissions to achieve the steep reductions necessary to mitigate the impacts of climate change. One critical area of focus is carbon capture, utilization and storage (CCUS) which climate models show plays a necessary role in achieving reductions, especially in hard to decarbonize industrial sectors.

**“We will grow the Canadian economy, train a new cadre of professionals to work in a low carbon world, and become an integral part of the race for a sustainable future.”**

The focus on CCUS has created an emerging global market for these technologies that has enormous potential. This is welcome news for Canada which has many strengths in the sector including recognized expertise in the carbon capture and storage industry and a robust innovation culture focused on developing new capture and utilization technologies.

This report is intended to increase the competitiveness of Canada’s CCUS sector by providing actionable information to Canadian technology companies as they look to tap into global markets. It identifies priority target countries, studies opportunities and barriers to entry, and provides market intelligence gathered from CCUS companies who have entered international markets. The result is a comprehensive package of information and resources for Canadian companies unsure of first steps when contemplating expansion into other countries.

Canada has a well-deserved reputation in technology innovation – including CCUS – and we hope this report will inspire confidence in companies and innovators to feed new markets with solutions for the climate problem. In doing so, we will grow the Canadian economy, train a new cadre of professionals to work in a low carbon world, and become an integral part of the race for a sustainable future.

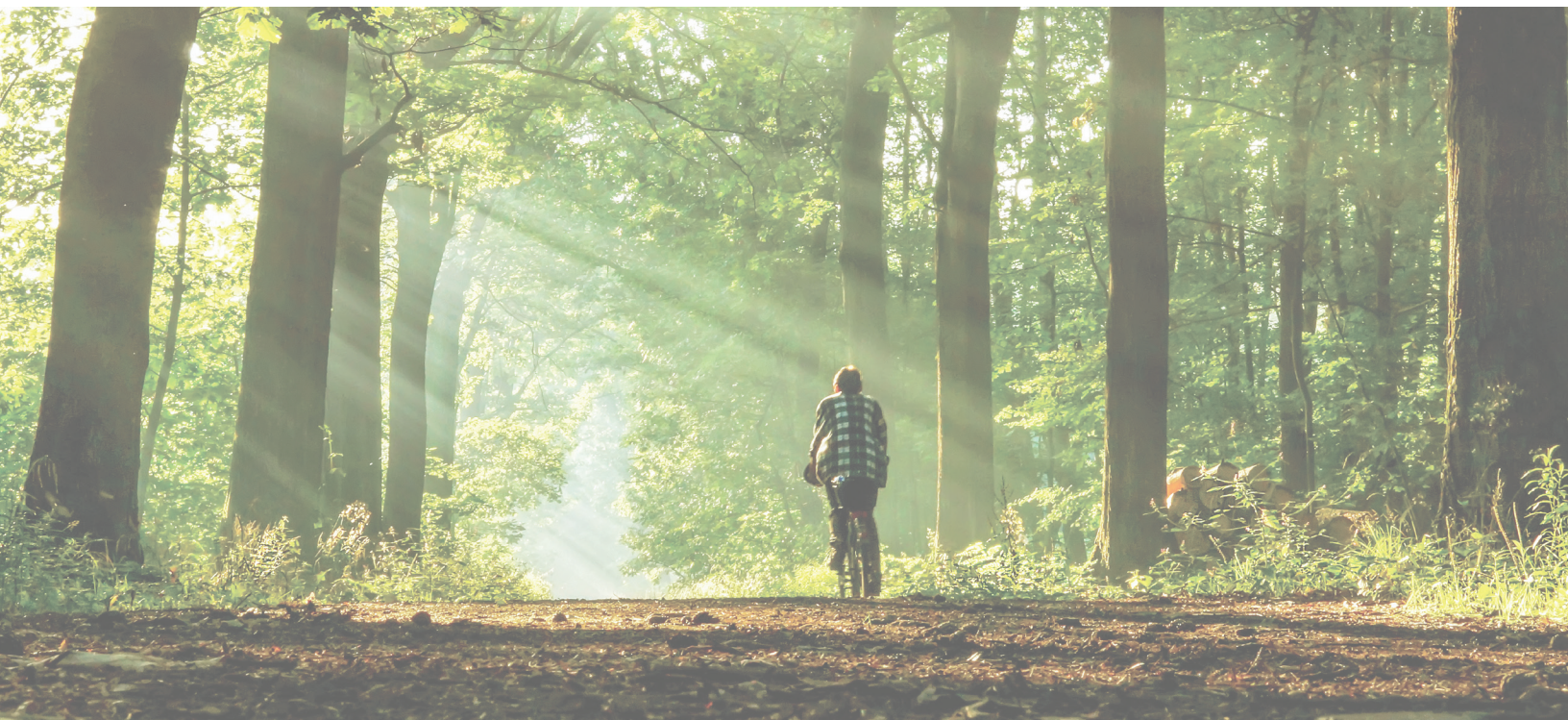
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## LIST OF ACRONYMS

<b>ACT</b>	Accelerating CCS Technologies	<b>EU</b>	European Union
<b>ADB</b>	Asian Development Bank	<b>GtCO<sub>2</sub></b>	Gigatonnes of carbon dioxide
<b>ANCLER&amp;D</b>	Australian National Low Emission Coal Research and Development initiative	<b>HESC</b>	Hydrogen Energy Supply Chain
<b>ARENA</b>	Australian Renewable Energy Agency	<b>IEA</b>	International Energy Agency
<b>BDC</b>	Business Development Bank of Canada	<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>BECCS</b>	Bioenergy with carbon capture and storage	<b>LCFS</b>	Low carbon fuel standard
<b>BEIS</b>	UK Department of Business, Energy and Industrial Strategy	<b>METI</b>	Japan Ministry of Economy, Trade and Industry
<b>CarbonSAFE</b>	Carbon Storage Assurance Facility Enterprise Initiative	<b>MMV</b>	Monitoring, measurement, and verification
<b>CC</b>	Carbon capture	<b>MOU</b>	Memorandum of Understanding
<b>CCGT</b>	Combined cycle gas turbine	<b>MtCO<sub>2</sub></b>	Million tonnes of carbon dioxide
<b>CCS</b>	Carbon capture and storage (includes EOR)	<b>MtCO<sub>2</sub>e</b>	Million tonnes of carbon dioxide equivalent
<b>CCS TF</b>	Carbon Capture and Storage Trust Fund	<b>Mtpa</b>	Million tonnes per annum
<b>CCU</b>	Carbon capture and utilization (includes carbon conversion)	<b>NEPIC</b>	North East of England Process Industry Cluster
<b>CCUS</b>	Carbon capture, utilization and storage	<b>OGCI</b>	Oil and Gas Climate Initiative
<b>CEFC</b>	Clean Energy Finance Corporation	<b>R&amp;D</b>	Research and development
<b>CEO</b>	Chief executive officer	<b>RD&amp;D</b>	Research, development, and deployment
<b>CO<sub>2</sub></b>	Carbon dioxide	<b>SMEs</b>	Small-to-medium enterprises
<b>CRC</b>	Cooperative Research Centres	<b>TCS</b>	Trade Commissioner Service
<b>DAC</b>	Direct air capture	<b>TRL</b>	Technology readiness level
<b>EOR</b>	Enhanced oil recovery	<b>UK</b>	United Kingdom
<b>ERA-NET</b>	European Research Area Network	<b>US</b>	United States of America
<b>ESG</b>	Environmental, social, and governance		



## EXECUTIVE SUMMARY

The Carbon Capture, Utilization, and Storage (CCUS) sector is growing rapidly as governments seek technology solutions to reach carbon neutrality by 2050 to comply with commitments under the Paris Agreement. This International Business Development Strategy is intended to act as a guide for Canadian CCUS technology companies, specifically small and medium enterprises (SMEs), to access key global markets where there has been significant development of the CCUS sector and inform the creation of business export plans. This guide can help Canada's CCUS companies enter target international markets, grow Canada's CCUS sector competitiveness, and ultimately increase foreign and domestic business opportunities.

To best use this document, it is recommended for Canadian CCUS companies to conduct a SWOT (strengths, weaknesses, opportunities, threats) analysis based on their unique circumstances to determine priority international markets to enter. It is suggested that companies first evaluate the internal strengths and weaknesses of their business to determine the types of markets suitable for their technology. Subsequently, an analysis of external opportunities and threats affecting the CCUS sector in each of the target markets addressed in this report can be cross-referenced with the internal evaluation and used to identify regions to focus international expansion efforts.



The following potential opportunities and threats can be ascertained from the country-specific information in this report for the external analysis:

### Potential Opportunities:

- Government funding or policy support for CCUS
- Development of CCUS “hubs” - clusters of industrial CCUS projects that share transport, storage and/or utilization infrastructure
- Existing or upcoming CCUS projects
- Prominent corporations with a demonstrated interest in CCUS
- Regional sub-sectoral focus (i.e., preference to storage, utilization or both)
- Key industrial point source emissions (to gauge emissions reduction demand and type of technology needed)
- Hydrogen sector growth plan (i.e., blue hydrogen will require CCUS)

### Potential Threats:

- Lack of government funding or policy support
- Legal or regulatory risks (i.e., tendency for litigiousness, risks to intellectual property (IP))
- Social acceptance of CCUS in a region
- Advanced local technology development and/or preference for local technology
- Differences in local business customs (i.e., language barriers, need for in-country representation, cultural differences)



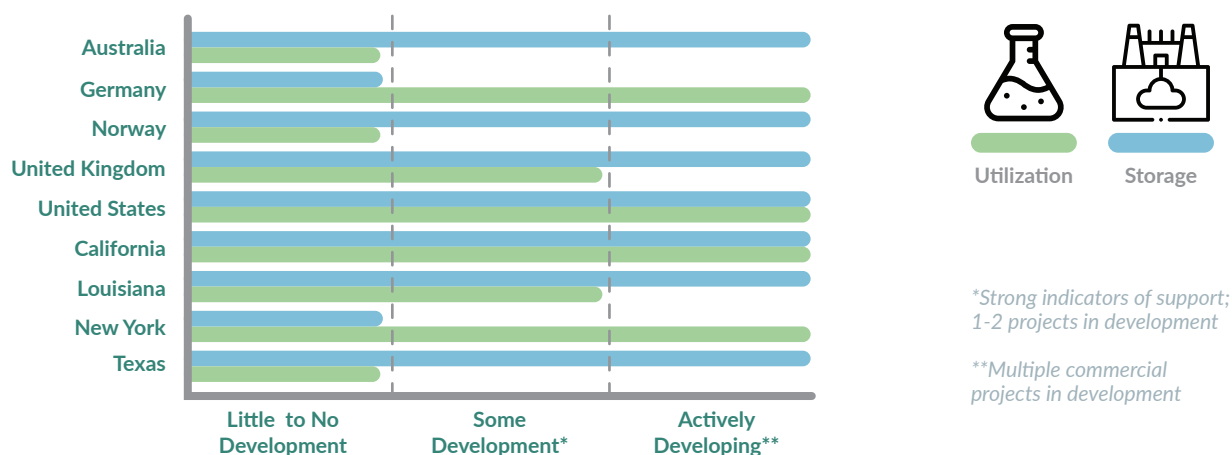
It is recommended that companies use this analysis to identify one to two target regions for international expansion. A specific business development strategy and market entry pathway can then be developed for selected target countries. Engaging with the Canadian Trade Commissioner Service (TCS) in both domestic and international offices and participating in market events can assist with market entry. Relevant contact information for the TCS and upcoming events in the CCUS sector are listed in this document's Appendices.

The CCUS sector can be segmented into sub-sectors of capture, utilization and storage; each variably favoured among different jurisdictions. Carbon capture (CC) is needed for any application to sequester carbon but the applicability of a specific capture technology will vary depending on the emissions source and will therefore find differing geographic demand relative to the prominent industries in a given region. The following general factors summarize considerations to understand a region's focus on storage (CCS) or utilization (CCU):

- **Policy Environment and Social Acceptance**
- **Nature of Domestic Industry**
- **Total Volume of Emissions**
- **Geological Storage Capabilities**

Five initial target market recommendations for Canadian CCUS companies to consider were identified through a research process that included a literature review, interviews with an expert advisory panel, and interviews with stakeholders around the world. Interviews with 30 international CCUS experts from government, industry, research organizations, and the TCS were completed to expand on-the-ground knowledge of the target markets. Information on the regional CCUS market, relevant policy and funding mechanisms, geological storage capabilities, key industry and point source emissions, CCUS hub or project development, and contact information for regional and international TCS offices and in-country organizations is provided for each target market, along with identification of potential opportunities and threats for each region. Case studies highlighting lessons learned and suggested practical actions from Canadian CCUS SMEs who have successfully entered international markets were also compiled.

The top five markets recommended for Canadian CCUS companies to consider international expansion (in alphabetical order), and the identified sub-sector focus in each region are:



While the study focused on the identification of the top five countries for potential export of Canadian CCUS technologies, France, Japan, and the Netherlands were also identified as markets of interest for CCUS sector development.

In the spirit of increasing the competitiveness and maturation of Canada's global CCUS sector generally, the following suggestions are recommended for Canadian governments:

1. **Support** the creation of a domestic CCUS industry cluster to foster full-scale project partnerships among technology companies and increase cooperation between different levels of government;
2. **Expand** public-private sector carbon utilization technology accelerators and value chain connection programs to minimize a company's time to market;
3. **Increase and sustain** government funding to support CCUS technology advancement and incentivize private sector companies to adopt domestic technology, including providing additional support for first demonstration, field piloting, and first-of-its-kind technology implementation in a variety of heavy industries;
4. **Provide support** to incentivize the establishment of a manufacturing base in Canada for CCUS technology in order to maximize the likelihood of job creation and economic diversification in Canada.

This strategy aims to help Canadian CCUS companies overcome challenges to international business development efforts and to position Canada as a worldwide industry leader in the CCUS market.

## INTRODUCTION

Climate change is well established as one of the largest challenges facing modern society. Since the Paris Agreement of 2015, governments around the world have begun implementing emissions reduction policies that will catalyze action to limit global warming to 1.5°C.<sup>2</sup> This climate threshold will require net zero emissions by 2050<sup>2</sup>, compelling countries to make fundamental economic changes, including exploring solutions to reduce their largest point source emissions.

It is understood in global emissions reduction scenarios that carbon capture, utilization, and storage (CCUS) technologies will be required as part of a suite of strategies to reduce global CO<sub>2</sub> emissions.<sup>3</sup> CCUS is a collective term for technologies that have the potential to separate carbon dioxide (CO<sub>2</sub>) from point source emissions (large, stationary sources of CO<sub>2</sub>) or through direct air capture (DAC), and either store it indefinitely, or utilize it through various processes that remove the carbon from atmospheric release. The International Energy Agency (IEA)'s Sustainable Development Scenario finds an opportunity for 9% of global emissions reductions to be achieved by 2050 through CCUS.<sup>4</sup>

**Canada has the potential to be a global leader in the development and export of CCUS technologies**

Capture, utilization, and storage are sub-sectors within the broader CCUS suite of technologies<sup>i</sup>. Carbon capture (CC) technologies remove CO<sub>2</sub> from emission-producing industrial processes or directly from the air and are a critical first element of both carbon utilization and carbon storage. Capture processes can vary in complexity depending on the purity, temperature, and pressure of the emissions stream. Carbon capture and storage (CCS) in geological reservoirs is widespread. The large volume capacity of underground storage reservoirs makes CCS an attractive CO<sub>2</sub> mitigation option, but a dramatic increase in annual storage efforts is needed to meet climate threshold goals in accordance with the Paris Agreement.<sup>1</sup> Carbon capture and utilization (CCU) technologies are a novel segment which involve the transformation of captured carbon to form products like mineral solids, chemicals, fuels, and carbon solids. These products turn waste CO<sub>2</sub> feedstock into goods with high potential value, but the market is new and the carbon sequestration potential is much smaller than the volume capacity of geological sequestration.

<sup>i</sup> This report considers EOR under the category of CCS, and groups carbon conversion and utilization as one category, termed CCU.



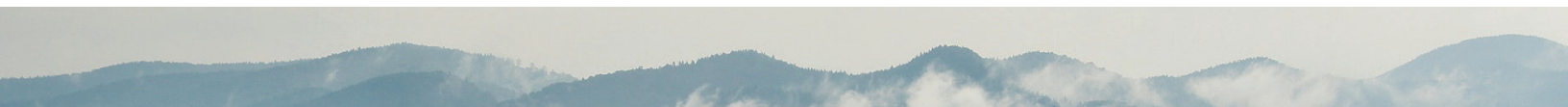
Canada has the potential to be a global leader in the development and export of CCUS technologies. With five large-scale CCS projects currently in operation<sup>5</sup>, Canadian project engineering, execution, and operation expertise from initiatives like Boundary Dam and Quest have the potential to be mobilized as a valuable service. Additionally, as reported in *The CarbonTech Innovation System in Canada*, with sufficient financial support and a favourable regulatory framework, Canada's growing carbon utilization sector may be in an advantageous position to become a market leader in CCU technologies.<sup>5</sup>

The objectives of this research are to assist in increasing the competitiveness of Canada's CCUS sector and provide insight for Canadian CCUS companies – particularly small and medium enterprises (SMEs) – to plan successful international business development efforts in the identified target countries.

#### Objectives include:

- **Identify** the priority geographic target markets for international expansion of Canada's CCUS companies;
- **Characterize** both near- and long-term market barriers and opportunities in these regions; and
- **Provide** supportive country-specific information and resources for Canadian companies considering and/or undertaking international expansion efforts.

Through literature review and direct engagement with international CCUS industry stakeholders, this project attempted to provide insights into global opportunities for CCUS companies within a rapidly evolving emerging global market where national emission reduction policies were changing across several countries within the five months of the report's development. Target sectors and countries were determined through analysis of CCUS and relevant climate change policies, geological storage capacity considerations, point source emissions, key industrial sector breakdown, social considerations and looking at hub region development, or clusters of industrial CCUS projects. The research is expected to provide key resources and act as a guide for Canadian CCUS companies to leverage as they create or review international business development strategies.



## GENERAL STRATEGY FOR INTERNATIONAL EXPORT

This section suggests steps for CCUS SMEs to evaluate and create an International Business Development Strategy to access global export markets. The 'Target Markets' section of this report will provide country-specific information, which is intended to inform SMEs of the nuances and sub-sector market development in each region. Suggested steps in the planning process include:

- 1. Conduct a SWOT Analysis to Identify Markets and Applications Best Suited for Your Technology**

As part of developing a strategy for international business development, it is valuable to perform a SWOT (strengths, weaknesses, opportunities, threats) analysis to help determine your company's strengths and allow you to recognise where lies the greatest opportunities<sup>i</sup>. The Strengths and Weaknesses analysis (inward-facing) should be performed first to identify the applications to which your technology is best suited and in what types of markets your company will best perform. Once your specific strengths and weaknesses are understood, the Opportunity and Threat analysis (outward-facing) should be completed for each market under consideration. Cross-referencing these analyses can be used to determine your target markets.

Depending on the nature of the technology and the application for which it is best suited, individual CCUS technology companies may have differing approaches to conducting the SWOT. One approach is to first look at the market pull and industrial composition of geographic regions, followed by identifying companies in those regions. Alternatively, determining target industries that fit your technology applications, finding key companies in this industry, and narrowing your focus to these companies' largest markets is another option. In both cases, intersections of geographic regions and key industry players will be identified as promising target markets.

Regardless of approach, the inward-facing analysis should identify Strengths and Weaknesses, where your technology fits best in the CCUS value chain, and the key industry applications. The external-facing analysis can help clarify where your technology would best align in consideration of your Strengths. Potential Opportunities and Threats for each of the target markets identified in this report are discussed in each country's section.

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<sup>i</sup> This report is not the venue for instruction in how to perform a SWOT analysis but there are many sources available online including one from BDC referenced in this report.<sup>6</sup>

The following Opportunities and Threats are suggested to consider for the external analysis of each market:

## Potential Opportunities

- Government funding or policy support for CCUS
- Hub region development
- Existing or upcoming CCUS projects
- Prominent corporations with a demonstrated interest in CCUS
- Regional sub-sectoral focus (i.e., preference to storage, utilization or both)
- Key industrial point source emissions (to gauge emissions reduction demand and type of technology needed)
- Hydrogen sector growth plan (i.e., blue hydrogen will require CCUS)

## Potential Threats

- Lack of government funding or policy support
- Legal or regulatory risks (i.e., tendency for litigiousness, risks to intellectual property (IP))
- Low social acceptance of CCUS
- Advanced local technology development and/or preference for local technology
- Differences in local business customs (i.e., language barriers, need for in-country representation, cultural differences)

**It is important to understand the legal risks associated with any market. If a region is known to be litigious or has a history of risks to IP rights, it would be valuable to consult a lawyer and/or a policy expert in the country to ensure that you have appropriate mitigation measures in place.**

## 2. Identify One or Two Target Regions for International Expansion and Build a Specific Strategy

Informed by the SWOT analysis, SMEs should next determine the best one to two promising markets for their technology. A more detailed review of the corresponding target markets section can be used to assemble an international business development strategy specific to your company or technology and target region.

## 3. Consider Methods to Entering the Target Region(s)

There are different methods to international business expansion that should be considered during the strategic planning process. The target market sections in this report have some recommendations for market entry specific to the respective country, which were advised through sector expert interviews. Entry pathways have been identified as follows<sup>7i</sup>:

- **Exporting**
- **Licensing/franchising**
- **Partnerships/alliances with local firms**
- **Acquisition**
- **Launch of wholly owned subsidiary**

The type of market entry pathway chosen should consider the technology offering, business model, market landscape, and cultural factors in each target country. An entry path to Norway, for example, would be advised to have in-country representation due to typically close-knit business relationships. An exporting pathway would therefore not be recommended as an entry to Norway, whereas exporting as a market entry strategy to Australia or the United States would be plausible.

Information gathered from stakeholder interviews and literature review has emphasized that in the CCUS sector, a critical element of successful entry to an international market is the development of strategic partnerships. It is important to understand the complete CCUS value chain in the target market because a full-scale CCUS operation requires multiple steps - several technologies comprise the full process including the capture of carbon, monitoring, measurement, and verification (MMV), and engineering integration. The existence of multiple steps in the value chain makes entering international markets through developing partnerships well suited to the industry.

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<sup>i</sup> Market entry pathways are explained in more detail in the references provided in this report.<sup>7,8</sup>

There are different types of partnerships that have been identified as providing potential competitive value (*Note: in the following table, “SMEs” refers to SMEs in the CCUS technology sector*):

PARTNERSHIP	RATIONALE	EXAMPLE
Between SMEs	To present a full system of technologies, marketed as a complete solution, to a large emitter	Capture + utilization
Between technology and engineering consulting firms	Innovative technology partnered with engineering and geoscience expertise, particularly in the CCS sector would provide extensive client access and commercial support	Capture + storage + MMV, reservoir assessment, seismic data analysis
Between SMEs and large multinationals	Dedicated partnerships with large multinational companies can provide significant financial benefits	This can be companies with emissions reductions mandates looking to adopt your technology, or companies looking to add your technology to what they offer their customers.  Financial support can be in the form of direct equity investment or specific project support.

The following general recommendations are advised to initiate opportunities for any intended market entry pathway:

### I. Engage with the Canadian Trade Commissioner Service

A valuable first point of contact for SMEs is the TCS in both domestic Regional Offices and in the country(ies) of interest. There are often one or more designated “clean technology” sector trade commissioners in each office with CCUS falling under their portfolio.<sup>9</sup> Appendix A lists the contact information for the cleantech trade commissioners based out of Regional Offices in Canada, and Embassies, Consulates, or the High Commissions in the countries featured in this report. The TCS website is a good resource for funding information, upcoming trade missions, and other partnership facilitation programs, as well as country-specific information.<sup>9</sup>

### II. Participation in On-The-Ground Market Events

There are a number of events that happen annually to foster partnerships and influence growth of the CCUS sector. TCS offices often host regional events, and there are a number of large-scale conferences, workshops, and summits related to the sector that happen on a regular basis, on a global scale. These gatherings that convene the right audiences for business development opportunities often present an efficient way to network and initiate relationships with multiple parties in a short time frame. A list of relevant upcoming events can be found in Appendix C, some of which may be virtual due to the Covid-19 pandemic.

## Additional Advice for Projects in Unfamiliar Regions

After identifying a project in a new region, a critical first step is to identify the stakeholders in the region relevant to your efforts and initiate conversations. Determine stakeholders who will be directly impacted by the project (i.e., client, government regulators, neighbours to project location) as well as indirect stakeholders who may be affected by elements of the project and ensure lines of communication are open and clear. Indirect stakeholders may include those affected by the project's supply chain, if shipping of hazardous materials requires passing through areas of interest (i.e., conservation lands, Indigenous lands or communities) or those who may be affected by the project itself, for example, if the project will affect the air quality in a region or bring significant construction activities. Communicating with stakeholders who will be affected by the project before initiating any development application can help ensure all parties are on the same page, avoid unnecessary blockades, and can influence public perception of the project. If a CCUS project will have positive effects on a community, like job creation or air quality improvement, increasing public knowledge of the project can buy social license and positive influence on regulation. Alternatively, public concern over an unfamiliar project can delay development.

**If a CCUS project will have positive effects on a community, like job creation or air quality improvement, increasing public knowledge of the project can buy social license and positive influence on regulation.**

Government regulators should be a priority contact before any formal applications to develop are submitted. It is recommended that companies set up a meeting with the regulating body once the target market is confirmed to discuss project plans, get feedback, and establish a cordial relationship. Having the regulators involved in development plans can also be beneficial to navigating the regulatory process. Check with local advisors for assistance on identifying regulators and indirect stakeholders. The local TCS office may be a reference point for finding knowledgeable advisors.



## CASE STUDY #1

# Svante

**Headquarters:** Burnaby, BC

**Founded:** 2007

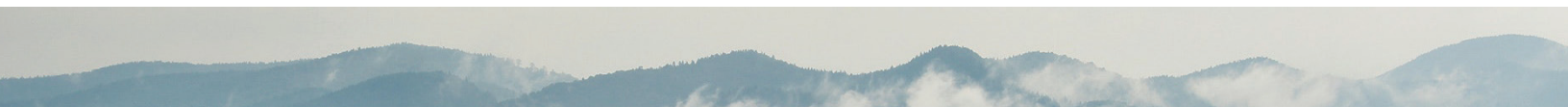
**Description:** Svante's technology captures carbon dioxide from post-combustion flue gas of industrial processes like steel, cement, aluminum, hydrogen, and fertilizer by separating it from other gases using nano-sized solid adsorbent materials.<sup>114</sup> The separated CO<sub>2</sub> can be stored or used in industrial applications.

**Background:** Svante was founded by former gas purification and separation industry colleagues in the Vancouver, BC area. Formerly known as Inventys, they have scaled up their capture capability since their founding in 2007 from half a tonne per day to up to 1000 tonnes per day and have since signed collaboration agreements and launched projects with large corporations like Total, LafargeHolcim, Oxy, and Chevron.<sup>114</sup>

**Export Experience:** Business has expanded across borders, with projects in the pipeline in the US as well as domestically in Canada. Working with multinational companies has proved fruitful and has led to projects with the same company in multiple locations. Svante has projects with LafargeHolcim and Total in Canada and the US. Svante has partnered with LafargeHolcim and Total on the CO2MENT capture and utilization project in Richmond BC.<sup>115</sup> The same group with Oxy Low Carbon Ventures is also working on a project, now in the feasibility study phase, to build a large carbon capture operation at the Holcim Portland Cement Plant in Colorado, US.<sup>116</sup>

Svante has also partnered with Chevron Technology Ventures to undertake the construction and installation of a 25 tonne per day carbon capture plant at a Chevron facility in California, US.<sup>117</sup>

**Since 2007, Svante has scaled up their capture capability from half a tonne per day to up to 1000 tonnes per day**



## LESSONS LEARNED

Some recommendations from Svante, taken from lessons learned during export development efforts are as follows:

### 1. **The TCS is a valuable connection.**

Svante has emphasized how the TCS can assist in making the export process easier. Working with trade commissioners to get the right contacts at the right places can help the process become more efficient and avoid “cold” networking efforts that might not yield responses.

### 2. **Concentrate efforts around hub regions to narrow your business development efforts.**

Looking at where the big ecosystems are in place to support CCUS is said to help avoid wasted time and narrow focus to regions and industries who are interested in exploring CCUS technologies. Having a sense of what type of technology would be needed based on the industrial demographics of a hub and in what sub-sector development has been focused on will help to further specify target parties. As CCUS technologies tend to be very technical and not often understood by the average person outside the sector, narrowing one’s focus to strategic targets can help avoid having repeated discussions to explain concepts rather than talking business.

### 3. **Partnerships and collaborations with other businesses are critical.**

It was pointed out that CCUS projects never involve only one party. There are typically four or more entities involved in a project, including the emitter, the government, the investors, the technology providers, and the recipient of the CO<sub>2</sub>. Partnerships are therefore necessary to move projects forward, particularly from a funding perspective. It was noted that from experience, a partnership with a large emitting company having equity financing in Svante has often resulted in a more secure partnership.

### 4. **Understand the regulatory frameworks and funding availability for each country.**

As regulations and policy related to CCUS and emissions reduction are constantly changing, it is very important to stay knowledgeable in this area. Keeping up to date with government incentives and funding programs can help a company understand what is uniquely desired and what gets projects off the ground in each region. In the current state of the market, government funding is critical to progressing projects in CCUS.

### 5. **Utilize the services of technology accelerators and industry organizations.**

Non-profit organizations that serve to advance the CCUS sector like technology accelerators can be valuable, particularly when entering an unknown market, to provide information on funding, make connections and partnerships, and inform on local business nuances.

## CASE STUDY #2



**Headquarters:** Dartmouth, Nova Scotia

**Founded:** 2007

**Description:** CarbonCure reduced embodied carbon in the built environment by enabling concrete producers to add CO<sub>2</sub> to the concrete manufacturing process, where the CO<sub>2</sub> mineralizes and is eliminated.<sup>118</sup> This mineralization process results in compressive strength gains, which enable CarbonCure concrete producers to realize environmental and economic benefits.

**Background:** Architects, structural engineers, owners and developers are seeking proven ways to reduce the embodied carbon of their building projects. Recognizing concrete as a solution, CarbonCure Technologies has developed an easy-to-adopt carbon removal technology that enables concrete producers to use captured carbon dioxide to produce reliable, low-carbon concrete mixes and achieve market differentiation. Available from hundreds of concrete plants, CarbonCure-based mixes are transforming the built environment and has a mission to permanently reduce carbon emissions by 500 megatonnes annually across the concrete supply chain.<sup>119</sup> CarbonCure's investors include Amazon, Breakthrough Energy Ventures, Microsoft, Shopify, Mitsubishi Corporation, and Carbon Direct.<sup>120</sup>

**CarbonCure has a mission to permanently reduce carbon emissions by 500 Mt annually across the concrete supply chain.**

**Export Experience:** CarbonCure had international aspirations from the start, with mindfulness of the opportunities the global concrete market presented. They have expanded throughout North America, made waves in Singapore, and have since grown industrial partnerships elsewhere in Southeast Asia and South America, and have licensed distributors in Australia.

A partnership with the largest Singaporean concrete company, Pan-United Concrete, has been a significant milestone for CarbonCure's international expansion efforts. Along with installation at eight of its concrete plants in Singapore, Pan-United has opened the door for further expansion into the Asian market, including to their operations in Malaysia and Viet Nam.<sup>121</sup>

## LESSONS LEARNED

Some recommendations from CarbonCure's export development experience are as follows:

### 1. **Protect your intellectual property.**

It has been stressed that it is critical to take steps to protect IP when doing business internationally. Spend the money to cover yourself, create non-disclosure agreements where necessary, and take all steps to protect your technology.

### 2. **Marketing of your brand and technology is important for business development.**

CarbonCure has remarked on how marketing efforts have resulted in increased business, with sales coming directly to them rather than vice versa. Getting your brand recognized, utilizing social media, having an informative, well-designed website, and exploring other media opportunities can lead to more business and more brand trust among potential customers.

### 3. **Know your target customer and focus efforts on regions with opportunities in that industry.**

For CarbonCure, target customers are concrete producers, so naturally, its target markets were regions with the largest total addressable market of concrete plants and where the value proposition is the strongest. Successful market entry will come from knowing where your technology would foster demand and comparing the geographic industry breakdown in countries of interest to focus business development efforts. It is also important to evaluate any industry regulatory considerations in different countries of interest, as this may have implications for the feasibility of your technology being adopted on a large scale.

### 4. **Understand the implications of any business partnership.**

It has been noted that partnerships with other businesses are important and a good market entry strategy for international markets, but it is crucial to understand the limitations of each partnership. A large, decentralized company with headquarters in another country may have many projects on the go at any one time, and may have considerable internal approval processes. There may be a learning curve with any distributor relationship as they adjust to your technology. Though these are valuable business collaborators, be aware of these external factors that may affect the export process.



## CCUS SECTOR ANALYSIS

### Sector Overview

The CCUS sector is rapidly growing and evolving as the scale and urgency of required global emissions reduction outlines the importance for innovative technological solutions. It should therefore be underscored that the CCUS sector is dynamic because of its relative immaturity as an emerging sector and subject to significant changes as governments, policies, and the economy frequently change.

Development of the hydrogen market has had implications for the CCUS sector. Blue hydrogen is a term used to describe hydrogen produced from natural gas reformation, paired with CCUS to decrease emissions, while green hydrogen is made by electrolysis of water from renewable energy sources. Regions developing blue hydrogen economies have spurred demand for CCUS technologies, which are typically areas with established natural gas production or significant access to natural gas.



Though CCUS as a sector is relatively new, global carbon storage research, development, and deployment (RD&D) has been active for decades, with the first CCS project implemented in 1972.<sup>5</sup> Prominent organizations including the Intergovernmental Panel on Climate Change (IPCC) have stressed the importance of including large-scale CCS in multiple scenarios that can lead to a stable concentration of atmospheric CO<sub>2</sub>.<sup>3</sup> The costs of CCS have been decreasing with improved modelling, project experience, and more cost-effective capture technologies. There is an affiliated market of monitoring, measurement, and verification (MMV) technologies that have developed alongside CCS. It should be noted that this report considers enhanced oil recovery a constituent of CCS, as the technologies deployed for EOR and geological carbon storage are similar.

CCU is less developed than CCS as a sub-sector but has the potential to create high-value products to offset the price of carbon capture. For the purposes of this report, technologies that utilize CO<sub>2</sub> as is, excluding Enhanced Oil Recovery (utilization) and technologies that convert carbon into another compound (conversion) are consolidated into one category, termed utilization or CCU. CCU technology categories have the following estimated global market values:<sup>11</sup>

- Building products (carbon mineralized aggregates) - \$1.4 trillion USD
- Fuels (carbon to gasoline, diesel, jet fuel, natural gas, biofuels) - \$3.8 trillion USD
- Plastics (carbon to polymers) - \$413 billion USD
- Chemicals (carbon to potash, formic acid, soda ash, carbon monoxide) - \$20 billion USD
- Agriculture/aquaculture (carbon to biomass from algae production) - \$170 billion USD
- Consumer goods (carbon to products i.e., diamonds, vodka, guitars) - \$24 billion USD

**The CCUS sector is rapidly growing and evolving as the scale and urgency of required global emissions reduction outlines the importance for innovative technological solutions**

These solutions range in technology readiness levels (TRL) and in the quantity of carbon they can sequester.



## SUB-SECTORAL CONSIDERATIONS

Viewed as sub-sectors, carbon capture, utilization, and storage each have different market considerations. Carbon capture is a necessary element for all CCUS applications but the effectiveness of capture technologies differs depending on the size and composition of a particular emission stream. Both utilization and storage of carbon have advantages and disadvantages, and are favoured differently by jurisdictions for a variety of reasons. Each sub-sector has been identified as beneficial to deploy alongside other decarbonization efforts to achieve a stable atmospheric carbon concentration<sup>12</sup> however, from a business development perspective, deployment of each of these has been considerably different. The following section summarizes general considerations that have influenced regional biases towards CCU or CCS, gathered from international stakeholder interviews and literature review. These anecdotal considerations are provided to keep in mind when exploring international export opportunities.

### I. Policy Environment and Social Acceptability

The extent to which a region favours CCU or CCS is reflected in a region's policy frameworks. National or regional policy may seek to bolster the economic diversification of its jurisdiction and thus may attribute incentives conducive to development of either storage resources or utilization technology. The policy outlook tends to also be reflective of whether or not a region has geological storage capacity, and the level of emissions reduction mandated or aspired to.

Related to policy is social acceptance of CCUS. Whitmarsh et al<sup>13</sup> remarked on the various reasons for a positive or negative public outlook on CCU or CCS depending on factors like proximity to a geological storage site, general understanding of the subject, or regional reliance on heavy industry or fossil fuels. It has been found that citizens in some jurisdictions object to geological carbon storage due to potential environmental concerns, some think it is a misguided attempt to justify society's continued dependence on fossil fuels, and some object to its cost.<sup>13</sup> In other regions, some citizens favour CCS as a viable method of mitigating climate change and others are favoured towards CCU as a method of reducing the carbon intensity of fossil fuel usage.<sup>13</sup> Government prioritization of CCS and CCU can be significantly influenced by public perception, and ultimately dictates whether either sub-sector sees active development. Germany, for example, has until recently seen little development in CCS for the past decade after protests and public opposition to storage projects led some state governments to impose a ban on CCS.<sup>14</sup> Currently, there are conversations happening in Germany to consider offshore storage, but the region has demonstrated a prioritization of utilization.

## II. Nature of Domestic Industry

Patricio et al <sup>15</sup> found that countries with high emissions coupled with a large industrial sector would theoretically be favourable for intensification of CCU efforts as the large industrial sector would present ample demand for carbon technology output products, such as chemical feedstocks.

Countries with significant economic reliance on the fossil fuel industry have tended to demonstrate more interest in developing a national CCS market. This can be attributed to the scale of fossil fuel emissions and the large potential for subsurface storage, as well as other factors like the opportunity to use CO<sub>2</sub> for enhanced oil recovery (EOR), or repurpose existing natural gas pipelines and depleted oil and gas reservoirs for CO<sub>2</sub> storage infrastructure.

## III. Total Quantity of Emissions

Interviews with sector experts showed that countries with significant emissions and emissions reduction policies were likely to explore CCS opportunities, if geologically feasible and socially acceptable, based on the scale of reduction required and the large volume capacity of underground storage reservoirs. CCU was typically identified as an additional, complementary opportunity in this case for broader economic diversification.

## IV. Geological Storage Capabilities

It has been noted that countries with geological sequestration potential generally have focused their interest in CCS exploration and implementation rather than CCU. Regions without the favourable geological formations for carbon storage have trended towards stating interest in developing the local CCU sub-sector.





## METHODOLOGY AND RATIONALE

A detailed analysis of the current and potential future global CCUS market was undertaken to determine the most fruitful international opportunities for Canadian technologies.

A wide-scope literature review was conducted of both domestic and international publications. Literature from organizations such as the Global CCS Institute, IEA, and IPCC were reviewed, alongside Canadian publications from CMC/Pembina Institute, and international governmental reports. A comprehensive map of stakeholders with extensive CCUS sector experience from around the world was compiled and interviews were conducted with 30 expert participants of varying backgrounds, including from government, industry, research organizations, and the TCS. An international advisory group of CCUS industry experts was also consulted at multiple stages of the project to confirm research direction.

Research was conducted in two phases, with advisory group consultation after each section. **Phase 1** involved compilation of a longlist of target countries with well-known interests in CCUS or demonstrated pilot development efforts. Conversations with stakeholders confirmed the longlist country selection. Research was then gathered on the longlist countries to assess the landscape for international market penetration. A qualitative ranking system was developed to determine the top five target markets from the longlist. Results were vetted through discussions with our expert advisory group.



**Phase 2** involved a detailed, forward-looking investigation to the CCUS market outlook in the top five countries in the following categories:

- National or regional policies and funding mechanisms regarding CCUS industry development
- Geological storage capacity
- Key industry and point source emissions
- Significant industrial emitters in the region
- Development of significant CCUS-related projects or cluster regions
- Existing CCUS sub-sector development
- Relevant contacts and organizations working to advance CCUS technology development and deployment
- Openness to international partnerships and technology import
- Identified concerns regarding CCUS market development (political landscape, social acceptability, etc.)

Multiple CCUS sector stakeholder interviews were conducted in each of the target markets, including conversations with members of the Canadian Trade Commissioner Service, to gain valuable insights on upcoming policy announcements, available incentives, cluster/hub project development, key partnership opportunities, and local business strategies to successfully enter these international markets. Advisory group input was also provided at the midpoint and completion of Phase 2 research to confirm the strategy's direction.

Key findings and potential opportunities and threats for each of the international target markets are discussed in the subsequent section, along with additional countries of interest.

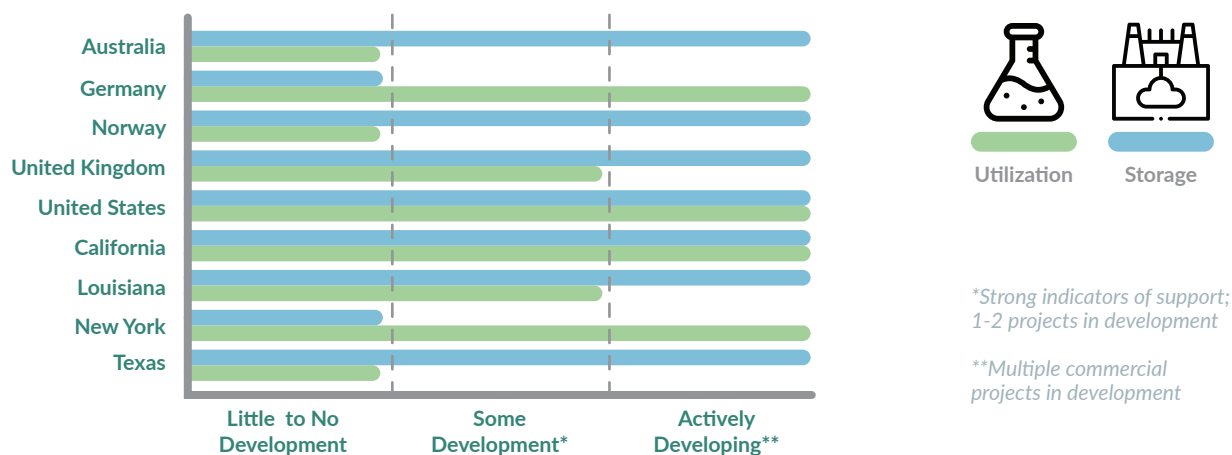




## INTERNATIONAL TARGET MARKETS

The top five recommended target markets for international export of Canadian CCUS companies are Australia, Germany, Norway, the United Kingdom (UK), and the United States of America (US). These countries have demonstrated significant development in the field of CCUS, and present as favourable markets for Canadian CCUS companies. Additional markets that are also of interest for CCUS sector development are considered in this section. Each jurisdiction will have a different market pull based on the needs of the region. Figure 1 summarizes the current strength of market pull of each sub-sector for the target countries.

Figure 1: Summary of demonstrated sub-sector development by target market





## AUSTRALIA

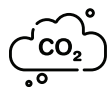
- Australia is primarily focused on CCS, with multiple large-scale projects planned in potential hub regions.
- Heavy industry has been driving sector progression, largely from the coal and oil and gas industries, with a focus on developing a blue hydrogen economy from natural gas and coal reserves.
- Similar to the United States, Australia is a good market for direct technology export and does not have the same cultural expectation of a local partnership
- While similar to Canada, companies should develop an awareness of subtle differences in Australian business culture. As in other countries, talking to local policy experts and the TCS is advised.

### CCUS Market Overview





## Capture



Australia's CCUS industry development to date has been largely driven by heavy industry. These large industrial players are mostly from the oil and gas and coal industries, and require applicable cost-effective capture technologies. The Otway International Test Centre in Victoria has concentrated on research and testing of capture technologies but has been broadening its expertise in carbon storage.

## Utilization



There is an emerging focus on utilization technologies in the country, mostly looking at fuel applications, and stakeholders have advised the interest in utilization is increasing. There may be future opportunities for CCU around hub regions, particularly the Hydrogen Energy Supply Chain (HESC). Organizations such as CO2CRC are actively interested in partnering with external or international technology organizations and are exploring utilization opportunities in the country.

## Storage



Partly due to Australia's abundant onshore and offshore geological storage capabilities, CCUS sector development in the country has so far been focused on CCS. Though there is political support, CCS activities have been predominantly driven by economics and industry movement. Large-scale CCS projects and hubs have been mostly spearheaded by large corporations proactively complying with a global shift to a low-carbon economy, or in pursuit of entering the blue hydrogen market.

## Hydrogen



With extensive natural gas and coal resources as well as solar and wind capacity, Australia has the potential to produce both blue and green hydrogen. Australia has indicated a desire to create an export economy for hydrogen, suggesting an interest in significant investment in hydrogen production infrastructure. With close trade ties to Asian markets and the proposed HESC partnership with Japan, a shift to a global hydrogen economy could present a large market opportunity for CCUS technologies to complement blue hydrogen production from coal resources, especially in Victoria where the proposed HESC hub is located.

## Relevant Policy and Funding Mechanisms

The Australian federal government has highlighted the importance of CCS and has begun to demonstrate an interest in developing the sector. This can be seen through upcoming policy changes such as the amendment of the carbon credits scheme to include CCS activities, and the addition of CCS to funding mechanisms like the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC).

POLICY NAME	DESCRIPTION
Australian Renewable Energy Agency (ARENA)	Federal government agency that supports research, innovation and deployment of clean and renewable energy technology. It was announced in 2020 that the mandate will be expanded to include CCS in 2021. Projects must be established with partners.
Carbon Credits (Carbon Farming Initiative) Act of 2011	Administered by the Clean Energy Regulator, the scheme awards carbon credit units to offsets projects.
Clean Energy Finance Corporation (CEFC)	Agency established by the Australian government that provides investment to clean energy projects. Also announced the addition of CCS to the mandate in 2021.
Climate Solutions Fund	Australia's continued investment in the Emissions Reduction Fund incentivized carbon credit trading program.
Emissions Reduction Fund + safeguard mechanism	Established under the Carbon Credits Act, an incentive for businesses to reduce emissions and store carbon. The safeguard mechanism is a legislated obligation on the largest emitters to keep net emissions below a limit.
National Hydrogen Strategy	National approach to developing a world-leading Australian hydrogen industry by 2030.
Technology Investment Roadmap	Framework for investment in low emissions technology innovation.

See Appendix B for more information.

## Geological Storage Capabilities

Australia is a country with abundant geological formations favourable to carbon storage. In the northwest coast of Western Australia there are considerable offshore, subsurface saline aquifers, sandstone formations, and shale barriers of suitable condition for storage of CO<sub>2</sub>, with a region called the Dupuy Formation selected for intensification of storage activities.<sup>16</sup> Offshore of the state of Victoria in the Gippsland Basin is another extensively studied area favourable to CO<sub>2</sub> storage with sandstone formations covered by a barrier of shale and coal.<sup>17</sup> Onshore storage in Queensland in a geological basin called the Surat Basin has also shown favourable conditions for carbon storage, with extensive sandstone aquifers.<sup>18</sup>



## Key Industry and Large Point Source Emissions

SECTOR*	EMISSIONS (MtCO <sub>2</sub> e) <sup>19</sup>
Energy	179.257
Manufacturing	27.152
Iron and Steel	26.211
Pulp & Paper	1.186
Total	233.806

\*note that sector definitions vary so these categories cannot be compared between countries

The electricity generation industry is the largest source of emissions in Australia, with many coal-fired power plants operating throughout the country.<sup>20</sup> Australia's economy is largely dependent on natural resources. With extensive brown and black coal and iron ore reserves, mining is one of the country's top industries and the second largest source of carbon emissions.<sup>21</sup> Australia also has a large oil and gas industry, with significant natural gas reserves found mostly in offshore wells concentrated off the coast of Western Australia; and abundant crude oil reserves concentrated off the coast of Victoria in the Bass Strait.<sup>22</sup>

Queensland has the highest emissions of all states in Australia<sup>23</sup>, with the majority being electricity generation from coal-fired power plants as well as mining, smelting, and the oil and gas industry.<sup>21</sup> The majority of emissions from New South Wales can also be attributed to coal-fired power plants. In Victoria, emissions are largely produced from the burning of carbon-intensive brown coal for power and from the manufacturing industry.<sup>21</sup> The largest mining sector emissions come from Western Australia.<sup>19</sup>

## Significant Industrial Emitters in the Region <sup>24</sup>

NAME	INDUSTRY
AGL Energy Ltd	Coal-fired power plants; gas-fired power plants
EnergyAustralia Holdings Ltd	Coal-fired power plants; gas-fired power plants
Stanwell Corporation Limited	Coal-fired power plants
Origin Energy Limited	Coal-fired power plants; gas-fired power plants; coal seam gas production
Chevron Australia Holdings Pty Ltd	Oil and gas; exploration
CS Energy Ltd	Coal-fired power plants; coal mining
OzGen Holdings Australia Pty Ltd	Power generation
Pioneer Sail Holdings Pty Limited	Coal-fired power plants
Woodside Petroleum Ltd	Oil and gas
NRG Victoria 1 Pty Ltd	Coal-fired power plants
Alcoa of Australia Limited	Metal mining; smelting
Glencore Australia Pty Ltd	Coal mining; metal mining; agriculture
Santos Limited	Oil and gas

## Hub Regions

PROJECT/ HUB NAME	LOCATION	KEY INDUSTRY	COMPANIES INVOLVED	SUB- SECTOR FOCUS	DETAILS
Carbonnet <sup>17</sup> / Hydrogen Energy Supply Chain (HESC) <sup>25</sup>	Latrobe Valley and Gippsland Basin, Victoria	Blue hydrogen from coal	<ul style="list-style-type: none"> <li>• Kawasaki Heavy Industries</li> <li>• J-Power</li> <li>• Iwatani Corporation</li> <li>• Marubeni Corporation,</li> <li>• Sumitomo Corporation</li> <li>• AGL</li> </ul>	CCS	Through HESC, blue hydrogen produced from coal in the Latrobe Valley would be shipped to Japan with captured carbon transported and stored in offshore Carbonnet storage reservoirs
Gorgon CO <sub>2</sub> Injection Project <sup>26</sup>	Western Australia	Natural gas production	<ul style="list-style-type: none"> <li>• Chevron</li> <li>• Exxon Mobil</li> </ul>	CCS	Large-scale offshore CCS operation on the Gorgon natural gas field
Otway International Test Centre <sup>27</sup>	Victoria	Testing and research	<ul style="list-style-type: none"> <li>• CO2CRC</li> <li>• BHP</li> <li>• Chevron</li> <li>• Shell</li> <li>• Total</li> <li>• ExxonMobil</li> <li>• Woodside</li> <li>• J Power</li> <li>• Santos</li> </ul>	CCS	CCS testing and research, in partnership with industry
Integrated Surat Basin CCS Project <sup>18</sup>	Surat Basin, Queensland	Coal-fired power plants	<ul style="list-style-type: none"> <li>• Carbon Transport and Storage Company (CTSCo), a subsidiary of Glencore</li> </ul>	CCS	Initial study stage of demonstration to evaluate onshore storage of CO <sub>2</sub> captured from nearby coal-fired power plants

## Potential Opportunities & Threats

- CCS is the main opportunity in Australia, though utilization is an emerging market.
- CCS technologies applicable to industrial oil and gas operations or blue hydrogen production from coal and natural gas are in demand.
- There are upcoming projects planned around hub regions, indicating an opportunity for early-stage partnerships, particularly in the Victoria hub region created around the HESC project.
- Demand is being driven by industry, therefore a recommended market entry strategy would be to connect with a large industrial company that has indicated an interest in pursuing CCUS, and also with those associated with large projects or hub development (see Hub Regions section).
  - Connect with the Canadian TCS to provide introductions.
  - Connect with CO2CRC. They have indicated an interest in partnering with international technology SMEs to facilitate projects if the venture is financially beneficial, as they are a for-profit industry-led research organization.<sup>28</sup>
  - Connect with the International CCS Knowledge Centre in Saskatchewan who are actively working with Australian players in the CCS space for coal emissions.
- Funding opportunities are more likely to come from the private sector, but there are some government funding programs from the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC) that will be available to support established CCS projects.
- Direct market entry is commonplace in Australia, similar to the United States, and does not necessarily require a local presence or partnership with an Australian company.
- Australia is a region that can be litigious, so having a local legal advisor to ensure compliance would be valuable.
- Business culture in Australia is different than in Canada despite similar Commonwealth background, so Canadian companies should consult a local business advisor or the TCS in the country to be mindful of cultural idiosyncrasies.
- Australia ranks 14th on the World Bank's Ease of Doing Business scale.<sup>29</sup>



## Relevant Contacts and Organizations

ORGANIZATION	DESCRIPTION	EMAIL
Consulate General of Canada in Sydney  Current Contact: Kishani Navaratnam Trade Commissioner, Cleantech	Canadian government representation in Australia	AustraliaTrade@international.gc.ca
CO2CRC	For-profit industry-led research organization	info@co2crc.com.au
Global CCS Institute	International think tank for advancing adoption of CCS, headquartered in Melbourne	info@globalccsinstitute.com
International CCS Knowledge Centre	Canadian CCS research organization based off learnings from Boundary Dam CCS project	info@ccsknowledge.com
Australian Low Emissions Coal Research & Development (ANLECR&D) Initiative	Research centre supporting CCS development for the coal industry	anlecrd.com.au/contact/
Australian Petroleum Production & Exploration Association (APPEA)	Upstream oil and gas industry association	appea@appea.com.au
National Energy Resources Australia (NERA)	Industry growth association for energy resources	contact@nera.org.au
Low Emissions Technology Australia (LETA)	Previously COAL21. Association investing in low emissions technology for black coal industry	info@letaaustralia.com.au





## GERMANY

- Germany has a lack of social license for CCS<sup>14,30</sup>, making this region a market for CCU.
- Germany's large industrial manufacturing sector would be interested in CCU to develop local industry capabilities and grow their export market. German multinational corporations would make valuable partners for a technology SME to grow capacity both in-country and internationally.
- Germany has significant chemical, cement and steel industries, indicating a variety of opportunities for carbon utilization at scale in multiple hard-to-decarbonize industries.

### CCUS Market Overview



## Capture



Germany's extensive heavy industrial manufacturing sector will necessitate capture technologies from a variety of point source emissions - notably, steel, cement, and chemical manufacturing. The country has stated an intention to move towards a renewable energy grid, therefore long-term opportunities for carbon capture will reside largely with hard-to-decarbonize industries.

## Utilization



Germany is the top emitting country in the EU. It has a goal of carbon neutrality by 2050, which is set to become required under the EU's European Climate Law.<sup>31,32</sup> The presence of hard-to-decarbonize industries like steel, cement, and chemicals in the country will require methods of significant emissions reduction without carbon storage. In light of these considerations, this presents a real opportunity for CCU.

## Storage



The German landscape for CCS is unique to the other top countries in this report. Germany had explored the potential for CCS in the early 2010s but faced protests against geological storage by the general public.<sup>14,30</sup> The Law for the demonstration of permanent storage of carbon dioxide gave states the right to impose a ban on CCS, which prompted states with geological storage capacity including Mecklenburg-Vorpommern, Niedersachsen, Schleswig-Holstein, Bremen and Brandenburg to do so.<sup>33</sup> The announcement of the CO<sub>2</sub> avoidance and use in raw material industries funding directive in 2021 indicates potential for offshore storage to be explored,<sup>34</sup> but at this time limited development in CCS has occurred.

## Hydrogen



Germany's Hydrogen Strategy was released in 2020 and indicates a significant interest in the transition to a hydrogen economy.<sup>35</sup> The report mentions the intention to focus development of the hydrogen industry from renewable sources (green hydrogen) but recognizes a transition period of the global market that would likely see fossil-based or blue hydrogen as a strong component.<sup>35</sup> The natural gas industry is reportedly interested in exploring CCUS options for blue hydrogen production.

## Relevant Policy and Funding Mechanisms

In 2021, the Federal Ministry for Economic Affairs and Energy announced a funding directive, CO<sub>2</sub> avoidance and use in raw material industries, to support companies to develop CCUS technologies.<sup>34</sup> Beginning May 2021, the program will support initiatives in offshore storage, DAC and BECCS, and will also look at increasing public acceptance of CCS going forward.<sup>34</sup>

As an EU member country, German CCUS initiatives qualify for multiple funding programs like Accelerating CCS Technologies (ACT) and the Innovation Fund that support RD&D of CCUS projects in participating countries.

POLICY NAME	DESCRIPTION
Accelerating CCS Technologies (ACT)	European Research Area Network (ERA-NET) consortium to provide funding for RD&D in CCUS.
EU Emissions Trading System Phase 3	Cap and trade among the EU, Norway, Iceland, Liechtenstein. Phase 4 to commence 2021. Limits emissions on power stations, industrial plants, airline travel.
Horizon 2020	Innovation/research funding for CCUS. Relevant funding areas include low emissions lime and cement (LEILAC), development of transport corridors to the North Sea (STRATEGY CCUS), and offshore storage monitoring (STEMM CCS). EU, Norway, Iceland.
Innovation Fund	Fund for low carbon technology. CCUS technology construction and operation are eligible activities.
Carbon2Chem	Government-funded RD&D project in partnership with industry to develop value-added products from steel production emissions.
Funding Directive - CO <sub>2</sub> avoidance and use in raw material industries	Funding directive from BMWi - Federal Ministry for Economic Affairs and Energy to support companies in development of CCUS technologies (upcoming - May 2021).
Law for the demonstration of permanent storage of carbon dioxide	Law permitting small-scale CCS projects on a national scale. Amended to give states the right to impose a ban.
National Hydrogen Strategy	Intended focus on developing green hydrogen, but recognizes the transition phase of blue hydrogen.

See Appendix B for more information.

## Geological Storage Capabilities

Germany has saline aquifers and depleted oil and gas reservoirs, but studies have shown that their prospective capacity is insufficient to abate the country's industrial emissions.<sup>36</sup> Development of onshore storage resources is unlikely as the concept has met opposition by the general population, and a federal regulation that gives German states the right to ban CCS has led some states to impose these bans.





## Key Industry and Large Point Source Emissions

SECTOR*	EMISSIONS (MtCO <sub>2</sub> e) <sup>19</sup>
Energy	296.533
Manufacturing	130.144
Iron and Steel	21.273
Chemical	6.697
Industrial	2.554
Total	457.201

\*note that sector definitions vary so these categories cannot be compared between countries

Germany's largest industries include automotive manufacturing, mechanical engineering, and chemical manufacturing.<sup>37</sup> Approximately half of Germany's industrial emissions come from chemical manufacturing, cement, and steel processing<sup>14</sup>, with coal fired power plants, oil and natural gas also providing a significant contribution to total greenhouse gas (GHG) emissions.<sup>20</sup> Germany has a coal phase-out law that will prohibit coal-fired electricity generation by 2038 and has also implemented a financial incentive for early shutdown of coal plants.<sup>38</sup>



## Significant Industrial Emitters in the Region <sup>39</sup>

NAME	INDUSTRY
RWE AG	Coal-fired power plants
Vattenfall Europe AG	Coal-fired power plants
Uniper SE	Natural gas, coal-fired power plants
HeidelbergCement AG	Building materials/Cement
LafargeHolcim Ltd	Building materials/Cement
Linde plc	Industrial gas
ThyssenKrupp AG	Steel manufacturing
ArcelorMittal Germany Holding GmbH	Steel manufacturing
Salzgitter AG	Steel manufacturing
BASF SE	Chemical manufacturing
Siemens AG	Industrial manufacturing

## Hub Regions

Germany has not initiated the development of any CCUS hub regions, however several large industrial companies have indicated an interest in exploring options for CCU. Companies such as thyssenkrupp, Siemens, and the German subsidiary of Hitachi have signalled interest in steel industry CCU development, and Germany's largest cement manufacturer, HeidelbergGroup, is actively involved in Norway's Northern Lights CCS project, with their Norcem facility being one of two point source carbon capture facilities in the project.<sup>40</sup>



## Potential Opportunities & Threats

- CCU is a big opportunity because public acceptance for geological storage is low. With Germany's large manufacturing sector and significant industrial emissions, the country must address hard-to-decarbonize industrial emissions without pursuing onshore carbon storage.
- Capture technologies focused on the cement, steel, and chemical industries would have a long-term market opportunity since these sectors make up the country's largest industries and half of the country's emissions<sup>14</sup>
- The large cement, steel, and chemical industries present a potential market opportunity for utilization at scale of converted carbon materials like mineralized carbon aggregates and carbon-to-chemical applications such as methanol.<sup>15</sup>
- Building partnerships with large German industrial companies is a viable market entry strategy. They will make valuable partners for CCU technology SMEs to grow as they expand their own market share of CCU domestically and internationally.
  - » Many of these German companies are multinational - exploring relationships with local subsidiary companies may be a pathway to initiate conversations.
  - » Look to the Canadian TCS office and TCS office in Germany for introductions, as they are actively promoting Canadian CCUS companies to the German market and frequently run events to encourage trade between the two countries.
  - » Partnering with German companies would allow access to the EU's funding mechanisms to develop CCU projects (see Relevant Policy and Funding Mechanisms section).
- The natural gas industry will be seeking opportunities in CCU as they look to adapt to a changing market and create partnerships to grow their blue hydrogen sector.
- From a marketing perspective, it is suggested to call CCUS a different term such as cleantech/carbontech/utilization technology to avoid negative perceptions of the term CCUS being tied to the fossil fuel industry.
- Though most people speak English in some capacity, attention should be paid to the language differences. An effort to provide information in German would be preferred in most cases.
- Germany ranks 22nd on the World Bank's Ease of Doing Business scale.<sup>29</sup>

## Relevant Contacts and Organizations

ORGANIZATION	DESCRIPTION	EMAIL
Embassy of Canada to Germany  Current Contact: Arndt Ulland Trade Commissioner, Cleantech	Canadian government representation in Germany	deutschland.commerce@international.gc.ca
Embassy of Canada to Germany  Current Contact: Pieter Bouwer European Regional Trade Commissioner, Cleantech	Canadian government representation in Germany	deutschland.commerce@international.gc.ca
European Cement Research Academy	Sustainability and innovation research in cement and concrete industries	info@ecra-online.org
Verband der Chemischen Industrie (VCI)	Chemical industry association in Germany	vci.de/kontakt/seiten.jsp
Institute for Advanced Sustainability Studies	International sustainability research institute	info@iass-potsdam.de
Fraunhofer Institute for Systems and Innovation Research ISI	Applied research institute on innovation	IL-Sekretariat-Edler@isi.fraunhofer.de
German-Canadian Centre for Innovation and Research	Trade and research facilitation between Canada and Germany. Also runs the Alberta-Europe Technology Collaboration Fund for SMEs.	info@gccir.ca
ClimateKIC	Innovation research and support network for a low-carbon, sustainable economy in the EU	germany@climate-kic.org
GFZ German Research Centre for Geosciences - Helmholtz Centre Potsdam	Research institute	info@gfz-potsdam.de
Wuppertal Institute  Current Contact: Peter Viebahn Head of Research Unit Sectors and Technologies, Future Energy and Industry Systems	Sustainability-focus research institute	peter.viebahn@wupperinst.org
Nova Institute	Research institute focused on renewable carbon applications	contact@nova-institut.de
CO <sub>2</sub> Value Europe	EU industry association for CCU, chaired by Uniper	contact@co2value.eu



## NORWAY

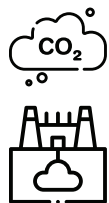
- Norway is focusing on CCS, though utilization will be of interest in the future.
- Norway is positioning itself to become a global CCS centre and are looking to create a market for selling their abundant storage capacity in the North Sea region to emitters within economic shipping distance.
- Though Norway has in-country CCS expertise to develop projects, existing CCUS clusters have interest in partnering with international SMEs if the technology presents an added value to an operation.
- Companies wanting to develop business opportunities in Norway should have an in-country presence, as typical business relationships are close-knit. Explore partnerships with hubs, companies associated with hubs, or look to set up a Norwegian subsidiary.

## CCUS Market Overview





## Capture & Storage



With Norway's economy heavily reliant on the petroleum industry, CCS is of key importance to adapt the country's economy to a low-carbon future. Because the capacity of offshore storage in Norway exceeds their current annual emissions, the country intends to create a market for selling storage space to adjacent regions around the North Sea and European continent. CCS has been actively pursued by the government, who have provided funding for the Longship/Northern Lights project and the Technology Centre Mongstad testing facility for CO<sub>2</sub> capture technology.<sup>41</sup> Technologies which support the capture and storage process for the indicated prevailing industrial emissions (petroleum, cement, etc.) would therefore be in demand.

## Utilization



Carbon utilization technologies are currently lower priority than CCS development but could likely see more momentum once Longship is operational in 2024.

## Hydrogen



Blue hydrogen will likely be of interest due to its projected lower cost over green hydrogen and because of Norway's abundant natural gas reserves.<sup>42</sup>



## Relevant Policy and Funding Mechanisms

Norway's government has actively supported development of the CCUS industry. CCS activities in the country are facilitated through the state enterprise Gassnova, which also administers the CLIMIT research and funding program and Technology Centre Mongstad.<sup>43</sup> The CO<sub>2</sub> tax on offshore oil and gas was implemented in 1991 and has since incentivized capture of CO<sub>2</sub> through tax reduction, which ultimately helped to enable the financial viability of Norway's existing Sleipner and Snøhvit CCS projects.<sup>44</sup> Though Norway is not a member of the EU, they are affiliated with funding programs like Horizon 2020, the Innovation Fund, and the EU Emissions Trading System.

POLICY NAME	DESCRIPTION
EU Emissions Trading System Phase 3	Cap and trade among the EU, Norway, Iceland, Liechtenstein. Phase 4 to commence 2021. Limits emissions on power stations, industrial plants, airline travel.
Horizon 2020	Innovation/research funding for CCUS. Relevant funding areas include low emissions lime and cement (LEILAC), development of transport corridors to the North Sea (STRATEGY CCUS), and offshore storage monitoring (STEMM CCS). EU, Norway, Iceland.
Innovation Fund	Fund for low carbon technology. CCUS technology construction and operation are eligible activities.
CLIMIT	Grant program for RD&D of CCUS technologies.
CO <sub>2</sub> tax on offshore oil and gas	Tax on mainland activities (mineral oil, auto diesel, petrol, natural gas, LPG) and CO <sub>2</sub> emissions from the continental shelf. CO <sub>2</sub> capture is incentivized for tax reduction.

See Appendix B for more information.

## Geological Storage Capabilities

Norway has favourable offshore conditions for geological sequestration of CO<sub>2</sub>.<sup>45</sup> The Utsira aquifer under the Norwegian continental shelf is a deep saline formation that has been used for years to store almost one million tonnes of CO<sub>2</sub> annually from the Sleipner, Snøvit, and Utgard natural gas fields.<sup>46</sup> The Aurora subsea storage area in development for Norway's Northern Lights project is in a different region than the Utsira formation.<sup>45</sup> There are also offshore storage options in depleted gas fields, but no suitable onshore storage sites have been identified.<sup>45</sup>

## Key Industry and Large Point Source Emissions

SECTOR*	EMISSIONS (MtCO <sub>2</sub> e) <sup>47</sup>
Oil	13.4
Manufacturing	11.6
Energy	1.6
Waste	0.9
Total	27.5

\*note that sector definitions vary so these categories cannot be compared between countries

Norway's largest industry is petroleum; the country is the third largest gas exporter globally.<sup>48</sup> Oil and gas is produced from offshore wells in the continental shelf below the North Sea.<sup>48</sup> Norway's heavy industry is concentrated in the southeast of the country. Production of petrochemicals, aluminum, fertilizers, and ferro-manganese are significant, as well as cement with Norcem - a Heidelberg Group subsidiary having two large facilities in Brevik and Kjølsvik.<sup>49</sup> The Norcem cement plant and Yara's ammonia facility are the southeast Greenland region's largest CO<sub>2</sub> sources.<sup>49</sup>

## Significant Industrial Emitters in the Region <sup>39</sup>

NAME	INDUSTRY
Equinor ASA	Petroleum; refineries
Norcem AS (HeidelbergCement)	Cement manufacturing
Norsk Hydro ASA	Aluminum
Yara International ASA	Fertilizer manufacturing (ammonia)
Ineos E&P Norge	Chemical Manufacturing
Alcoa Norway ANS	Aluminum
Esso Norge AS (ExxonMobil)	Petroleum; refineries
Eramet Norway AS	Manganese production
Fortum Oslo Varme AS	Waste incineration
ConocoPhillips Skandinavia AS	Petroleum
Wintershall Dea Norge AS	Petroleum
Lundin Energy Norway AS	Petroleum
Aker BP ASA	Petroleum





## Hub Regions

PROJECT/ HUB NAME	LOCATION	KEY INDUSTRY	COMPANIES INVOLVED	SUB- SECTOR FOCUS	DETAILS
Longship <sup>51</sup> / Northern Lights <sup>40</sup>	Oslo, Brevik, North Sea	Cement and waste -to- energy	<ul style="list-style-type: none"> <li>• Norcem (Heidelberg Group)</li> <li>• Fortum Oslo Varme</li> <li>• Equinor</li> <li>• Shell</li> <li>• Total</li> <li>• Gassnova (state-owned)</li> </ul>	CCS	Longship is a large-scale CCS project funded by the Norwegian government and represented by an entity called Gassnova. A CCS chain will transport captured emissions from Norcem's cement plant and Fortum Oslo Varme's waste incineration facility to be stored in undersea aquifers off the west coast. Equinor, Shell and Total form the transport and storage governance entitled Northern Lights.



## Potential Opportunities & Threats

- CCS is the current market emphasis. Norway is looking to create a market to sell CO<sub>2</sub> storage to emitters around the North Sea region. Offshore storage capacity in Norway exceeds their current emissions reduction requirement.
- Though Norway has domestic CCS project development expertise, existing CCUS clusters have interest in partnering with international SMEs if technologies present opportunities for generating added value.
- Doing business in Norway typically requires partnering with a Norwegian company or having visible market presence through an in-country subsidiary.
  - » Connect with the TCS in Norway to facilitate introductions with prospective domestic partners.
  - » Connect with the Innovate Norway office in Toronto or the Invest in Norway office for information about entering the Norwegian market and to facilitate introductions with prospective partners.
- Carbon utilization has been identified as a potential future opportunity. A growing demand for decarbonization of the buildings sector may create a market for utilization of carbon products like carbon mineralized aggregates.
- Blue hydrogen has been emphasized in Norway as a significant opportunity for CCUS technology. Norway has indicated a trend toward blue over green hydrogen based on the lower market cost for blue hydrogen and to leverage abundant natural gas resources.
- Having a Norwegian subsidiary or partner with a Norwegian organization number gives access to government incentives supporting CCUS sector development.
  - » Look for incentives from Gassnova, the state-run enterprise responsible for national CCS activities. Bodies under Gassnova include the Longship/Northern Lights project, Technology Centre Mongstad and the CLIMIT funding program, which provides funding for CCS RD&D and emphasizes international partnerships.<sup>43</sup>
- Norway and Canada are frequent trade partners.
- Most citizens are fluent in English, but an effort to provide information in Norwegian will be appreciated.
- The World Bank has rated Norway in the top 10 on their Ease of Doing Business scale.<sup>29</sup>

## Relevant Contacts and Organizations

ORGANIZATION	DESCRIPTION	EMAIL
The Embassy of Canada to Norway  Current Contact: Tone Nymoen Trade Commissioner, Cleantech	Canadian government representation in Norway	<a href="mailto:Tone.Nymoen@international.gc.ca">Tone.Nymoen@international.gc.ca</a> <a href="mailto:NordiCommerce@international.gc.ca">NordiCommerce@international.gc.ca</a>
Invest in Norway	Norway government technology trade import service	<a href="http://invinor.no/contact-us/">invinor.no/contact-us/</a>
Innovation Norway  Current Contact: Alana Prashad Senior Advisor, Energy and Environment Lead, Americas	Norway government technology trade export service	<a href="mailto:alana.prashad@innovationnorway.no">alana.prashad@innovationnorway.no</a>
Technology Centre Mongstad  Current Contact: Matthew Campbell Principal Technologist	CCUS technology RD&D test center	<a href="mailto:matthew.campbell@tcmda.com">matthew.campbell@tcmda.com</a>
NORCE	Independent research institute	<a href="mailto:post@norceresearch.no">post@norceresearch.no</a>
Equinor & Techstars Energy Accelerator	Technology accelerator for oil and gas innovation	<a href="http://techstars.com/contact">techstars.com/contact</a>







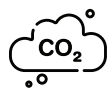
## UNITED KINGDOM

- The primary driver in the UK is becoming carbon neutral after a law mandating net zero emissions was enacted in 2019<sup>52</sup>. CCUS technologies that can assist in reaching this goal would be of interest.
- The UK's CCUS sector is focused on developing CCS hub regions, and partnering with these hubs present the greatest opportunity for attracting funding.
- Hubs and associated companies are looking for technology partnerships, but in-country representation should be established.
- The UK has a strong presence of government offices in Canada that facilitate trade import of Canadian companies into the UK, indicating an opportunity for assistance with market entry and guidance on establishing in-country representation.

### CCUS Market Overview



## Capture



The UK's CCUS hub regions (see Hub Regions section) are planned around areas of significant industrial emissions. Capture technologies for prominent hard-to-decarbonize industries in these regions will likely be required. Heavy industrial sources of emissions in hub regions include steel, petroleum, petrochemicals, refineries, chemical manufacturing, and blue hydrogen production.

## Utilization



Though carbon storage is the primary focus in the UK's hub regions, sources have indicated that there is still interest in carbon utilization technologies. The UK Government's December 2020 update on business models for CCUS mentions the importance of carbon utilization in supporting cost reduction on large-scale projects<sup>53</sup> and expressly mentions the CCU market potential and importance of allocating research and development resources to progress the sub-sector.<sup>54</sup> The Department of Business, Energy, and Industrial Strategy (BEIS) awarded 4.2 million GBP to Tata Chemicals in 2019 to develop a pilot carbon mineralization facility that is set to be operational in 2021.<sup>54</sup>

## Storage



With vast storage resources in the North Sea, existing natural gas pipeline infrastructure, and an aggressive legislated emissions reduction mandate, the strategy of CCUS hub development is largely focused on CO<sub>2</sub> transport and offshore storage networks.

## Hydrogen



The national government plans to release its hydrogen strategy in 2021. Currently, plans to produce both green and blue hydrogen are in development over the next decade. Stakeholders have indicated that blue hydrogen is a key value driver in many of the hub projects, and will likely be actively pursued with abundant natural gas resources.

## Relevant Policy and Funding Mechanisms

The UK was the first major economy to sign into law a mandate for net zero emissions by 2050.<sup>52</sup> The government has been pursuing CCUS to contribute to meeting this emissions reduction goal and have released several reports such as the CCUS Action Plan and the CCUS Business Plan in support of guiding sector development. Federal funding support from the BEIS Energy Innovation Programme and Clean Growth Fund aim to scale up commercialization of clean energy and low-carbon technologies including CCS. The UK is also associated with the European Commission's Accelerating CCS Technologies (ACT) program, which provides funding for RD&D in CCUS.

POLICY NAME	DESCRIPTION
Accelerating CCS Technologies (ACT)	European Research Area Network (ERA-NET) consortium - European Commission.
BEIS Energy Innovation Programme	Funding support from the UK government's Department of Business, Energy and Industrial Strategy to accelerate commercialization of clean energy technology.
Carbon Price Support	Under Climate Change Levy. Applies to power generators.
CCUS Business Models	Government report on potential business models for CCUS in the UK, plus a specific amendment for the proposed commercial frameworks for transport and storage, power, and industrial carbon capture.
CCUS support in 2020 budget	2020 budget mentioned support of an 800 million GBP carbon capture and storage infrastructure fund. Indicated carbon capture support in two sites over 20 years and support for at least one capture-equipped gas power plant by 2030.
Clean Growth Fund	Fund for scale-up of low-carbon technologies. Industrial CCS is an eligible application, but must be a UK-based company.
Clean Growth Strategy and Industrial Strategy	Strategy indicating goals to invest in industrial innovation. CCUS is a key focus.
Emissions Trading Scheme	Planned ETS replacement of previous EU scheme after Brexit finalized.
UK CCUS Action Plan	Action plan to deploy CCUS at scale by the 2030s. Discusses cluster creation and strategies to promote innovation.

See Appendix B for more information.

## Geological Storage Capabilities

The UK has significant deep saline aquifers, depleted oil and gas fields, and sandstone formations favourable to offshore CO<sub>2</sub> storage in the UK continental shelf in the North Sea off the eastern coast of the country.<sup>55</sup> The proximity of the North Sea has enabled development of several CCS hub regions in the UK. The Endurance is the most-studied offshore saline aquifer and is currently intended to serve as the storage reservoir for the Net Zero Teesside and Zero Carbon Humber clusters.<sup>56</sup>



## Key Industry and Large Point Source Emissions

SECTOR*	EMISSIONS (MtCO <sub>2</sub> e) <sup>57</sup>
Energy	180.8
Manufacturing	18.4
Waste	14.4
Refineries	13.1
Iron and Steel	9.8
Gas	8.9
Cement	4.4
Chemical	1.1
Mining	0.5
Total	251.4

\*note that sector definitions vary so these categories cannot be compared between countries

The UK has several regions of carbon intensive industrial activity around which proposed CCUS clusters have been developing.

The North East of England Process Industry Cluster (NEPIC)<sup>58</sup> is an industrial hub in the Tees Valley area largely based around chemical manufacturing, including steel processing, petrochemicals, and agricultural products manufacturing. Also in the Tees Valley region is the energy intensive industrial manufacturing cluster Wilton International<sup>59</sup> and the industrial redevelopment of former steel manufacturing sites by the South Tees Development Corporation.<sup>60</sup> The industrial cluster in Yorkshire, near the mouth of the Humber River is the largest source of industrial emissions in all the UK, at approximately 12.5 MtCO<sub>2</sub> annually.<sup>61</sup> In addition to several power stations, petroleum refineries, chemical manufacturing, cement manufacturing, petrochemicals, glass processing, as well as steel manufacturing are all located in this region.<sup>61</sup>

Northeast Scotland is also a significant region of the UK's industrial emissions in the UK. The region around Aberdeen has a prominent oil and gas industry, with natural gas coming onshore from North Sea wells through the St. Fergus gas terminal.<sup>62</sup> There are also heavy industrial emissions from chemical manufacturing and crude oil refining in Grangemouth.<sup>62</sup> There is a proposed hydrogen cluster around the east coast industrial sectors of Scotland, utilizing the existing natural gas supply chain paired with CCS to create blue hydrogen.<sup>62</sup>

## Significant Industrial Emitters in the Region <sup>50</sup>

NAME	INDUSTRY
RWE Generation UK PLC	Natural gas-fired power plants
Tata Steel UK Ltd	Steel manufacturing
Uniper UK Limited	Natural gas-fired power plants
EP UK Investments Ltd (EPH)	Natural gas-fired power plants
EDF Energy UK Ltd	Coal - fired power plants *
British Steel Limited (Jingye Group)	Steel manufacturing
SSE plc	Natural gas; Utility
Intergen (UK) Ltd	Natural gas-fired power plants
Vitol Finance UK Ltd	Natural gas-fired power plants, oil and gas, energy and commodities trading
ExxonMobil Corporation	Oil and gas, refineries, petrochemicals
Triton Power Partners LP (Energy Capital Partners)	Natural gas-fired power plants

\*The UK has stated an intention to close all unmitigated coal-fired power plants by 2025 <sup>63</sup>



PROJECT/ HUB NAME	LOCATION	KEY INDUSTRY	COMPANIES INVOLVED	SUB- SECTOR FOCUS	DETAILS
Acorn <sup>64, 62</sup>	Aberdeen, Scotland	Natural gas production and blue hydrogen from natural gas	<ul style="list-style-type: none"> <li>• Shell</li> <li>• Total</li> <li>• Chrysaor</li> <li>• Pale Blue Dot Energy</li> </ul>	CCS	Using existing natural gas infrastructure to transport captured CO <sub>2</sub> from gas processing through the St Fergus gas terminal to offshore storage sites. The project is intended to eventually produce blue hydrogen, forming part of the proposed Hydrogen Coast hub around Aberdeen.
Net Zero Teesside <sup>65</sup>	Northeast England	Natural gas power plant; chemicals, steel, fertilizer, petro- chemicals	<ul style="list-style-type: none"> <li>• BP</li> <li>• ENI</li> <li>• Equinor</li> <li>• Shell</li> <li>• Total</li> </ul>	CCS	CCUS cluster planned around decarbonizing the heavily industrialized area in northeast England, near the mouth of the River Tees, coupled with implementation of a combined cycle gas turbine (CCGT) plant with CCS in the region.
Zero Carbon Humber <sup>66</sup>	Yorkshire	Blue hydrogen from natural gas; refineries, chemicals, cement, petro- chemicals, glass, steel; BECCS	<ul style="list-style-type: none"> <li>• Drax Group</li> <li>• National Grid</li> <li>• SSE</li> <li>• British Steel</li> <li>• Centrica</li> <li>• Mitsubishi Power</li> <li>• PX Group</li> <li>• Equinor</li> <li>• Triton Power</li> <li>• Uniper</li> </ul>	CCS	Cluster in the region with the largest industrial emissions in the UK aimed at industrial carbon capture and offshore storage. Will also involve blue hydrogen production and a bioenergy with carbon capture and storage (BECCS) pilot project at the nearby Drax power station.
HyNet North West <sup>67</sup>	Northwest England and North Wales	Blue hydrogen from natural gas; chemicals, glass, refineries	<ul style="list-style-type: none"> <li>• Cadent</li> <li>• Progressive Energy</li> </ul>	CCS	Cluster for industrial carbon capture and blue hydrogen production from natural gas, with carbon transport and storage in the depleted oil and gas fields offshore of Liverpool.
South Wales Industrial Cluster <sup>68</sup>	South Wales	Blue hydrogen from natural gas; LNG, refineries, paper, steel, cement, chemicals, insulation, nickel	<ul style="list-style-type: none"> <li>• Costain</li> <li>• Lanzatech</li> <li>• Lightsource bp</li> <li>• Progressive Energy</li> <li>• RWE</li> <li>• Shell</li> <li>• Simec Power</li> <li>• Tarmac</li> <li>• Tata Steel</li> <li>• Valero Energy</li> <li>• Wales &amp; West</li> <li>• Utilities</li> </ul>	CCUS	Hub in the earliest stages of planning, with discussions centered around methods of decarbonization in South Wales, including blue hydrogen production and industrial carbon capture with utilization and CO <sub>2</sub> shipping.

## Potential Opportunities & Threats

- CCS presents the greatest opportunity in the UK, with Canadian expertise from large-scale CCS project engineering, execution, and operation from projects like Boundary Dam, Quest, and CaMI Field Research Station being of particular interest.
- There is some demand for utilization technology around hub regions. As the UK's key driver for developing CCUS is for emissions reduction to comply with the net zero by 2050 law, there is priority on carbon technology that permanently sequesters large amounts of carbon.
- Canadian companies should focus on entering the UK market through hub regions and have in-country representation. Large companies that are actively involved in developing hub regions are interested in partnering with technology companies to create systems oriented CCUS clusters that create economic diversification.
  - » Connect with the TCS for introductions to hub regions
  - » Connect with the UK government offices in Canada that facilitate import of Canadian companies to the UK for market entry assistance and introductions to hub regions:
    - » British Consulate General
    - » Scottish Development International
- Government support is available for international companies to develop technologies, but is focused on those associated with or benefitting hub development.
- Developing partnerships with other Canadian CCUS companies to consolidate project capabilities and offer full-scale systems solutions is recommended as a strategy to gain access to hub regions.
- CCUS is needed for blue hydrogen, natural gas processing, and industrial decarbonization applications, which are the emphasis of the identified hub regions.
- There is demand for MMV technologies to assist in quantifying emissions reduction efforts.
- In light of the UK Government's passing of net zero by 2050 laws<sup>52</sup>, there is demand for more efficient capture technologies on fossil fuel-based power plants, and for the long term on hard-to-decarbonize industrial point sources.<sup>69</sup>
- The UK is a familiar place for Canadian companies to do business and is actively open for foreign companies to establish representation and operate within the country.
- The UK is ranked in the top 10 on the World Bank's Ease of Doing Business scale.<sup>29</sup>



## Relevant Contacts and Organizations

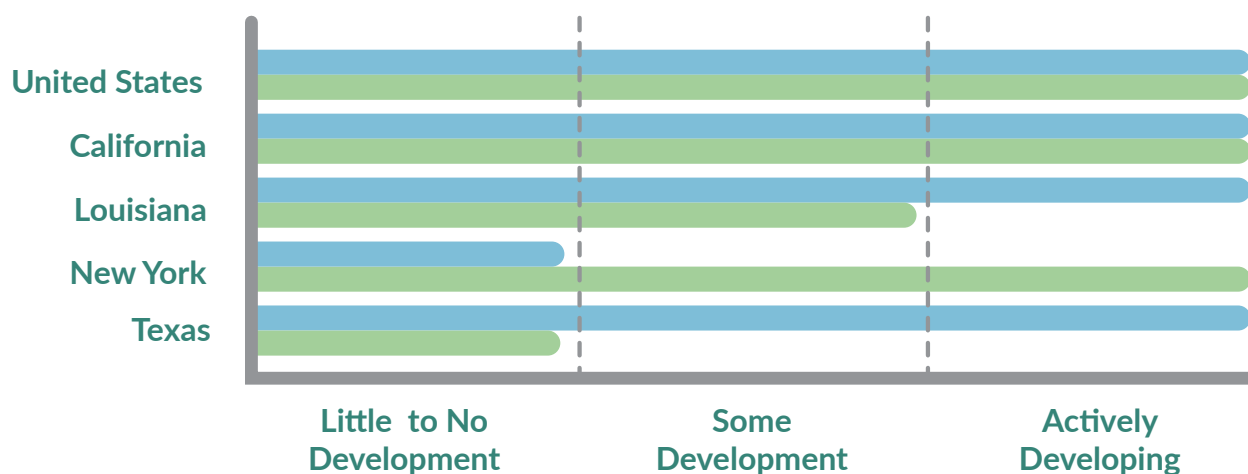
ORGANIZATION	DESCRIPTION	EMAIL
High Commission of Canada to the UK (London)  Current Contacts: Megan Wood Marcin Zydowicz Trade Commissioner, Cleantech	Canadian government representation in UK	ldn-td@international.gc.ca
British Consulate General (Toronto, Montreal, Calgary, Vancouver)	British government representation in Canada	researchcanada@mobile.trade.gov.uk
Scottish Development International  Current Contact: Usman Ghani Vice President, Americas	International trade and investment facilitation for Scotland	Usman.Ghani@scotent.co.uk
Catapult Network	Accelerator organizations focused on innovative topics including Energy Systems	es.catapult.org.uk/get-in-touch/
Oil and Gas UK	Trade association actively supporting low-carbon technology development	info@oilandgasuk.co.uk
Carbon Capture and Storage Association	Trade association for CCUS industry	info@ccsassociation.org
UK CCS Research Centre	Research organization and industry collaborator for CCS in the UK	info@ukccsrc.ac.uk
Net Zero Teesside	CCUS Hub Region - Northeast England	netzeroteesside.co.uk/contact/
Zero Carbon Humber	CCUS Hub Region - Yorkshire, England	zerocarbonhumber.co.uk/contact/
HyNet North West	CCUS Hub Region - Northwest England	0203 116 5919
South Wales Industrial Cluster	CCUS Hub Region - South Wales	swic.cymru
Acorn Project	CCUS Hub Region - Aberdeen, Scotland	acorn@pale-blu.com



## UNITED STATES

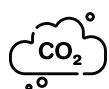
- It is commonplace to enter the US market through direct B2B company export because of Canada's close trade relationship.
- The existing market size, the 45Q incentive, the new federal government's emission reduction focus, and the large presence of readily available investors makes the US an attractive market as partners are actively looking for Canadian technology.
- A state-by-state approach to the US market is required because policies and drivers can differ significantly between states .
- The following states have demonstrated a significant interest in CCUS:
  - » California
  - » Louisiana
  - » New York
  - » Texas
- There has been significant development in the CCUS sector in other states such as Illinois, Indiana, Wyoming, Montana, North Dakota, Nebraska, Kansas, Colorado, and Utah. These markets are also addressed in this section but are not the focal point.

### CCUS Market Overview



Sub-sector development of the US CCUS market differs between states. In general, sources have said CCS is being heavily explored due to the massive scale of emissions reduction required, abundant storage resources, and valorization offered by the section 45Q incentive. There is also growing demand for high-value products created from carbon utilization technology.

## Capture



Capture technologies represent a large expense for CCUS implementation. Particularly in the US, where point source emissions can be extraordinarily large, sufficient need will exist in coming years to scale up capture capacity for these hard-to-abate sources. With the majority of US emissions coming from coal and natural gas-fired power plants, there is a need for capture technologies in these applications, as well as from a variety of industrial operations. Blue hydrogen is also of interest to the US both regionally and federally, which may indicate potential CCUS technology opportunities. Sources have advised that DAC is also a technology of interest, especially in regions with net zero emissions mandates to comply with regulations if carbon capture cannot achieve 100 percent efficiency. California's Low Carbon Fuel Standard (LCFS) considers DAC as eligible, and its operation is not required to be in-state. More LCFSs are expected to become enacted in the near future.

## Utilization



The CCU market in the US is new but growing. States like New York and Hawaii are implementing policies to incentivize utilization technology deployment by creating a policy or tax credit for using carbon mineralized cement products (Appendix B). Governor Andrew Cuomo of New York proposed an agenda to support the development of carbon utilization technologies to create value-added products.<sup>70</sup> The Carbon to Value Initiative is a project supported by the New York state government and the Government of Canada, and is intended to act as a carbon technology industry accelerator.<sup>71</sup> California has also signaled an expanding CCU market. Many start-ups in the carbon technology field are operating pilots in the state, particularly in Silicon Valley. The market is in early stages but has significant momentum, particularly due to the amendment of California's Low Carbon Fuel Standard (LCFS) to include CCUS activities.

## Storage



Many states with large oil and gas or coal industries and geological storage capabilities are focusing on CCS. States like Wyoming, Nebraska, Kansas, and North Dakota have begun pilot storage operations - frequently under the National Energy Technology Laboratory's CarbonSAFE initiative<sup>72</sup> - and most have implemented state-level tax incentives to support development of CCS in the fossil fuel industry (Appendix B). CCS for industrial emissions is a large focus of Illinois and Indiana. The Wabash and Macon County CarbonSAFE projects in bordering counties of the two states are proposing CCS for large industrial emitters in the region.<sup>73,74</sup> The OGCI has announced an investment in this storage facility, which will capture carbon from the Wabash Valley Resources ammonia facility.<sup>75</sup> Additionally, Texas and Louisiana are already deploying CCS, largely through EOR, but Louisiana's proposed Gulf Coast Sequestration project indicates further development in this area. Louisiana has made strides in developing the state CCUS activity with several large projects underway, and implementation of policy supporting the sector. The Governor of Louisiana declared a net zero by 2050 goal at the end of 2020, indicating a commitment to decarbonizing the state's lofty industrial emissions.<sup>76</sup> It should be noted that the Petra Nova carbon capture for EOR project on a coal-fired power plant in Texas was shut down in 2020 due to financial concerns amid declining oil prices during the Covid-19 pandemic, indicating a strong tie to the oil and gas industry, and highlighting an inherent risk of EOR projects related to oil demand prospects.<sup>77</sup> California is an emerging market for CCS, with the first project, Elk Hills CalCapture in development. The project will deploy carbon capture technology on the Elk Hills natural gas-fired power plant, and use the CO<sub>2</sub> for EOR.<sup>78</sup>

## Hydrogen



The US has released several hydrogen strategies over the past two decades, starting with the National Hydrogen Vision in 2002 and including the more recent Office of Fossil Energy's Hydrogen Strategy and Department of Energy's Hydrogen Program Plan in 2020,<sup>79-81</sup> indicating a national interest in developing the sector. To date, there has been some production of blue hydrogen in the US at ammonia and refinery operations, with the CO<sub>2</sub> used for EOR.<sup>82</sup> It is projected that blue hydrogen will be of significant demand in the future due to the low projected cost of production in the US, indicating a potential market for CCUS.<sup>80</sup>





## Relevant Policy and Funding Mechanisms

At the federal level, the Section 45Q incentive that provides a tax credit for CO<sub>2</sub> capture, storage, or utilization has been a large factor in development of the CCUS sector in the US to date. An extension of the 45Q credit was announced in late 2020.<sup>83</sup> In addition to 45Q, the Carbon Storage Assurance Facility Enterprise Initiative (CarbonSAFE) and the pending Utilizing Significant Emissions with Innovative Technologies (USE IT) Act are other federal policies of interest providing support to CCUS sector development. The new federal administration has highlighted emissions reduction as an area of focus, indicating the potential for upcoming policy and/or regulatory changes.

The policy landscape for CCUS in the United States is complex and differs at the state level (see below chart and Appendix B). Many states such as Texas, Louisiana, Illinois, Indiana, Wyoming, Montana, North Dakota, Nebraska, Kansas, Colorado, and Utah have implemented tax incentives for geological storage of CO<sub>2</sub> and for CO<sub>2</sub> use in EOR. Notable policies incentivizing growth of the CCUS industry include California's Low Carbon Fuel Standard that was amended to provide credits for CCS and DAC, and New York's pending law - the Low Embodied Carbon Concrete Leadership Act - that is intended to stimulate a market for carbon enhanced or mineralized concrete technologies.

JURISDICTION	POLICY NAME	DESCRIPTION
California	Executive Order B-55-18 - net zero by 2045	Net zero by 2045 goal (not yet codified).
California	Low Carbon Fuel Standard	Set of programs to decrease carbon intensity of fuel. Includes the CCS Protocol. DAC is also eligible and does not have to be in-state.
California	Senate Bill 100	Legal mandate to achieve 100% zero carbon electricity by 2045.
Louisiana	Bill 661	State assumption of long-term liability for geological storage of CO <sub>2</sub> .
Louisiana	Executive Order - net zero by 2050	Net zero emissions by 2050.
Louisiana	HB 61, 62	Tax exemption for CO <sub>2</sub> -EOR oil production.
New York	Carbon to Value Initiative	Program with various initiatives supporting carbontech innovation and scaleup. Supported by NY State, Consul General of Canada in New York.
New York	Climate Leadership and Community Protection Act	Emissions reduction mandate of 85% by 2050 with 15% carbon sequestration.
New York	The New York State Low Embodied Carbon Concrete Leadership Act	Requires low carbon concrete from carbon technology be used in state projects and establishes a tax credit (pending).
Texas	HB 1976	State assumption of long-term liability for geological storage of CO <sub>2</sub> .
Texas	HB 3732	Direct Financial Assistance for clean energy projects with tax incentives for CO <sub>2</sub> -EOR oil production.
Texas	HB 469	Tax credit for CCS at coal-fired power plants.
National	American Reinvestment and Recovery Act - CCUS	US\$3 billion USD funding for CCUS technology RD&D.
National	Carbon Storage Assurance Facility Enterprise Initiative (CarbonSAFE)	Initiative to fund CO <sub>2</sub> storage projects for deployment by 2025-2030. Projects include RD&D, geological modelling and monitoring.
National	Section 45Q credit	Federal tax credit for CO <sub>2</sub> storage, amended to include utilization and emissions reductions. Extended at the end of 2020.
National	Section 48A Qualifying Advanced Coal Project Credit	Federal tax credit for efficiency upgrades at coal-fired power plants to reduce emissions. CCUS for post-combustion is currently not eligible, but an amendment is proposed to include this.
National	The Utilizing Significant Emissions with Innovative Technologies (USE IT) Act	An amendment to the US Clean Air Act to support carbon utilisation and direct air capture research, as well as the construction and development of CCUS facilities and CO <sub>2</sub> pipelines (pending).

See Appendix B for more information.



## Geological Storage Capabilities

Many regions around the continental US have geology favourable for CO<sub>2</sub> storage. Northern landlocked states like Wyoming, Montana, and North Dakota have ideal storage conditions of deep saline aquifers, porous rock formations and impermeable cap rocks.<sup>84-86</sup> Illinois and Indiana have similar formations.<sup>73</sup> Southern states on the Gulf coast like Texas and Louisiana have mature oil reservoirs that can be used for storage with EOR, as well as saline aquifers.<sup>87,88</sup> California has abundant storage potential in the Central Valley and Ventura basins, with large subsurface formations of sandstone, saline aquifers, and shale layers.<sup>89</sup> There is some uncertainty over the geological CO<sub>2</sub> storage capabilities in the state of New York; some studies have indicated a low storage potential of some of New York's geological basins due to a lack of depth of the ideal formations, among other factors<sup>90</sup>, while a New York State Government report listed an approximate storage potential of 14 GtCO<sub>2</sub> in saline formations, depleted oil and gas reservoirs and shale formations.<sup>70</sup>

## Key Industry and Large Point Source Emissions

SECTOR*	EMISSIONS (MtCO <sub>2</sub> e) <sup>91</sup>
Energy	2,350.959
Oil and Gas	231.401
Industry	152.497
Waste	121.961
Chemical	68.137
Manufacturing	55.792
Mining	53.449
Iron and Steel	45.751
Total	3,079.950

\*note that sector definitions vary so these categories cannot be compared between countries

The largest source of GHG emissions in the US is from fossil-powered energy production like coal and natural gas-fired power plants, which contribute 63 percent of electricity.<sup>92</sup> Industrial emissions are the third largest contributor of GHG in the US and are largely attributed to the combustion of fossil fuels in industrial processes, as well as from petrochemical production, chemicals, metal, and cement manufacturing.<sup>92</sup> The key industries and emissions differ from state to state and are summarized as follows, for the focus of this report:

### **California**

The second largest emitter of CO<sub>2</sub> by state, but also the most populous, is California. The top emitting sector is power generation, followed by refineries, chemical processing, mineral production and cement manufacturing, and petroleum and natural gas.<sup>93</sup>

### **Louisiana**

Chemical manufacturing is the top emitting sector in Louisiana, largely from the “Chemical Corridor” region.<sup>88,93</sup> Other key industries include petroleum and coal production, oil refineries, natural gas processing, petrochemicals, waste, and pulp and paper.<sup>88</sup>

### **New York**

New York’s heavy point source emissions are largely from fossil fuel fired power plants, as well as from waste, cement and mineral production, production of aluminum and other metals, and petroleum and natural gas.<sup>93</sup>

### **Texas**

Texas is the largest emitter of CO<sub>2</sub> by state in the US, with most industries centred on fossil fuel production. The top source of emissions come from coal and natural gas-fired power plants, and other key industrial sector emissions from petroleum and natural gas production, refineries, cement and mineral production, chemical production, waste, metal processing, and pulp and paper.<sup>93</sup>



## Significant Industrial Emitters in the Region <sup>93</sup>

NAME	INDUSTRY	STATE
Marathon Petroleum Corporation	Refineries	California
Chevron Corporation	Refineries	California
Martinez Refining Company LLC	Refineries	California
PBF Energy Inc	Refineries	California
Valero Energy Corporation	Refineries	California
Vistra Corp - Moss Landing	Natural gas-fired power plants	California
CEMEX Inc	Cement manufacturing	California
ExxonMobil Corporation	Oil and gas; Refineries	Louisiana
Cleco Corporate Holdings LLC - Brame Energy Center	Power plants (coal, natural gas, petroleum coke, biomass)	Louisiana
Cheniere Energy Inc - Sabine Pass LNG	Natural gas processing	Louisiana
Citgo Petroleum Corporation	Oil and gas	Louisiana
Entergy Corporation - Nine Mile Point	Natural gas-fired power plants	Louisiana
Marathon Petroleum Corporation	Refineries	Louisiana
Shell Oil Products US, Shell Chemicals - Norco Manufacturing Complex	Petrochemicals; Refineries	Louisiana
Astoria Energy LLC	Natural gas-fired power plants	New York
Consolidated Edison Inc - East River	Natural gas-fired power plants	New York
Vistra Corp - Independence	Natural gas-fired power plants	New York
Public Service Enterprise Group Inc - Bethlehem Energy Center	Natural gas-fired power plants	New York
Competitive Power Ventures Inc - Valley Energy Center	Natural gas-fired power plants	New York
National Grid USA Service Company Inc - Northport	Natural gas-fired power plants	New York
LaFargeHolcim Ltd	Building Materials/Cement	New York
NRG Energy Inc - W A Parish, Limestone	Coal-fired power plants; Natural gas-fired power plants	Texas
Vistra Corp - Martin Lake, Oak Grove	Coal-fired power plants	Texas
ExxonMobil Corporation	Oil and gas; Refineries	Texas
Lower Colorado River Authority - Sam Seymour	Coal-fired power plants	Texas
Marathon Petroleum Corporation	Refineries	Texas
CPS Energy - J K Spruce	Coal-fired power plants	Texas
Aramco Services Company	Refineries	Texas



## Hub Regions

CCUS activity in the US is developing regionally at the state level, rather than in nationally coordinated industrial clusters as in some other countries identified in this report. Texas and Louisiana have seen development of the CCUS sector for decades, with Texas being the location of the first CCS project, Val Verde, in 1972.<sup>94</sup> OGCI has identified both Louisiana and Texas as states with high potential.<sup>95</sup>

The extensive industrial sector and oil production activity in the Gulf of Mexico in both Louisiana and Texas and the resultant emissions suggest a need for CCUS. Louisiana has several large CCUS projects underway and has policies to support the sector's growth.

The Governor of Louisiana declared a net zero by 2050 goal at the end of 2020, indicating a commitment to decarbonizing the state's industrial emissions.<sup>76</sup> Projects in the southwest of the State like Lake Charles Methanol, a proposed methanol production plant with capture of CO<sub>2</sub> for EOR use<sup>96</sup>, and Gulf Coast Sequestration, a proposed geological storage hub<sup>97</sup>, indicate a continued growth of the CCUS sector. The demand for CCUS in Texas has been predominantly driven by oil companies like Occidental Petroleum, who are the largest user of EOR in the Permian Basin region of the state.<sup>98</sup> Occidental's subsidiary, Oxy Low Carbon Ventures is also commissioning the world's largest DAC facility with Canadian-based company Carbon Engineering's technology in the west of Texas.<sup>99</sup>

## Potential Opportunities & Threats

- The 45Q regulation - which was extended at the end of 2020, the presence of stackable, state-level incentives like the LCFS, and the large field of readily available investors makes the US an attractive market as partners are actively looking for Canadian technology.
- It is recommended to evaluate the target market to the state level, looking at sub-sector development, the prominent industries as well as geological storage development in states of interest to be aware of what technology is in demand in that region. The following states and their sub-sector focus are described in more detail above:
  - » California - utilization, storage
  - » Louisiana - storage, some utilization
  - » New York - utilization
  - » Texas - storage
- Consider federal and state regulations, incentives, and legislation in detail, and hire a local policy consultant to ensure all incentives are being utilized and stacked where applicable.
- Seeking the advice of a lawyer is recommended for legal compliance in a region that can be litigious.
- Developing strategic partnerships with large, heavy emitting companies with a declared interest in CCUS is a strategy for entering the US market.
  - » Connect with the TCS in the region of interest to help make connections with corporations of interest.
  - » Participate in regional innovation challenges and technology accelerator programs, often affiliated with the TCS, which convene the appropriate people from large multinationals to facilitate partnerships. See Appendix C for upcoming events.
- The US is a market that can be entered through direct export because of Canada's close trade relationship and free trade agreement.
- The World Bank ranks the US in the top 10 on the Ease of Doing Business scale.<sup>29</sup>

## Relevant Contacts and Organizations

ORGANIZATION	DESCRIPTION	EMAIL
The Consulate General of Canada, Denver  Current Contact: Stephen Davis Trade Commissioner, Cleantech	Canadian government representation in MO, WY, CO, UT, KS	stephen.davis@international.gc.ca  denvr-td@international.gc.ca
The Consulate General of Canada, New York  Current Contact: Ian Philp Trade Commissioner, Head of Energy and Environment; Carbon to Value Initiative	Canadian government representation in NY, NJ, CT, PA, DE, Bermuda	ian.philp@international.gc.ca  cngnytd@international.gc.ca
The Consulate General of Canada, Houston  Current Contact: Maria Bofill Trade Commissioner, Cleantech	Canadian government representation in TX	hston-td@international.gc.ca
The Consulate General of Canada, San Francisco	Canadian government representation in San Francisco	sfran-td@international.gc.ca
The Consulate General of Canada, Los Angeles  Current Contact: Patrick Courcelles Trade Commissioner, Cleantech	Canadian government representation in CA	cal.info@international.gc.ca
The Embassy of Canada to the United States of America  Current Contact: Genevieve Fletcher Trade Commissioner, Cleantech	Canadian government representation in USA	Genevieve.Fletcher@international.gc.ca  wshdc.infocentre@international.gc.ca
The Consulate General of Canada, Chicago  Current Contact: Ann Rosen Trade Commissioner, Cleantech	Canadian government representation in IL	ann.rosen@international.gc.ca  chcgo-td@international.gc.ca
Carbon180	Nonprofit climate change organization	hello@carbon180.org
Circular Carbon Network	Nonprofit investment catalyst for carbon utilization applications	<a href="https://circularcarbon.org/contact/">circularcarbon.org/contact/</a>



## Relevant Contacts and Organizations

ORGANIZATION	DESCRIPTION	EMAIL
Carbon Capture Coalition Current Contact: Jessie Stolark Public Policy & Member Relations Manager	Nonprofit CCUS business/ organization collaboration	<a href="mailto:jstolark@carboncapturecoalition.org">jstolark@carboncapturecoalition.org</a>
Carbon Utilization Alliance	Index for CCUS sector players	<a href="http://cua.earth/ccus-companies">cua.earth/ccus-companies</a>
XPRIZE	Large-scale incentive prizes for technology innovation	<a href="http://xprize.org/contact">xprize.org/contact</a>
Greentown Labs	Climate technology accelerator	<a href="mailto:hello@greentownlabs.com">hello@greentownlabs.com</a>
Third Derivative	Climate and clean energy technology accelerator	<a href="http://third-derivative.org/contact-us/">third-derivative.org/contact-us/</a>
Global CO <sub>2</sub> Initiative at the University of Michigan	Research, development and deployment for CCU	<a href="http://globalco2initiative.org/contact/">globalco2initiative.org/contact/</a>





## OTHER MARKETS OF INTEREST

Acknowledging one goal of this report was to prioritize up to five countries of particular interest for the export of Canadian CCUS technologies, the following countries also have CCUS markets of interest:

### France

France is actively expanding its national CCUS market, with a focus on developing carbon utilization applications. This has been largely led by France's strong industrial sector, with corporations like LafargeHolcim, Total, Engie, and Michelin all publicly indicating an interest in CCUS.

**Opportunities:** With French global conglomerates developing CCUS projects, there is opportunity for Canadian technology companies to develop mutually beneficial partnerships. Carbon capture and utilization technologies are more likely to be in demand as on-shore storage has been deemed unfavourable by public opinion. As a member of the EU, multiple financing mechanisms would be available to in-country projects if an EU-based partner is involved.

**Recommendations:** Connect with the TCS in France, as this office is particularly interested in developing Canadian CCUS sector presence (Appendix A).



## OTHER MARKETS OF INTEREST

### Japan

A significant number of Japanese companies have begun developing CCUS technologies. The government has also successfully piloted an offshore storage operation, the Tomakomai Demonstration Project,<sup>100</sup> and has entered into a potential partnership with Australia for the HESC project,<sup>25</sup> all of which indicate a strong interest in the sector. However, Japan's regulatory framework is currently not positioned to incentivize deployment of CCUS technologies, with no price on carbon or mandated emissions reduction policies. The government recently announced a goal of net zero emissions by 2050, indicating a potential future shift in policy framework to begin accelerating deployment. The seismic activity in Japan eliminates the potential for onshore storage due to safety concerns, and though there has been successful offshore storage testing, the complexity and cost of these projects have led to a market shift towards utilization over storage.

**Opportunities:** The biggest opportunity for Canadian companies in Japan may be to partner with export-focused Japanese trading houses. Entities like Mitsubishi are themselves developing CCUS technology and looking to export outside of the country due to the limited domestic market. This indicates the current CCUS market inside Japan is not yet ready for the export of Canadian technologies. Though this may change with the recent net zero by 2050 declaration, developing a partnership with a Japanese trading house could provide a market entry pathway once the regulatory landscape has changed and may also provide a significant advantage for entering other global markets. In general, it has been advised that large Japanese trading houses make for valuable investing partners. Acquisition is not typically the end goal of these investments - these Japanese entities can make supportive, long term partners if the relationship is financially beneficial and SMEs have the resources to go through long due diligence processes. As an example, if an SME has a technology that is a good fit for a large Japanese trading house, there is an opportunity for the company to both invest in the SME and to work jointly in marketing that technology globally.

**Recommendations:** If there is capacity for patience during a long due diligence period, a partnership with a large Japanese multinational would be an option to explore in the near future, with a caveat that the market for CCUS technologies in Japan itself may be limited in the near term. The TCS in Japan is a good contact to facilitate connections and can help navigate norms of Japanese business culture. Industry associations do exist in the sector, as do Japanese government ministries (Ministry of Economy, Trade and Industry (METI)) that focus on sector development, however, these bodies are focused on advancing Japanese industry interest.

## OTHER MARKETS OF INTEREST

### Netherlands

The Netherlands has two major CCUS projects, Athos and Porthos, around the port regions of Amsterdam and Rotterdam.<sup>101,102</sup> Both projects intend to create hub regions of industrial carbon capture, transport, and offshore storage in depleted oil and gas reservoirs in the North Sea. Both projects have also indicated a potential to support utilization applications with the infrastructure in development, either in industry, or in nearby greenhouses.<sup>101,102</sup>

**Opportunities:** The Porthos and Athos hubs have the potential to provide opportunities in all areas of CCUS, with Porthos being the more developed project. Athos is being developed in partnership with Tata Steel, and will capture carbon emissions from a steel processing plant in the North Sea Canal area. It is intended to be an open access network of CO<sub>2</sub> transport pipelines for any of the surrounding industry.<sup>101</sup> Porthos is currently intended to capture emissions from Air Liquide, Air Products, ExxonMobil and Royal Dutch Shell, but is open to other partners and will also be an open access storage network.<sup>102</sup> This indicates capture from a wide range of industries will potentially be needed, as well as applications for storage, related technologies (i.e., MMV), and utilization, particularly those that create value-added products for agricultural or industrial applications. Representatives from the Netherlands have indicated that the country is planning a move to renewable energy, so the CCUS projects related to the power sector are a transition solution. Long-term opportunities for CCUS will likely be limited to hard-to-decarbonize industrial sectors. As an EU country, multiple financing mechanisms are available to projects in the Netherlands if an EU-based partner is involved.

**Recommendations:** Connecting with the TCS is a good option to foster connections with the Porthos and Athos projects (Appendix A).





## ADDITIONAL MARKETS TO CONSIDER

Other countries have advancing markets for CCUS that are highlighted here. It is advised that SMEs should consider political environments and potential risks to IP when evaluating entry into some of these markets.

China has had significant development in the CCUS sector, with the government releasing strategies like the Roadmap to CCUS.<sup>1</sup> They have been actively pursuing CCUS to reduce emissions because they are the highest CO<sub>2</sub> emitting country in the world<sup>20</sup> and have an energy grid powered with many coal-fired power plants. They have a large scale CCS facility in operation, with seven more facilities under development.<sup>1</sup> OGCI has listed North-West China as one of their four Kickstarter Hub projects.<sup>95</sup>

Saudi Arabia has demonstrated a need for decarbonizing their economy and has made significant efforts to advance their CCUS industry with projects like Saudi Aramco's Uthmaniyah CO<sub>2</sub>-EOR project.<sup>103</sup> They have also publicly indicated an interest in pursuing green and blue hydrogen projects.<sup>104</sup>

The United Arab Emirates has two large-scale CCS EOR projects operated by Abu Dhabi National Oil Company that capture CO<sub>2</sub> from a steel plant and a natural gas processing plant.<sup>105</sup> They have also indicated plans to develop green and blue hydrogen projects and expand CCUS further to more oil and gas industry operations.<sup>106</sup>

Singapore has identified CCUS as a component of their long-term emissions reduction strategy.<sup>107</sup> Though the country does not have formations for subsurface geological storage, key industry players have begun exploring other options including collaboration with international partners, notably Australia.<sup>107</sup>

South Korea and South Africa have also indicated an interest in CCUS, particularly as these countries' are heavily reliant on fossil fuel like coal as energy sources.<sup>108,109</sup> South Africa was selected to receive support from the World Bank's Carbon Capture and Storage Trust Fund (CCS TF) to assist developing countries in exploring CCS for a low carbon transition.<sup>109</sup> Mexico was also selected for the CCS TF<sup>110</sup>, and has implemented several policy instruments like the Technology Roadmap of CCUS.<sup>111</sup> Two short-term pilot projects and ten medium to long-term projects are in development by the Government of Mexico.<sup>112</sup>

There is also a substantial need for CCUS across many developing countries in Asia, notably, India, Indonesia, Viet Nam, and Thailand. India has a large quantity of carbon emissions from the power generation sector and heavily polluting industries like cement and refineries. Sources have advised of a general interest in pursuing CCU over storage in the country. Viet Nam, Thailand, and Indonesia have all expressed interest in CCUS technologies, with a need for decarbonization of the large industrial manufacturing sectors. A resource for a Canadian company looking to enter these markets is the Asian Development Bank (ADB). The ADB's Carbon Capture and Storage Fund, established with Australia and the UK, supports capacity building and research in CCS, with China, India, Indonesia, and Viet Nam as priority countries.<sup>113</sup>

**In all...CCUS markets, particularly in developing countries, it is important to have a trusted local partner to navigate cultural nuances.**

Another potential emerging market for CCUS is Turkmenistan. With large gas reserves, no access to subsea storage, and a desire to find alternative use for fossil fuel resources, CCUS could prove as an attractive option. However, entrance to this market and partnership opportunities may be challenging to find.

In all the above CCUS markets, particularly in developing countries, it is important to have a trusted local partner to navigate cultural nuances.



## SUGGESTED NEXT STEPS FOR CANADIAN GOVERNMENT

This strategy is intended to maximize the potential of the Canadian CCUS industry and increase its competitiveness in the global market. To assist Canadian CCUS companies in successfully growing the international market share, some interviewed stakeholders recommended that government considers the following:

1. **Support the creation of a domestic CCUS industry cluster to foster full-scale project partnerships among domestic technology and other value chain companies, and increase harmonization between levels of government with an interest in the sector.**

It is recommended for governments to support the creation of a CCUS hub or industry cluster to support export. An industry cluster can bring companies and organizations together to achieve synergistic CCUS solutions across sub-sectors to export full-scale project capability, which has been a need echoed during several stakeholder interviews. Industry clusters could also engage businesses in rural and indigenous communities to encourage CCUS product development, implementation and export. Consolidating CCUS technologies and expertise into exportable solutions can increase the sector's competitiveness on a domestic and global scale.

**Consolidating CCUS technologies and expertise into exportable solutions can increase the sector's competitiveness on a domestic and global scale.**

Governments, including the TCS, may also see value in deeper collaboration with Canadian CCUS companies to increase awareness of industry successes and challenges that would underscore national sector strengths to build on, and highlight areas requiring additional support.

In addition to increasing collaboration between private and public sector stakeholders, an industry cluster can provide a platform for increased cooperation and harmonization between various levels of government with an active interest in the CCUS sector. Having representation from federal, provincial, and municipal governments involved in the industry cluster from a nonpartisan standpoint would create more open collaboration. Creation of the cluster with multi-level government involvement can contribute to depoliticizing CCUS and therefore may also provide the stability needed for increased investment in the sector.

## **2. Expansion of public-private sector carbon utilization technology accelerator and value chain connection programs.**

Development or support of programming that intends to accelerate the carbon utilization industry and foster connections between large industry, government, and technology SMEs to support commercialization has been recommended as valuable to build in Canada and with international partners. Accelerator programs that shorten technology development time and increase the likelihood of technology adoption will support SMEs in successfully entering international markets. Furthermore, programs that involve international partners can provide a platform for SMEs to connect with large industry players and outline a pathway to enter a strategic market.

## **3. Increase and sustain government funding to support CCUS technology advancement and incentivize private sector companies to adopt domestic technology.**

It has been noted through conversations with Canadian CCUS SMEs that government funding to support direct advancement of CCUS technology is the most critical catalyst for implementation of projects. Canadian governments should provide further incentives for domestic adoption of technologies in a way that advances demonstration of Canadian technologies at a sufficient scale to meet global commercial requirements. This can include providing additional support through subsidies and/or incentives for first demonstration, field piloting, and first-of-its-kind technology implementation in a variety of heavy industries.

## **4. Provide support to incentivize establishment of a manufacturing base in Canada for CCUS technology.**

As the domestic CCUS ecosystem matures, there will be an increasing need for incentives to build a CCUS manufacturing base in Canada. When CCUS technology progresses and attracts international investment, SMEs in Canada have felt significant pressure to permanently relocate operations to the location of investors and customers, which is often out of the country. Supporting a manufacturing base in Canada would allow development of the domestic CCUS sector to progress to commercialization, provide incentive for SMEs to remain in Canada, as well as produce jobs, tax revenue, and economic diversification.





## CONCLUSION

Canada is in a strong position to become a global leader in CCUS technology. Though the worldwide CCUS market is new and evolving as governments adjust policies and emissions reduction strategies, the efforts of Canada to-date to develop large-scale projects, invest in innovation, and support research in the field have positioned the country to compete for market share in this emerging sector<sup>5</sup>.

With continued support from the Canadian government, national CCUS technology companies are positioned to be competitive in these target countries. Leveraging beneficial partnerships, collaborating with the TCS, and being thoroughly aware of regulations, policies, industries, emissions, and sub-sector emphases of countries of interest are valuable considerations for SMEs when considering entering foreign markets. This report is intended to act as a resource for CCUS to assist businesses to develop a competitive international strategy in a rapidly changing, but critically important technological market and bring Canada's CCUS sector to new heights.

## APPENDIX A - CONTACTS LIST

ASSOCIATED COUNTRY	ORGANIZATION	DESCRIPTION	EMAIL
Canada	Trade Commissioner Service - Atlantic Region	Regional office	ROATL-ATLANTIC@international.gc.ca
Canada	Trade Commissioner Service - Quebec and Nunavut	Regional office	quebec.tcs-sdc@international.gc.ca
Canada	Trade Commissioner Service - Ontario	Regional office	Ontario.TCS-SDC@international.gc.ca
Canada	Trade Commissioner Service - Manitoba and Saskatchewan	Regional office	Manitoba.Saskatchewan.TCS-SDC@international.gc.ca
Canada	Trade Commissioner Service - Alberta and Northwest Territories	Regional office	Alberta.TCS-SDC@international.gc.ca
Canada	Trade Commissioner Service - British Columbia and Yukon	Regional office	pacific-pacifique.tcs-sdc@international.gc.ca
Canada	International CCS Knowledge Centre	Canadian CCS research organization based off learnings from Boundary Dam CCS project	info@ccsknowledge.com
Australia	Consulate General of Canada in Sydney  Current Contact: Kishani Navaratnam Trade Commissioner, Cleantech	Canadian government representation in Australia	AustraliaTrade@international.gc.ca
Australia	CO2CRC	For-profit industry-led research organization	info@co2crc.com.au
Australia	Global CCS Institute	International think tank for advancing adoption of CCS, headquartered in Melbourne	info@globalccsinstitute.com
Australia	Australian Low Emissions Coal Research & Development (ANLECR&D) Initiative	Research centre supporting CCS development for the coal industry	anlecrd.com.au/contact/
Australia	Australian Petroleum Production & Exploration Association (APPEA)	Upstream oil and gas industry association	appea@appea.com.au
Australia	National Energy Resources Australia (NERA)	Industry growth association for energy resources	contact@nera.org.au
Australia	Low Emissions Technology Australia (LETA)	Previously COAL21. Association investing in low emissions technology for black coal industry	info@letaaustralia.com.au

ASSOCIATED COUNTRY	ORGANIZATION	DESCRIPTION	EMAIL
Germany	Embassy of Canada to Germany Current Contact: Arndt Ulland Trade Commissioner, Cleantech	Canadian government representation in Germany	deutschland.commerce@international.gc.ca
Germany	Embassy of Canada to Germany Current Contact: Pieter Bouwer European Regional Trade Commissioner, Cleantech	Canadian government representation in Germany	deutschland.commerce@international.gc.ca
Germany	European Cement Research Academy	Sustainability and innovation research in cement and concrete industries	info@ecra-online.org
Germany	Verband der Chemischen Industrie (VCI)	Chemical industry association in Germany	vci.de/kontakt/seiten.jsp
Germany	Institute for Advanced Sustainability Studies	International sustainability research institute	info@iass-potsdam.de
Germany	Fraunhofer Institute for Systems and Innovation Research ISI	Applied research institute on innovation	IL-Sekretariat-Edler@isi.fraunhofer.de
Germany	German-Canadian Centre for Innovation and Research	Trade and research facilitation between Canada and Germany. Also runs the Alberta-Europe Technology Collaboration Fund for SMEs.	info@gccir.ca
Germany	ClimateKIC	Innovation research and support network for a low-carbon, sustainable economy in the EU	germany@climate-kic.org
Germany	GFZ German Research Centre for Geosciences - Helmholtz Centre Potsdam	Research institute	info@gfz-potsdam.de
Germany	Wuppertal Institute Current Contact: Peter Viebahn Head of Research Unit Sectors and Technologies, Future Energy and Industry Systems	Sustainability-focus research institute	peter.viebahn@wupperinst.org
Germany	Nova Institute	Research institute focused on renewable carbon applications	contact@nova-institut.de

ASSOCIATED COUNTRY	ORGANIZATION	DESCRIPTION	EMAIL
Germany	CO <sub>2</sub> Value Europe	EU industry association for CCU, chaired by Uniper	contact@co2value.eu
Norway	The Embassy of Canada to Norway  Current Contact: Tone Nymoen Trade Commissioner, Cleantech	Canadian government representation in Norway	Tone.Nymoen@international.gc.ca NordiCommerce@international.gc.ca
Norway	Invest in Norway	Norway government technology trade import service	invinor.no/contact-us/
Norway	Innovation Norway  Current Contact: Alana Prashad Senior Advisor, Energy and Environment Lead, Americas	Norway government technology trade export service	alana.prashad@innovationnorway.no
Norway	Technology Centre Mongstad  Current Contact: Matthew Campbell Principal Technologist	CCUS technology RD&D test center	matthew.campbell@tcmda.com
Norway	NORCE	Independent research institute	post@norceresearch.no
Norway	Equinor & Techstars Energy Accelerator	Technology accelerator for oil and gas innovation	techstars.com/contact
United Kingdom	High Commission of Canada to the UK (London)  Current Contacts: Megan Wood Marcin Zydowicz Trade Commissioner, Cleantech	Canadian government representation in UK	ldn-td@international.gc.ca
United Kingdom	British Consulate General (Toronto, Montreal, Calgary, Vancouver)	British government representation in Canada	researchcanada@mobile.trade.gov.uk
United Kingdom	Scottish Development International  Current Contact: Usman Ghani Vice President, Americas	International trade and investment facilitation for Scotland	Usman.Ghani@scotent.co.uk
United Kingdom	Catapult Network	Accelerator organizations focused on innovative topics including Energy Systems	es.catapult.org.uk/get-in-touch/
United Kingdom	Oil and Gas UK	Trade association actively supporting low-carbon technology development	info@oilandgasuk.co.uk



ASSOCIATED COUNTRY	ORGANIZATION	DESCRIPTION	EMAIL
United Kingdom	Carbon Capture and Storage Association	Trade association for CCUS industry	info@ccsassociation.org
United Kingdom	UK CCS Research Centre	Research organization and industry collaborator for CCS in the UK	info@ukccsrc.ac.uk
United Kingdom	Net Zero Teesside	CCUS Hub Region - Northeast England	netzeroteesside.co.uk/contact/
United Kingdom	Zero Carbon Humber	CCUS Hub Region - Yorkshire, England	zerocarbonhumber.co.uk/contact/
United Kingdom	HyNet North West	CCUS Hub Region - Northwest England	0203 116 5919
United Kingdom	South Wales Industrial Cluster	CCUS Hub Region - South Wales	swic.cymru
United Kingdom	Acorn Project	CCUS Hub Region - Aberdeen, Scotland	acorn@pale-blu.com
United States	The Consulate General of Canada, Denver  Current Contact: Stephen Davis Trade Commissioner, Cleantech	Canadian government representation in MO, WY, CO, UT, KS	stephen.davis@international.gc.ca  denvr-td@international.gc.ca
United States	The Consulate General of Canada, New York  Current Contact: Ian Philp Trade Commissioner, Head of Energy and Environment; Carbon to Value Initiative	Canadian government representation in NY, NJ, CT, PA, DE, Bermuda	ian.philp@international.gc.ca  cngnytd@international.gc.ca
United States	The Consulate General of Canada, Houston  Current Contact: Maria Bofill Trade Commissioner, Cleantech	Canadian government representation in TX	hston-td@international.gc.ca
United States	The Consulate General of Canada, San Francisco	Canadian government representation in San Francisco	sfran-td@international.gc.ca
United States	The Consulate General of Canada, Los Angeles  Current Contact: Patrick Courcelles Trade Commissioner, Cleantech	Canadian government representation in CA	cal.info@international.gc.ca

ASSOCIATED COUNTRY	ORGANIZATION	DESCRIPTION	EMAIL
United States	The Embassy of Canada to the United States of America  Current Contact: Genevieve Fletcher Trade Commissioner, Cleantech	Canadian government representation in USA	Genevieve.Fletcher@international.gc.ca  wshdc.infocentre@international.gc.ca
United States	The Consulate General of Canada, Chicago  Current Contact: Ann Rosen Trade Commissioner, Cleantech	Canadian government representation in IL	ann.rosen@international.gc.ca  chcgo-td@international.gc.ca
United States	Carbon180	Nonprofit climate change organization	hello@carbon180.org
United States	Circular Carbon Network	Nonprofit investment catalyst for carbon utilization applications	circularcarbon.org/contact/
United States	Carbon Capture Coalition  Current Contact: Jessie Stolark Public Policy & Member Relations Manager	Nonprofit CCUS business/organization collaboration	jstolark@carboncapturecoalition.org
United States	Carbon Utilization Alliance	Index for CCUS sector players	cua.earth/ccus-companies
United States	XPRIZE	Large-scale incentive prizes for technology innovation	xprize.org/contact
United States	Greentown Labs	Climate technology accelerator	hello@greentownlabs.com
United States	Third Derivative	Climate and clean energy technology accelerator	third-derivative.org/contact-us/
United States	Global CO <sub>2</sub> Initiative at the University of Michigan	Global CO <sub>2</sub> Initiative at the University of Michigan	globalco2initiative.org/contact/

## APPENDIX B - POLICIES

COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
Australia	National		Australian Renewable Energy Agency (ARENA)	2021	Federal government agency that supports research, innovation and deployment of clean and renewable energy technology. It was announced in 2020 that the mandate will be expanded to include CCS in 2021. Projects must be established, with partners
Australia	National		Carbon Credits (Carbon Farming Initiative) Act of 2011	2011	Administered by the Clean Energy Regulator, the scheme awards carbon credit units to offsets projects
Australia	National		Clean Energy Finance Corporation (CEFC)	2021	Agency established by the Australian government that provides investment to clean energy projects. Also announced the addition of CCS to the mandate in 2021
Australia	National		Climate Solutions Fund	2019	Australia's continued investment in the Emissions Reduction Fund incentivized carbon credit trading scheme
Australia	National		Emissions Reduction Fund + safeguard mechanism	2015	Established under the Carbon Credits Act, an incentive for businesses to reduce emissions and store carbon. The safeguard mechanism is a legislated obligation on the largest emitters to keep net emissions below a limit
Australia	National		National Hydrogen Strategy	2019	National approach to developing hydrogen industry to place as global leader by 2030
Australia	National		Technology Investment Roadmap	2020	Framework for investment in low emissions technology innovation

COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
Germany	International	EU	Accelerating CCS Technologies (ACT)	2016	European Research Area Network (ERA-NET) consortium to provide funding for RD&D in CCUS
Germany	International	EU	EU Emissions Trading System Phase 3	2013	Cap and trade among EU, Norway, Iceland, Liechtenstein. Phase 4 to commence 2021. Limits emissions on power stations, industrial plants, airline travel
Germany	International	EU	Horizon 2020	2013	Innovation/research funding for CCUS. Relevant funding areas include low emissions lime and cement (LEILAC), development of transport corridors to the North Sea (STRATEGY CCUS), and offshore storage monitoring (STEMM CCS). EU, Norway, Iceland
Germany	International	EU	Innovation Fund	2019	Fund for low carbon technology. CCUS technology construction and operation are eligible activities
Germany	National		Carbon2Chem	2016	Government-funded RD&D project in partnership with industry to develop value-added products from steel production emissions
Germany	National		Funding Directive - CO2 avoidance and use in raw material industries	2021 (upcoming)	Funding directive from BMWi - Federal Ministry for Economic Affairs and Energy to support companies in development of CCUS technologies (upcoming - May 2021)
Germany	National		Law for the demonstration of permanent storage of carbon dioxide	2012	Law permitting small-scale CCS projects on a national scale. Amended to give states the right to impose a ban
Germany	National		National Hydrogen Strategy	2020	Intended focus on developing green hydrogen, but recognizes the transition phase of blue hydrogen



COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
Norway	International	EU	EU Emissions Trading System Phase 3	2013	Cap and trade among the EU, Norway, Iceland, Liechtenstein. Phase 4 to commence 2021. Limits emissions on power stations, industrial plants, airline travel
Norway	International	EU	Horizon 2020	2013	Innovation/research funding for CCUS. Relevant funding areas include low emissions lime and cement (LEILAC), development of transport corridors to the North Sea (STRATEGY CCUS), and offshore storage monitoring (STEMM CCS). EU, Norway, Iceland
Norway	International	EU	Innovation Fund	2019	Fund for low carbon technology. CCUS technology construction and operation are eligible activities
Norway	National		CLIMIT	2005	Grant program for RD&D of CCUS technologies
Norway	National		CO2 tax on offshore oil and gas	1991	Tax on mainland activities (mineral oil, auto diesel, petrol, natural gas, LPG) and CO2 emissions from the continental shelf. CO2 capture is incentivized for tax reduction
United Kingdom	International		BEIS Energy Innovation Programme	2015-2021	Funding support from the UK government's Department of Business, Energy and Industrial Strategy to accelerate commercialization of clean energy technology
United Kingdom	National		Carbon Price Support	2015	Under Climate Change Levy. Applies to power generators
United Kingdom	National		CCUS Business Models	2020	Government report on potential business models for CCUS in the UK, plus a specific amendment for the proposed commercial frameworks for transport and storage, power, and industrial carbon capture

COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
United Kingdom	National		CCUS support in 2020 budget	2020	2020 budget mentioned support of an 800 million GBP carbon capture and storage infrastructure fund. Indicated carbon capture support in two sites over 20 years and support for at least one capture equipped gas power plant by 2030
United Kingdom	National		Clean Growth Fund	2020	Fund for scale-up of low-carbon technologies. Industrial CCS is an eligible application, but must be a UK-based company
United Kingdom	National		Clean Growth Strategy and Industrial Strategy	2017	Strategy indicating goals to invest in industrial innovation. CCUS is a key focus
United Kingdom	National		Emissions Trading Scheme	2021	Planned ETS replacement of previous EU scheme after Brexit finalized
United Kingdom	National		UK CCUS Action Plan	2018	Action plan to deploy CCUS at scale by the 2030s. Discusses cluster creation and strategies to promote innovation
United States	State	California	Executive Order B-55-18 - net zero by 2045	2018	Net zero by 2045 goal (not yet codified)
United States	State	California	Low Carbon Fuel Standard	2019	Set of programs to decrease carbon intensity of fuel. Includes the CCS Protocol. DAC is also eligible and does not have to be in-state
United States	State	California		2018	Legal mandate to achieve 100% zero carbon electricity by 2045
United States	State	Colorado	HB 06-1281	2006	Utility Cost Recovery Mechanism to construct IGCC coal power plants with carbon capture
United States	State	Hawaii	HB 2182 - net zero by 2050	2018	Net zero emissions by 2050 - first state to declare

COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
United States	State	Hawaii	State Building Construction; Carbon Dioxide Mineralized Concrete (HB1282 HD1)	2019	Requires low carbon concrete from carbon technology be used in state projects
United States	State	Illinois	Clean Coal Portfolio Standard Law (PA 95-1027)	2009	Utility sourcing agreements with clean coal, utility cost recovery for CC on coal plants, goal of 25% by 2025
United States	State	Illinois	Illinois Power Agency Act (SB1592)	2007	Development of Renewable Energy Resources Trust Fund and Coal Technology Development Assistance Fund for coal-fired power plants with capture tech
United States	State	Kansas	HB 2419	2007	Tax incentives for CCUS
United States	State	Kentucky	HB 259	2011	State assumption of long-term liability for geologic storage of CO2
United States	State	Kentucky	Incentives for Energy Independence Act (HB 1)	2007	Tax incentives for carbon capture-ready facilities and CO2 pipelines
United States	State	Louisiana	Bill 661	2009	State assumption of long-term liability for geological storage of CO2
United States	State	Louisiana	Executive Order - net zero by 2050	2020	Net zero emissions by 2050
United States	State	Louisiana	HB 61, 62	2016	Tax exemption for CO2-EOR oil production
United States	State	Michigan	Clean, Renewable and Efficient Energy Act - SB 213	2008	15% renewable energy standard for energy providers. Includes up to 1% through coal-fired power generation with 85% CCS
United States	State	Mississippi	HB 1459	2009	Tax incentives for CO2-EOR
United States	State	Montana	Jobs and Energy Development Incentives Act (HB3)	2007	Tax incentives for advanced coal R&D, sequestration from coal gasification. Includes a property tax abatement for CCS equipment

COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
United States	State	Montana	SB 498	2009	State assumption of long-term liability for geological storage of CO <sub>2</sub>
United States	State	New Mexico	SB 994	2009	Utility Cost Recovery Mechanism to construct coal power plants with carbon capture
United States	State	New York	Carbon to Value Initiative	2020	Program with various initiatives supporting carbotech innovation and scaleup. Supported by NY State, Consul General of Canada in New York
United States	State	New York	Climate Leadership and Community Protection Act	2019	Emissions reduction mandate of 85% by 2050 with 15% carbon sequestration
United States	State	New York	The New York State Low Embodied Carbon Concrete Leadership Act	2021 (pending at time of publication)	Requires low carbon concrete from carbon technology be used in state projects and establishes a tax credit
United States	State	North Dakota	SB 2034	2009	Tax exemption for oil produced by EOR
United States	State	North Dakota	SB 2095	2009	State assumption of long-term liability for geological storage of CO <sub>2</sub>
United States	State	North Dakota	SB 2221	2009	CO <sub>2</sub> capture tax credit for coal conversion facilities (20% captured +, up to 50% tax reduction for 80% emissions capture)
United States	State	North Dakota	SB 2318	2015	Property tax exemption for CO <sub>2</sub> EOR equipment and systems
United States	State	Texas	HB 1976	2009	State assumption of long-term liability for geological storage of CO <sub>2</sub>
United States	State	Texas	HB 3732	2007	Direct Financial Assistance for clean energy projects with tax incentives for CO <sub>2</sub> -EOR oil production



COUNTRY	JURISDICTION	REGION	POLICY NAME	YEAR ENACTED	DESCRIPTION
United States	State	Texas	HB 469	2009	Tax credit for CCS at coal-fired power plants
United States	State	Utah	Clean Energy Standard - SB 202	2008	Coal and gas fired power plants with carbon capture determined as eligible to meet state renewable energy goal
United States	State	Virginia	SB 1416	2007	Utility cost recovery mechanism for coal-fired power plants with carbon capture technology
United States	State	Wyoming	Tax incentive		Tax exemption for CO <sub>2</sub> used in EOR
United States	National		American Reinvestment and Recovery Act - CCUS	2009	3 billion USD funding for CCUS technology RD&D
United States	National		Carbon Storage Assurance Facility Enterprise Initiative (CarbonSAFE)	2016	Initiative to fund CO <sub>2</sub> storage projects for deployment by 2025-2030. Projects include RD&D, geological modelling and monitoring
United States	National		Section 45Q credit	2008	Federal tax credit for CO <sub>2</sub> storage, amended to include utilization and emissions reductions. Extended at the end of 2020
United States	National		Section 48A Qualifying Advanced Coal Project Credit	2005	Federal tax credit for efficiency upgrades at coal-fired power plants to reduce emissions. CCUS for post-combustion is currently not eligible, but an amendment is proposed to include this
United States	National		The Utilizing Significant Emissions with Innovative Technologies (USE IT) Act	2019	An amendment to US Clean Air Act to support carbon utilisation and direct air capture research, as well as the construction and development of CCUS facilities and CO <sub>2</sub> pipelines (pending)

## APPENDIX C - EVENTS

TITLE	LOCATION	DATE	DESCRIPTION
ADIPEC (Abu Dhabi International Petroleum Exhibition & Conference)	Abu Dhabi, UAE	Nov 8-11, 2021	ADIPEC hosts oil, gas and energy companies to engage and identify opportunities for new value in an evolving energy landscape.
CERAWeek 2021	Virtual	Mar 1-5, 2021	Hosted by IHS Markit, this event will convene the foremost global thought leaders and decision makers in the fields of energy, technology, business, government, and finance to bring clarity and perspective to the future landscape of climate and energy.
Post Combustion Capture Conference	TBD, UK	Oct 19-21, 2021	A forum to discuss and share experiences regarding the various scale up challenges related to post-combustion capture technologies status and development. Special attention will be given to capture pilot plants and large-scale demonstration project results, challenges and future plans.
16th Carbon Dioxide Utilization Summit	Montreal, Canada	Sep 8-9, 2021	This event will bring together senior experts from various CO <sub>2</sub> emitting industries to discuss sustainability, technological and commercial aspects of CO <sub>2</sub> utilization globally. Panelists will share insights into commercial applications and technology development.
SPE (Society of Petroleum Engineers) Virtual Workshop: Sustainability Stewardship – CCUS Opportunities in Global Energy Transition	Virtual	Feb 24-25, 2021	The key themes for this event are: <ul style="list-style-type: none"> <li>• CO<sub>2</sub> capture technology advancement and innovations</li> <li>• CO<sub>2</sub> storage: reservoir selection and monitoring</li> <li>• CCUS and CO<sub>2</sub> EOR: project planning, key drivers, and enablers</li> <li>• CO<sub>2</sub> EOR, development in subsurface studies, wells and completion design</li> <li>• CO<sub>2</sub> EOR, development in new materials selection, wells and facilities</li> </ul>
GHGT (Greenhouse Gas Control Technologies)-15	Abu Dhabi, UAE	Mar 15-18, 2021	International conference on greenhouse gas mitigation technologies with a focus on CO <sub>2</sub> capture and storage.

TITLE	LOCATION	DATE	DESCRIPTION
COP (Conference of Parties) 26: UN Climate Change Conference	Glasgow, Scotland, UK	Nov 1-6, 2021	The COP26 summit will bring parties together to accelerate action towards the goals of the Paris Agreement and the UN Framework Convention on Climate Change.
Carbon Capture Technology Conference & Expo	Stuttgart Messe, Germany	June 9-10, 2021	This event will discuss the increasing role that Carbon Capture, Utilization & Storage (CCUS) will play in transition to a net-zero carbon economy. Leading experts from around the world will discuss the latest advances in new technology for carbon capture, storage and transport, as well as unique ways of utilizing CO <sub>2</sub> .
GRC (Gordon Research Conference): Carbon Capture, Utilization and Storage - Permanently Removing CO <sub>2</sub> from Our Emissions and Atmosphere	Waterville Valley, USA	May 3-June 4, 2021	This event will foster interdisciplinary discussion on decarbonizing energy and industry, and negative emission technologies.
9th Conference on CO <sub>2</sub> -based Fuels and Chemicals	Virtual & Maternushaus, Cologne	Mar 23-24, 2021	The first day of this conference will focus on CO <sub>2</sub> -based transport and aviation fuels, the second on CO <sub>2</sub> -based bulk and fine chemicals.
17th Carbon Dioxide Utilisation Summit	Brussels, Belgium	Oct 27-28, 2021	For the 2021 European edition, this conference will explore CO <sub>2</sub> utilisation projects, the importance of creating partnerships through industrial clusters, LCA best practice, and the policy & regulations that can help strengthen the industry and the latest technology developments. This event will also use case studies to explore the diverse uses of CO <sub>2</sub> .
NAM27 Cat (27th meeting of the North American Catalysis Society)	New York, USA	May 22-27, 2022	This event will feature technological challenges, breakthrough discoveries, and state-of-the art academic and industrial research in catalysis research and development.
GRC (Gordon Research Conferences) – Electrochemical Interfaces in Energy Conversion and Storage	Ventura Beach Marriott, Ventura, CA, US	June 27-July 2, 2021	This event will create a forum for discussion at the frontiers of energy conversion and storage. It will focus on the new understanding of interfacial phenomena including both experimental and theoretical advances in both aqueous and non-aqueous solvents, and solid electrolytes at the atomic level.

TITLE	LOCATION	DATE	DESCRIPTION
2nd Carbon Dioxide Conversion Catalysis Conference	Lisbon, Portugal	Nov 6-9, 2021	This event will gather academic and industrial experts focusing on the catalytic conversion of carbon dioxide into value-added products. The main objective of the conference is to become a key reference for networking, and exploration of new ideas and collaborations in CO2 valorisation.
ACEME 2021: Accelerated Carbonation for Environmental and Material Engineering International Conference	Virtual	May 16-19, 2021	The 7th edition of the ACEME Conferences promotes research and development activities on accelerated carbonation at an international level, favoring the sharing of knowledge and discussing future development and implementation in the field.
29th European Biomass Conference & Exhibition	Virtual & Marseille, France	April 26-29, 2021	During the conference, experts from both academia and industry will share and discuss ground-breaking ideas, technologies, applications, and solutions for the sourcing, production, and utility of biomass.
SPE (Society of Petroleum Engineers) Virtual Workshop: Offshore CCUS - The Size of the Prize and the Way Forward	Virtual	April 6-13, 2021	This workshop will gather experts to cover key questions related to geologic characterization, monitoring, field development, risk analysis and management, business models and case studies, as well as policy and regulation.
Bonn Climate Change Conference (SB 52)	Bonn, Germany	TBD	Was originally scheduled for October 2020, but has been postponed to 2021. Program details are not yet available.
EMRS	Strasbourg, France	May 30-June 3, 2022	This international event will provide a forum to discuss recent advances in the field of materials science.
241st ECS (Electro Chemical Society)	Vancouver, Canada	May 29-June 2, 2022	Program details not yet available.
ACS (American Chemical Society) Fall Meeting – Sustainability in a Changing World	Chicago, USA	August 21-25, 2022	Program details not yet available.
UNFCCC COP 26 (United Nations Framework Convention on Climate Change Conference of Parties)	Glasgow, UK	TBD	This is an annual conference. COP 26 was originally expected to take place in 2020, but is being rescheduled to 2021. Program details not yet available.

For more information on the events, see <https://www.selectco2.eu/index.php/ressources/conferences>



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