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CARBON CAPTURE AND STORAGE INFORMATION DOCUMENT

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Welcome to the dynamic world of Carbon Capture and Storage (CCS), a key player in the fight against climate change. The global CCS market, worth USD 3.28 billion in 2022, is set to grow at a CAGR of 6.2% until 2030, reaching USD 5.61 billion. This growth is propelled by technological advancements, governmental support, and increased offshore oil & gas exploration. The U.S. is expected to lead this industry due to its high-capacity CCS plants and CO2 usage in Enhanced Oil Recovery techniques.

Despite the costs associated with capturing, transporting, and storing CO2, the market for carbon mineralisation credits is expanding, reflecting the market's readiness to invest in innovative climate solutions. The global carbon credit market, valued at US$978.56 billion in 2022, is projected to reach US$2.68 trillion by 2028, driven by regulatory pressure on corporations to reduce emissions.

Please refer to our pricing table for detailed information on CCS market value. [1] [2] [3] [4] [5]

[1] https://doi.org/10.1016/j.joule.2020.09.004
[2] https://doi.org/10.1016/j.joule.2017.09.018
[3] https://doi.org/10.1016/j.joule.2020.09.002
[4] https://www.salesforce.com/news/press-releases/2022/09/20/salesforce-announces-carbon-credit-marketplace/

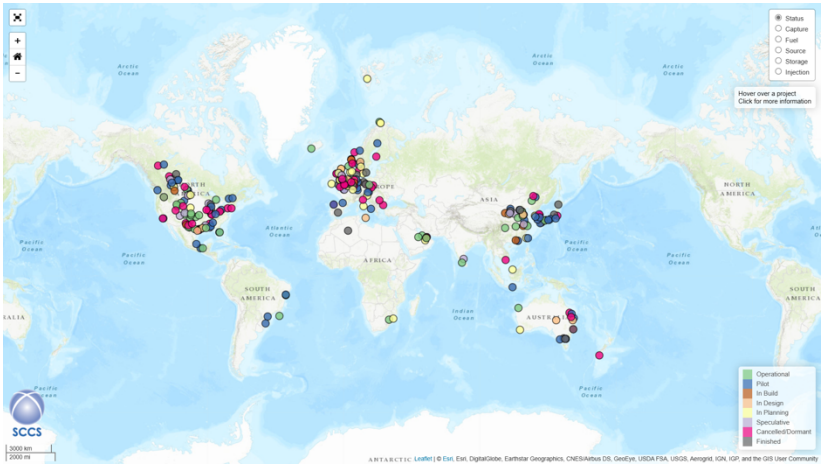
[5] https://www.marketwatch.com/press-release/carbon-capture-and-storage-market-size-and-reserach-overview-2023-2030-2023-05-09

1 MARKET OVERVIEW

The Carbon Capture and Storage (CCS) market originated in the mid-20th century with the oil and gas industry. It gained prominence in the 2000s with the first commercially viable project introduced and was an answer to rising concerns about climate change[6]. Today, it's a key tool for carbon reduction. The global (CCS) market has seen significant growth in recent years, with its value standing at USD 3.28 billion in 2022 and is expected to grow at a compound annual growth rate (CAGR) of 6.2% from 2023 to 2030[7]. The growth of this market is primarily driven by increasing concerns regarding the detrimental effects of carbon emissions on the environment. Governments worldwide are encouraging the implementation of CCS technology through pilot projects across various industries due to its potential as a large-scale solution for achieving high CO2 emission reduction targets and climate control goals.

The key markets for CCS include the United States, Canada, and Europe. These regions have seen a prominent use of CCS due to their commitment to reducing greenhouse gas emissions and their advanced industrial sectors. North America currently provides the most CCS projects, whether these are under construction, planned projects or in use. This is followed by Europe and Asia, with the latter significantly less populous[8]. The U.S. is anticipated to dominate the global industry due to the presence of several high-capacity CCS plants in the region, as well as the increasing usage of CO2 in Enhanced Oil Recovery (EOR) techniques. Canada also holds a significant share of the market, with its first-ever CCS project becoming operational in 2000. Europe, on the other hand, has been supporting the development of commercial-scale CCS projects and accelerating R&D activities related to carbon capture and storage.

Government initiatives and regulations aimed at reducing carbon footprints have also played a significant role in driving the growth of this market. Furthermore, advancements in technology have made CCS more efficient and cost-effective, further propelling market growth.



Despite the promising growth, there are some barriers to the adoption of CCS. For instance, the new government's lack of interest in carbon capture could lead to sluggish growth in the market for Carbon Capture, Utilization, and Storage (CCUS). There are also high costs associated with the technology, technological challenges in capturing and storing the carbon, and regulatory hurdles.

6 Carbon capture and storage (CCS) - statistics & facts | Statista

7 Carbon Capture And Storage Market Size & Share Report, 2030 (grandviewresearch.com)

8 Facilities - Global CCS Institute (co2re.co)

2 VALUE AND TRADING OF CCS CREDITS

CCS Credits are traded OTC and also on Exchanges such as Changeblock.

The pricing information below is derived from the tables including within and pertains to various carbon capture and storage technologies, as well as biochar and bio-based construction methods. These technologies and methods are used to mitigate climate change by capturing and storing carbon dioxide (CO2). Below are some examples.

Enhanced Weathering

This involves the use of minerals that react with CO2 to form stable carbonates. Examples include greenSand Olivine Enhanced Weathering priced at $124 and Everest Carbon Enhanced Weathering priced between $159 and $299.

Concrete Carbon Avoidance and Mineralization

These technologies involve the use of CO2 in the production of concrete, either by curing concrete with CO2 (avoidance) or by mineralizing CO2 within the concrete. Examples include CarbonBuilt Concrete Carbon Avoidance priced at $160 and CarbonCure Concrete Mineralization priced at $165.

Direct Air Capture

This technology captures CO2 directly from the ambient air. Examples include CarbonCapture Direct Air Capture priced at $500 per ton and AspiraDAC Centralized Direct Air Capture priced at $900 per ton.

Biochar

This involves the conversion of biomass into charcoal through a process called pyrolysis. The charcoal, or biochar, is then used to improve soil fertility and store carbon. Prices vary widely depending on the location and specific project, ranging from 110 € per credit for Douglas County Forest Products Biochar to 535 € per credit for Biochar - ECOERA Millennium 1 in Sweden.

Bio-based Construction

This involves the use of bio-based materials in construction, which can store carbon and reduce emissions compared to conventional construction materials. Examples include Bio-based Construction CORCs from Austria priced at 30 € per credit and LEKO - Wooden elements from Finland priced at 25 € per credit.

Please note that these prices are subject to change and may vary depending on the specific project, location, and market conditions.

Technology	Price	Location	Type
Neustark Concrete Mineralization	$1,000 / t	N/A	Concrete Injection
AspiraDAC Centralized Direct Air Capture	$900 / t	N/A	Centralized Direct Air Capture
CarbonCapture Direct Air Capture	$500 / t	USA	Centralized Direct Air Capture
Carbon Upcycling Technologies Enhanced Building Materials	$300 / t	N/A	Concrete Injection
UNDO Enhanced Weathering	$400 - $500 / t	N/A	Enhanced Weathering
Eion Enhanced Weathering	$300 - $500 / t	N/A	Enhanced Weathering
Carbon Limit CO_2 Capturing Concrete - Removals Only	$240 / t	N/A	Concrete Curing
Carbon Limit CO_2 Capturing Concrete - Avoidance and Removals	$180 / t	N/A	Concrete Curing
CarbonCure Concrete Mineralization	$165 / t	N/A	Concrete Injection
CarbonBuilt Concrete Carbon Avoidance	$160 / t	N/A	Concrete Curing
Everest Carbon Enhanced Weathering	$159 - $299 / t	India	Enhanced Weathering
Bahamas Grey Carbon Concrete Curing - Removals Only	$150 / t	N/A	Concrete Curing
Bahamas Grey Carbon Concrete Curing - Avoidance Only	$150 / t	N/A	Concrete Curing
Neustark Concrete Mineralization	$1,000 / t	N/A	Concrete Injection
CarbonCure Concrete Mineralization	$165 / t	N/A	Concrete Injection
CarbonBuilt Concrete Carbon Avoidance	$160 / t	N/A	Concrete Curing
Carbon Limit CO_2 Capturing Concrete - Avoidance and Removals	$180 / t	N/A	Concrete Curing
Carbon Limit CO_2 Capturing Concrete - Removals Only	$240 / t	N/A	Concrete Curing
Eion Enhanced Weathering	$300 - $500 / t	N/A	Enhanced Weathering
UNDO Enhanced Weathering	$400 - $500 / t	N/A	Enhanced Weathering
Carbon Upcycling Technologies Enhanced Building Materials	$300 / t	N/A	Concrete Injection
CarbonCapture Direct Air Capture	$500 / t	USA	Centralized Direct Air Capture
AspiraDAC Centralized Direct Air Capture	$900 / t	N/A	Centralized Direct Air Capture
Neustark Concrete Mineralization	$1,000 / t	N/A	Concrete Injection
Freres Biochar	110 € / t	USA	Biochar
Douglas County Forest Products Biochar	110 € / t	USA	Biochar
Biochar Carbon Removal by BC Biocarbon	120 € / t	Canada	Biochar
Aperam BioEnergia Biochar - Brazil	140 € / t	Brazil	Biochar
Bussme Biochar - Sweden	150 € / t.	SWEDEN	Biochar
Biochar from Australian nutshell	155 € / t	Australia	Biochar
Biochar - Australia	188 € / t	Australia	Biochar
DarkBlack	250 € / t	UK	Biochar
VGrid Energy Systems, Inc.	250 € / t	USA	Biochar
Biochar - Finland	270 € / t	Finland	Biochar
Biochar in Sweden, Hjelmsäters Egendom	275 € / t	Sweden	Biochar
Biochar from France	320 € / t	France	Biochar
Carbon cycle, Germany. Premium quality biochar	320 € / t	Germany	Biochar
Bella Biochar Corporation	500 € / t	Canada	Biochar

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3 COSTS

The cost structure of CCS can be divided into several key components, each with its own set of factors driving costs and potential trends in cost reduction. The cost of capturing carbon dioxide depends on the specific technology used, the scale of the project, and the type of emission source. There are various methods for capturing CO2, including post-combustion capture, pre-combustion capture, and oxyfuel combustion. Estimates suggest that the capital costs for carbon capture range from $60 to $180 per ton of CO2 captured, while operating costs can range from $20 to $70 per ton of CO2.

The choice of carbon capture technology can significantly impact costs. Advancements in technology and thus increased deployment have the potential to lower costs. Continued investment [find example] in research and development is driving innovation within carbon capture technologies, leading to cost reductions and market uptake of such.

Larger-scale CCS projects can benefit from economies of scale, reducing the cost per ton of CO2 captured. This is due to the fact that early stage projects have smaller overall capacity, engineering prudence smaller existing supply chains for many necessary components.[9] Different sources of CO2 emissions have varying capture challenges. Industrial processes like cement production or steelmaking may require tailored solutions, impacting costs. However, the implementation of CCS projects are increasing, as governments and international organizations are implementing policies and providing financial incentives to accelerate and support CCS deployment and cost reduction.

After capture, carbon dioxide must be transported to storage or utilization sites. The cost of transportation depends on the distance, infrastructure requirements, and the mode of transportation (e.g., pipelines or ships). [10] Transport costs can vary widely, these costs can increase if there are specific transport infrastructure required over long distances. Pipelines are generally considered the most cost-effective option for large-scale CCS projects, while shipping may be more suitable for smaller-scale or remote projects. In order to reduce transportation costs, the industry must develop and expand international and regional pipeline and shipping networks, as well as their design and monitoring systems to optimise efficiency, thus reducing costs. According to the government of Trinidad and Tobago, pipelines are preferred for transporting large amounts of CO2 for distances around 1000km.[11]

The final step in the CCS process is the long-term storage or utilization of captured CO2. Storage costs can vary depending on the storage site and the geology involved. Estimates suggest costs ranging from $5 to $30 per ton of CO2 stored. Utilization costs depend on the specific application and the value created from the use of CO2.
Factors driving the costs of storage include the suitability and accessibility of storage sites. Sites with favourable geology and infrastructure are typically more cost-effective. Advanced geophysical and geological techniques can enhance site selection and reduce exploration and development costs. As the market develops regional clusters of CCS projects and shared infrastructure, this optimises costs and utilization opportunities[12]. Moreover, the type of application utilised, such as enhanced oil recovery or the production of chemicals, also determines the associated costs.

In summary, the cost structure of CCS involves capturing, transporting, and storing or utilizing CO2 emissions. The factors driving costs include technology choices, project scale, emission sources, distance, infrastructure, storage sites, and utilization applications. Ongoing research, policy support, infrastructure development, and technological advancements are expected to contribute to cost reductions in the CCS industry.

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9 https://www.theccc.org.uk/wp-content/uploads/2015/06/P%C3%B6yry-Element-Energy2015-Potential-CCS-Cost-Reduction-Mechanisms-Summary.pdf

10 https://www.iea.org/commentaries/is-carbon-capture-too-expensive

11 https://www.energy.gov.tt/our-business/carbon-capture-utilization-and-storage-ccus/

12https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/198823/ccsa_ctrf_interim_report.pdf

4 FUTURE TRENDS AND PROJECTIONS

The Carbon Capture and Storage (CCS) market is poised for significant growth in the coming years. As of 2022, the global CCS market size was valued at USD 3.28 billion and is expected to grow at a compound annual growth rate (CAGR) of 6.2% from 2023 to 2030,[13] reaching an estimated market size of USD 5.61 billion by 2030.

There are several factors driving this growth including technological advancements leading to increased global adoption of CCS technologies. Governments are encouraging the implementation of these technologies through pilot projects across various industries due to their potential to significantly reduce CO2 emissions.

One key trend is the expansion of offshore oil & gas exploration and production activities, which is expected to result in a surge in the use of gas injection Enhanced Oil Recovery (EOR) techniques. Carbon dioxide is used in the extraction of crude oil, and the growing need for CO2 for EOR activities in the oil & gas industry is likely to drive market growth.

In addition, the U.S. is anticipated to dominate the global industry due to the presence of several high-capacity CCS plants and the increasing usage of CO2 in EOR techniques. Large-scale development projects of carbon capture, utilization, and storage are predicted to increase rapidly in contrast to other regions, contributing to North America's market share in the CCS sector.

The future of the CCS market looks promising, with technological advancements and supportive government policies playing a crucial role in shaping its trajectory.

[13] https://www.grandviewresearch.com/industry-analysis/carbon-capture-storage-ccs-market

APPENDIX B – REGULATORY ENV.

The regulatory landscape for the Carbon Capture and Storage (CCS) market is complex and varies significantly across different regions.

In the United States, the 45Q tax credit, which provides a financial incentive for each tonne of CO2 captured, has been a significant driver for the development of CCS projects. The credit was recently extended and increased, providing further support for the industry. However, regulatory challenges persist, particularly around the long-term liability for stored CO2 and the permitting process for storage sites.

In Europe, the EU Emissions Trading System (ETS) provides a financial incentive for CCS by placing a price on carbon emissions. However, the price has historically been too low to drive significant CCS deployment. The EU is also supporting CCS through its Innovation Fund, which aims to help bring innovative low-carbon technologies to the market.

In China, the government has identified CCS as a key technology for achieving its climate goals and is supporting its development through various policies and initiatives. However, there is currently no nationwide carbon pricing system, which could provide a significant boost to the industry.
In addition to these national and regional policies, there are also international regulations to consider, particularly around the transboundary movement of CO2 for offshore storage.

While these policies and incentives are helping to drive the development and deployment of CCS, there are also significant regulatory challenges and hurdles. These include the long-term liability for stored CO2, the lack of a clear regulatory framework in many countries, and public opposition to CCS in some areas. Furthermore, the cost of CCS remains high, and without a significant price on carbon or other financial incentives, it may be difficult for CCS to compete with other low-carbon technologies.

APPENDIX A – (SOME) KEY PLAYERS

The Carbon Capture and Storage (CCS) market is characterized by the presence of several key players, both established companies and start-ups, that are contributing significantly to the market's growth.

Here are some of the main companies/organizations in the CCS market:

Shell Cansolv: A subsidiary of Shell Global, Shell Cansolv is a leading provider of gas absorption solutions, including CO2 capture from post-combustion flue gases. They have been involved in several key CCS projects, including the Boundary Dam project in Canada, which is the world's first power station to successfully use CCS[14].

Fluor Corporation: An American multinational engineering and construction firm, Fluor is a major player in the CCS market. They have developed the Econamine FG Plus technology, which is used to capture CO2 from flue gases[15].

Equinor: A Norwegian multinational energy company, Equinor is involved in several CCS projects, including the Sleipner field project in the North Sea, where they have been storing CO2 since 1996[16].

Chevron: This American multinational energy corporation is involved in various aspects of the CCS market. They are part of the Gorgon CCS project in Australia, which is one of the world's largest CCS projects in operation having captured more than 7 million tonnes of Co2 to date[17].

Aker Solutions: A Norwegian engineering company, Aker Solutions provides technology and solutions for CCS. They have developed a carbon capture technology known as "Just Catch," which is a cost-effective solution for capturing CO2[18].

Carbon Clean Solutions: A global leader in low-cost carbon dioxide capture technology, Carbon Clean Solutions has significant operations in Europe, the USA, and India. Their technology is used in over 10 commercial-scale projects globally.

Climeworks: A Swiss startup, Climeworks is disrupting the CCS market with its Direct Air Capture technology. They capture CO2 directly from the air and sell it to various industries[19].

Global Thermostat: Another startup disrupting the CCS market, Global Thermostat uses a unique technology to capture CO2 directly from the air or flue gas, making it available for commercial use[20].

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14 Shell CANSOLV® CO_2 Capture System | Shell Global)

15 Fluor Carbon Capture Process Technologies: CO2 Recovery

16 Hi – we're Equinor

17 Chevron's global CCUS efforts help lower carbon intensity — Chevron

18 Just Catch™ – Aker Carbon Capture

19 Fight climate change by removing excess CO_2 from the atmosphere (climeworks.com)

20 Global Thermostat + Carbon Capture Research | Energy Factor (exxonmobil.com)

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These companies have a significant market share in the global CCS market, and their innovative technologies and projects are contributing to the growth and development of the market.