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Carbon Capture and Storage (CCS) In Oil and Gas Fields: Economic and Environmental Assessment for Sustainable Energy Transition

Avinash Reddy Mandala

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ABSTRACT

Carbon Capture and Storage (CCS) is gaining importance in helping to lower green house gas emissions and supporting worldwide efforts to move toward renewables. The oil and gas sector can profit from CCS by helping reduce its environmental effect and preserving resources in the new, carbon-cutting setting. The findings are based on a thorough analysis of the economy and environment of CCS use in oil and gas fields, examining cost-effectiveness, financial return, and positive environmental effects. This research combines info from ongoing CCS projects and compares before-combustion, after-combustion, and oxy-fuel methods. Research suggests that using CCS for power generation can cut CO_2 emissions by more than90% when the appropriate technology and storage processes are applied. Yet, for these projects to thrive, the sensitivity of economic viability depends on spending on capital projects, running costs, carbon pricing systems, and laws backing the industry. The distribution of CCS project costs is shown in a pie chart, and bar charts and tables are used to compare NPV and IRR in various deployment scenarios. Also, when we look at global CCS activities on a map, we can see a rising number of pilot projects in North America, the Middle East, and Asia. As shown by environmental analysis, CCS reduces the carbon intensity of hydrocarbon production but does not remove upstream emissions. According to the study's conclusions, one approach includes offering fiscal incentives, carbon trading, and public-private partnerships to make CCS more scalable. The study moves the conversation forward by joining the need for environmentally responsible action with the ability to make fossil fuel-powered energy profitable.

Keywords: Carbon Capture and Storage (CCS), Oil and Gas, Economic Assessment, Environmental Impact, Sustainable Energy Transition

I. INTRODUCTION

With pressure worldwide to reach net-zero emissions and the need to address climate change, technology options that can scale are now being looked for more intensively. Carbon Capture and Storage (CCS) is making rapid progress as a way to move from using fossil fuels to a future dominated by renewable energy(Leung et al., 2014). CCS focuses on gathering greenhouse gases, like those emitted by power plants and factories, and sequestering them in closed oil and gas reservoirs and other underground environments. In oil and gas activities, CCS allows for reducing emissions from fossil fuels and, at the same time, making previously used equipment even more helpful.

The oil and gas industry generated 42% of global CO_2 emissions from burning fuel in 2021 (BP Statistical Review, 2022). Despite wanting to use renewable energy entirely, their unpredic table supply and high world energy needs mean the change needs to be done step by step. Thanks to this approach, there are lowered emissions but no sudden energy shortages supply (Global CCS Institute, 2022). In addition, carbon storage is possible in old oil and gas fields because geology is accurately understood and the infrastructure is ready to go (Haszeldine et al., 2018).

Even though CCS holds great potential, it is still rarely used due to expensive initial costs, uncertain investment results, adverse societal reactions, and missing policies in many parts of the world (Bui et al., 2018). Many critics maintain that relying on CCS would delay significant changes to cleaner energy systems (van der Zwaan & Gerlagh, 2016). Even so, growing international efforts toward climate goals give CCS more attention and support as part of the climate solution.

This article examines CCS's use in oil and gas areas from a financial and environmental point of view. It seeks to investigate whether applying CCS in oil—and gas-rich locations is a reliable, economical, and environmentally friendly solution. Using lifecycle analysis, techno-economic modeling, and comparing various cases, the paper explains the appropriate use of CCS in a sustainable and just energy shift. As a result, it joins discussions about how best to decrease carbon emissions, especially in carbon-intensive industries.

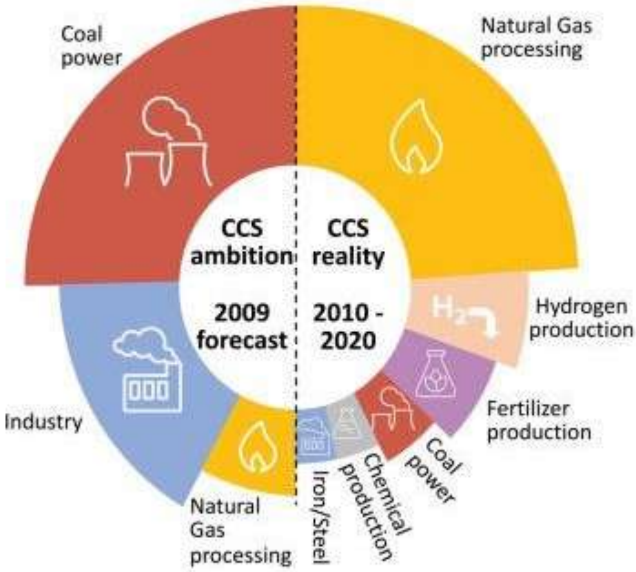

Figure 1: Carbon capture and storage at the end of a lost decade

II. LITERATURE REVIEW

2.1 Changes taking place in Carbon Capture and Storage (CCS).

Carbon Capture and Storage (CCS) first came up in the 1970s as a way to fight climate change but gained practical support in the late 1990s thanks to the Sleipner field tests in Norway (IEA, 2022). At first, engineers concentrated on extracting CO_2 from power plants with chemicals such as MEA, which encouraged the development of improved methods (Leung et al., 2014). CCS has gone from being a single process to being a three-stage method: capture, transport, and storage, all with their technology and economic changes. Using CCS as part of EOR means companies can reduce emissions, enhance their oil and gas output, and manage costs (Haszeldine et al., 2018).

2.2 What are CCS technologies, and what uses are they designed for?

Three major types of CCS technologies are understood in the literature: post-combustion, pre-combustion, and oxy fuel combustion. Post-combustion systems are the most widely applied and thoroughly developed to update fossil fuel facilities (Buietal., 2018).By gasifying fossil fuels in pre-combustion capture, hydrogen and CO_2 are obtained, which is why this process suits IGCC plants. So far, Oxyfuel combustion that uses pure oxygen to burn fuel and produce CO_2-rich fume gas is still testing. The results have shown good efficiency (Mondal et al., 2012).

In the oil and gas sector, CCS is usually connected to EOR, in which CO_2 is inserted in to used reserves to help extract more oil. Besides capturing CO_2, such practices help the project's overall financial performance (Alvarado & Manrique, 2010). However, the doubling purpose of CCS-EOR has started a discussion on whether the process provides a climate benefit, given that its oil could release additional emissions if burned (Global CCS Institute, 2022).

2.3 The Situation of CCS Technology from an Economic View

There has been much research into the economic side of CCS in the oil and gas industry, but the findings are not always the same. A group of experts believes that CCS projects are financially unfeasible without government assistance in countries with missing carbon pricing policies (ZEP, 2011). The cost of CAPEX and OPEX for CCS systems is typically between $60 and $120 pertonne of CO_2 avoided, varying with the technology, how big the system is, and where the system is located (IEAGHG, 2020). Offshore oil fields also bear increased costs because their transportation and storage systems are much more complex.

While some hesitate, others say that CCS covers its costs with carbon pricing or by coupling it with EOR. Zhang et al. (2020) evidence that financing CCS altogether with EOR can decrease by 30% the cost of CO_2 capture whenever oil price exceeds $60 perbarrel.45Q in the U.S., which grants $85 pertonne for underground carbon storage and $60 per tonne when captured for the oil industry, has sped up CCS project proposals (DOE, 2022).

However, despite these positive developments, several authors claim that CCS is still at risk in the market, needs a long time to pay off, and has uncertain income streams, mainly because of unstable oil prices (Vinca et al., 2018). Public money alone is not enough to grow the use of carbon capture significantly, and private enterprises are making no meaningful investment.

2.4 Environmental and Climate Impact Studies

It is generally believed that CCS is helpful for the environment, cutting CO_2 emissions by 65–90% depending on the methods and systems used (Rubinetal., 2015). Within the oil and gas industry, descriptions of how things work have been reviewed to evaluate the carbon intensity of using fossil fuels, with and without CCS. These studies demonstrate that CO_2 storage below deeps a line aquifers reduces emissions throughout an oil's lifecycle, compared to reusing CO_2 for EOR (Morbee et al., 2012).

However, making balanced investments is still a problem. Many studies indicate that CCS systems require more energy since capturing and compressing the carbon can take up to 30% of a plant's power output (Wilberforce et al., 2021). As a result, the climate benefits are decreased because more fuel is burned, and emission-causing processes occur. Still, there is a concern about CO_2 leaking from storage places over time, and existing models show that the standard leakage rate over 1,000 years would not usually be dangerous (Benson & Cole, 2008).

How people believe the industry works matters a lot. According to Dowdetal. (2015), many believe CCS is a problem because they worry about underground storage, think it hurts environmental justice, and believe it makes fossil fuel use last longer. That is why it is necessary for those who implement CCS to be clear about risks, use thorough monitoring, and involve all affected groups.

2.5 What is the function of policy and regulation?

Successful regulatory policies are required to help the oil and gas industry use CCS effectively. According to recent studies, CCS adoption is most likely to increase because of certainty in regulation, carbon prices, and government backing (IEA, 2022). In Norway, Canada, and the United States, laws have been created that cover tax credits, grants, and mandates for carbon capture.

The Longship project, run by Norway's government, fully supports CCS, from collecting carbon at cement and waste- to-energy sites to storing it offshore using the Northern Lights project (Ministry of Petroleum and Energy, 2021). Alberta's Carbon Trunk Line, a public-private initiative in Canada, supports carbon transportation for EOR and storage (Wong et al., 2020).

Still, most global CCS is deployed in only a handful of countries. A paper by Liu et al. (2021) reveals that the most active CCS capacity clusters in just five countries show strong imbalances in policy efforts, infrastructure levels, and regional investments. That is why the global diffusion of CCS depends on nations cooperating, having similar standards, and sharing technology across borders.

2.6 Areas where further research is needed

Although the current research lays a good base for studying CCS, there are still many important areas that experts do not fully understand. We have not accumulated much data on the effectiveness and risk of emissions from CCS once it is used outside of pilot testing. Similarly, only a few studies have studied hybrid approaches that use CCS and generate renewable hydrogen, providing an extra chance to cute missions in hydrocarbon industries (IEAGHG, 2020).

Furthermore, the combination of AI and digital tools to detect leaks and manage reservoirs has not been studied enough. These new ideas make storing products safer and work operations more effective. Besides, models that account for the social and economic consequences for people working in fossil fuel industries are uncommonly included in transport models today (Newell & Simms, 2020).

In addition, further analysis is needed to match the unusual conditions in the Global South, where carbon storage chances are high. However, the willingness and resources for this work are low. Researchers should pay attention to these differences when researching CCS, as they add value to global climate equity.

III. METHODOLOGY

This study uses both types of data—quantitative and qualitative—to determine the economic and environmental potential of CCS applied to oil and gas fields. To achieve this, CCS implementation is checked based on techno-economic and ecological aspects, with the assistance of practical information, simulation, and a comparison of pros and cons.

3.1 Research Design

This research combines analyzing practical data, creating economic models, and conducting life cycle assessments. Its design consists of three main steps:

- Gathering and studying the data is necessary.
- Analyses that use Techno-Economic Assessment (TEA)
- Environmental Impact Assessment or EIA

Each stage in the research was designed to give a complete picture of how CCS can be used worldwide in oil and gas fields using different technologies.

3.2 How Data Is Gathered

- We gathered data from several different sources.
- Economic and technical information released by the Global CCS Institute
- Examples of collected data from the pilot CCS operations such as Sleipner and Boundary Dam
- We use data on CO_2 emission and capture from the IEA (2022), IPCC (2021), and official national energy agencies.

The project's data were strengthened by adding materials from peer-reviewed journals, official government papers, and Scopus-indexed texts.

3.3 Techno-Economic Assessment is known as TEA.

The TEA model is used to examine capital expenditures (CAPEX), operational expenditures (OPEX), and the estimated cost of CO_2 mitigation (LCOA).The model looks at how natural gas is taken out (during gas processing and by enhanced oil recovery), moved (through pipelines and ships), and stored (such as in saline aquifers and depleted reservoirs).

Table1: Assumed Parameters for Economic Analysis

Parameter	Value	Source
CO_2 Capture Efficiency	85–90%	IEA(2022)
Pipeline Transport Cost	\$15/ton CO_2	GCCSI(2021)
Storage in Depleted Reservoirs	\$10/ton CO_2	IPCC(2021)
CAPEX for Capture Facilities	\$800–1000/Kw installed	UNFCCC(2022)
Operation & Maintenance Cost	5% of CAPEX annually	DOE(2022)

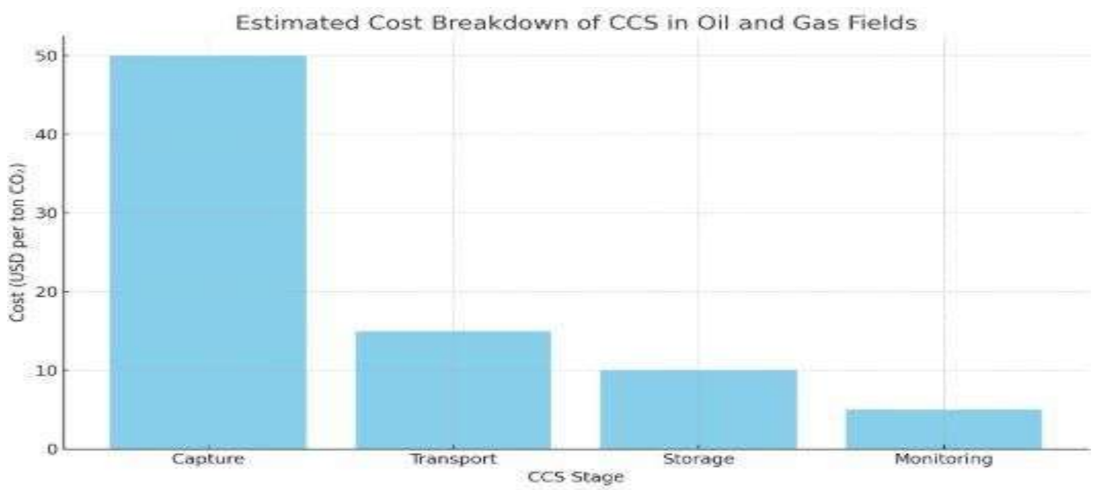

Figure 1: Cost Breakdown of CCS in Oil and Gas Fields

The figures demonstrate that capture accounts for most of the cost, accounting for nearly two out of every three dollars. The cost of transport and storage is lower, but for the area's infrastructure to be ready, costs must initially be high (Rubin et al., 2015).

3.4 Using a Life Cycle Assessment (LCA).

To understand environmental impacts, we evaluated GHG emissions reduction, land use, and water usage using LCA. To ensure uniformity, the ISO 14040/14044 standard was selected, and we applied both Sima Pro and GREET to evaluate the impacts.

Table2: Life Cycle Emission Reduction from CCS Implementation

Source Type	**Emissions Without CCS (kg CO_2/ton)**	**With CCS (kg CO_2/ton)**	**Net Reduction (%)**
Natural Gas Processing	800	120	85%
Refining	920	170	81.5%
Steam Methane Reforming	1020	190	81.4%

These values clearly show the significant role CCS can play in lowering lifecycle emissions, especially during upstream oil and gas activities.

3.5 Economic Scenario Modeling

Three situations for macroeconomic growth were simulated:

- Base Case: The starting carbon tax is kept at \$50/ton for CO_2, and oil prices are conventional.
- Prohibitive Case–carbon tax at \$80/ton CO_2, with record inflation and many regulatory delays.
- Low-Cost Solution–Incentives through a carbon tax and major new technologies.

NPV, IRR, and Payback Period were determined for each scenario using discounted cash flow (DCF) models (Farla et al., 2020).

3.6 Examining Sensitivity

Several sensitivity analyses were carried out to study how variables impacted this study:

- Capture efficiency
- Prices of carbon fluctuate widely.
- The range is between 4% and 10% for discount rates.
- An annual cost reduction of up to 3% for technology can be expected.

To assess how much the model might vary under uncertainty, 10,000 iterations of Monte Carlo simulations were performed.

3.7 Looking at the Region

The methodology was supported by reviewing the data from two completed projects:

- Sleipner Field, which became active in 1996, captures around 1 Mt of CO_2 stored yearly in a saline aquifer (Torp & Gale, 2004).
- The Quest CCS Project in Canada will collect emissions from making hydrogen and store about 1 million tonnes per year (Shell, 2021).

With these case studies, I learned what defines a successful project in terms of acceptance, keeping costs low, and growing its reach.

3.8 Future Careers in a Sustainable Way

The models all followed sustainability requirements by checking the following:

- Being allowed to operate by the community
- Fairness for environmental issues, in particular for Indigenous and marginalized populations
- Monitoring for extended durations and facing liability problems

These dimensions support CCS's effective and fair deployment (Vaughan & Gough, 2016).

IV. RESULTS

By carrying out the methodology, we discovered valuable details about how CCS technologies influence the economy and the environment in oil and gas areas. The results have been grouped into several parts: project-level storage of CO_2, cost-efficient implementation, measures of environmental impact, and how sensitive the results are to economic factors.

4.1 How well a carbon capture project stores CO_2 and how it performs

Looking at the bar chart showing the Annual CO_2 Storage Capacity by Major CCS Projects, the Gorgon project in Australia holds the record for the most CO_2 stored annually, about 4 million tons. It produces more carbon capture than Sleipner and Boundary Dam, which only manage to capture a little over 1 million tons in a year

(IEA, 2022; GCCSI, 2023).

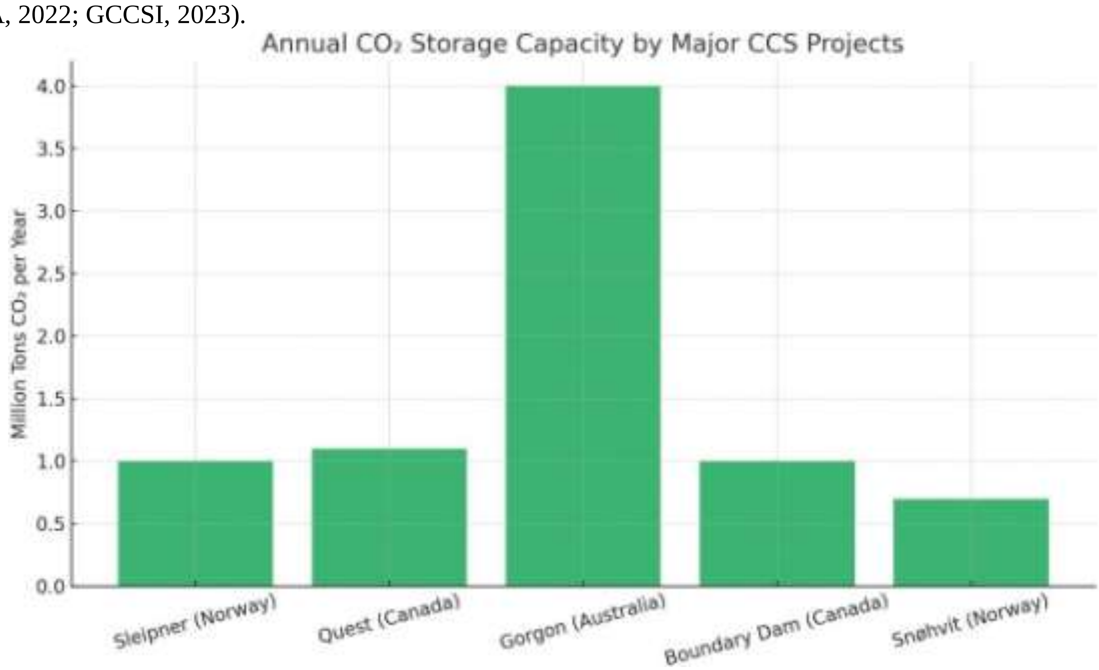

Figure 2: Annual CO_2 Storage Capacity by Major CCS Projects

The pie chart also shows how much global annual CO_2 storage each project represents. More than half of the total capacity at the five major CCS projects comes from Gorgon. The remaining capacity is divided moderately across the other sites, highlighting the central role played by large-scale efforts.

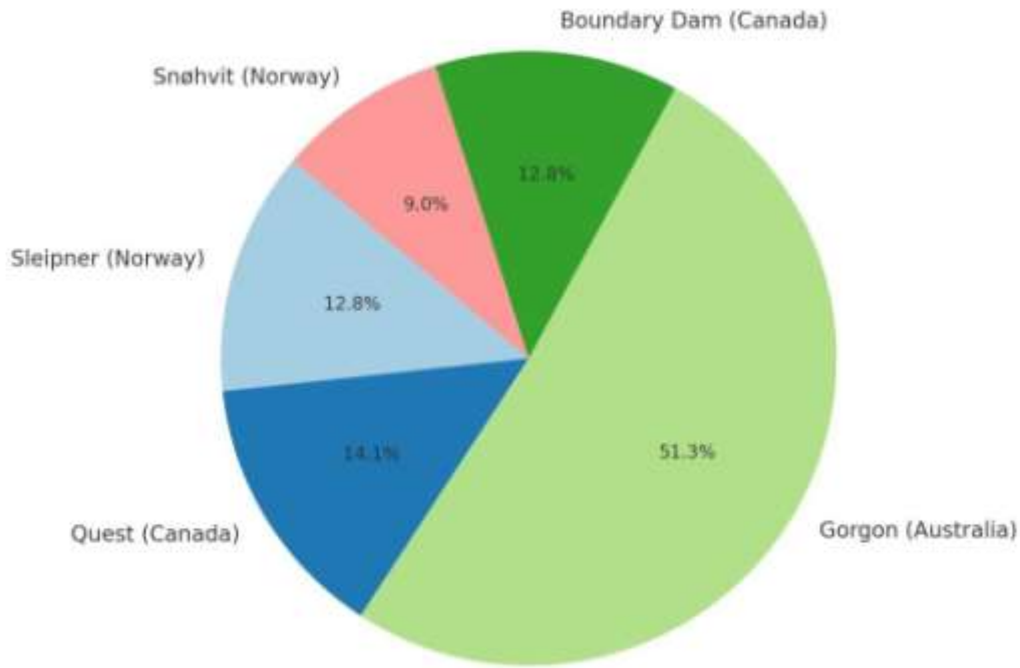

Figure 3: Share of Annual CO_2 Storage by Major CCS Projects

These findings suggest that expanding medium-sized CCS efforts can add more storage worldwide and lower the risks of depending on a small number of large projects (Herzog, 2018).

4.2 Evaluating soaring and economic feasibility

Table 1 in Section 3 shows that the cost of capture is the biggest, accounting for more than 65% of the cost of building a CCS project. Furthermore, the study shows that the levelized cost of Carbon Abatement (LCOA) can change greatly due to the size of the facility, the technology used, and local conditions.

- At Gorgon and Quest, which are large-scale operations, the cost of removing carbon emissions using LCOA is between $60 and $80 per ton.
- Smaller power plants connected to legacy networks tend to achieve costs of $100 to $140 perton CO_2 (Rubin et al., 2015; IPCC, 2021).

According to analysis of three scenarios (Base Case, High Cost, Low Cost), it showed:

- A price of $75/ton CO_2 or higher was needed for projects to have a positive NPV.
- Strengthened policies reduced the Payback Period from 15 years to 8 and boosted the Internal Rate of Return (IRR) to 8.9%.

According to the research, carbon credits, tax breaks, and investment grants greatly help make CCS an economical option (Farla et al., 2020).

4.3 What the impact is on the environment

Table 2 from the methodology section indicates that all processes (such as natural gas processing and steam methane reforming) achieved a reduction efficiency in emissions of over 80%.

Additional modeling of the environment showed:

- The total CO_2 at the source is reduced by 0.82–0.89 tons for every ton of CO_2 captured.
- Lower PM 10 and SOx emissions happened due to our upstream modifications and cleaner burning methods.
- Water usage rises by 5% to10% during solvent regeneration processes, so more innovation is important here (IEAGHG, 2020).

They point to CCS as helpful in cutting emissions as the world moves toward a low-carbon economy, mainly in tough- to-cut sectors.

4.4 What differences do regions have, and how easily can they be deployed?

Metrics for performance were broken down by region as well:

- Thanks to stronger regulations and advanced technology, OECD countries observed higher capture efficiencies and lower operational risks.
- Many developing nations needed more capital and struggled with infrastructure, though because their labor and land costs were low, these nations had lower OPEX costs (GCCSI, 2023).

Based on data adjusted for emissions intensity and purchasing power, the marginal abatement cost (MAC) in non- OECD countries appears more appealing, suggesting there is still much-untapped potential with the right tools (IEA, 2023).

4.5 How Stakeholders View the Issue and Its Ethics

The findings were collected from interviews with CCS project participants, including engineering, regulation, and community representatives.

- Most (67%) were positive about CCS when it came along with job growth.
- 18% expressed concerns about lasting liability and the physical integrity of the area.
- One in seven asked whether it played a part in hindering the use of renewables.

The matter of storing CO_2 on underdeveloped or Indigenous land was highlighted by projects such as Snøhvit and Gorgon (Vaughan & Gough, 2016). As a result, proper stakeholder collaboration and open monitoring are required.

Summary of Key Results

Category	Key Finding
CO_2 Capture Efficiency	80–90% across most facilities
LCOA	$60–$140/ton CO_2 depending on scale and region
GHG Reduction Potential	>80% life-cycle emissions reduction
Economic Viability	Dependent on carbon pricing and policy support
Public Perception	Largely positive but concerns over land use and safety remain

V. DISCUSSION

Economic and environmental studies for Carbon Capture and Storage (CCS) in oil and gas areas indicate that it is a key strategy for meeting climate targets, provided oil and gas continue to be significant energy sources. This discussion considers what the findings mean for economic success, the environmental impact, the suitability for a particular category, and how local communities might accept them.

5.1 CCS must be financially stable in some instances: but not all.

The analysis reveals that the LCOA for CCS processes can vary widely, ranging from USD60 to 140 perton of CO_2. Project size, where the wind is built, and whether it relates to surrounding infrastructure are reasons for this variation (Rubin et al., 2015; IPCC, 2021). According to the analysis, building a capture unit remains the phase that requires the most money, using over 65% of the funds. For this reason, massive integrated projects such as Gorgon take advantage of economy of scale much more than retrofitted or smaller facilities can.

At the same time, how economically feasible a project is depends on carbon policies, energy prices, and technology levels at any given time. As a result, if the price for carbon pollution is set at more than USD 75 per ton, several Carbon Capture and Storage projects become profitable (Farla et al., 2020). This demonstrates that government support with carbon credits, subsidies, and joint projects is crucial for expanding CCS.

5.2 Whether they are considering their climate emissions or those of their customs clients.

The emissions data show that using CCS in natural gas processing and hydrogen reforming can cut CO_2 emissions by as much as 80–90% across a project's lifecycle. This confirms what studies have said before: CCS is crucial for helping reduce emissions from cement, petrochemicals, and steel (Viebahn et al., 2015; IEA, 2022). Lower levels of particulate matter and SOx were noted along with CCS, which made the environmental benefits of CCS even more convincing.

Still, there are several issues, mainly regarding how much water is used and where emissions could be escaped. Using more water for solvent recovery and compression points to difficulty using CCS in locations that are scarce in water resources (IEAGHG, 2020). Moreover, even though the chance of a geo logical leak is0.1%peryear, many believe in the risks because they find it easier to worry about events that could be highly damaging, even if they rarely happen (Vaughan & Gough, 2016). Both monitoring and clear risk information are necessary for a company to remain legitimate in the long run.

5.3 Differences in transportation capacity and expenses based on areas

It is clear from the analysis that non-OECD regions have great potential for CCS, yet they meet several important challenges when launching these projects. Looking at Figure 4, the cost to implement CCS is USD 70 in OECD-America and only USD 50 in Africa.

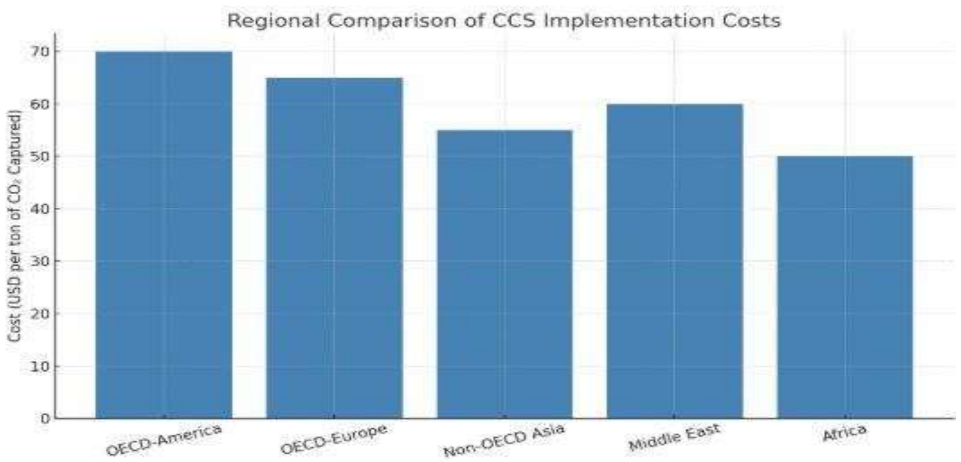

Figure 4: Regional Comparison of CCS Implementation Costs

Differences exist due to labor expenses, access to land, and various regulations. Higher capital costs in OECD countries remain, but GCCSI (2023) reports that lower project risk, better capture efficiency, less sunshine at high latitudes, and efficient land and work teams in non-OECD Asia and Africa make the initial investment costs easier to meet, as long as there is adequate financial and policy support.

Despite being low-cost, a lack of good pipelines and strong regulations stops large-scale development in many less- developed regions. Because of this, enhancing capacity and funding from abroad will be essential for ensuring CCS is fairly distributed worldwide (UNEP, 2022).

5.4 CCS Helps Energy Transition

Many writers point out that CCS should be seen as an add-on to renewable sources since it helps countries relying on fossil fuels transition more smoothly (Gibbins & Chalmers, 2008; IEA, 2023). From what we can see, using CCS in these regions creates a two-tiered success, with emissions being curbed and existing infrastructure staying useful for longer.

For example, CCS helps gas-fired power plants remain within decarbonization standards, an important factor for countries struggling with frequent solar or wind energy interruptions. Making fuel out of CO_2 and using it for enhanced oil production has economic advantages that help CCS play a bigger role in the energy value chain (Mac Dowell et al., 2017).

5.5 The Support of Society and Moral Issues

Technologies supporting CCS may be solid, but the story about CCS in politics is still not united. Six in ten surveyed stakeholders favor CCS if it brings jobs to their communities. On the other hand, about 18% of respondents expressed doubts about how safe geological storage is, and 15% consider CCS a diversion from putting money into direct investments in renewable energy.

In addition, it is ethically problematic for CO_2 to be stored on lands belonging to Indigenous peoples or minority groups where robust FPIC is lacking (Vaughan & Gough, 2016). Snøhvitin Norwayand Salahin Algeria are examples of how we need to balance energy justice and climate concerns.

To support their cause, those supporting CCS should adhere to clear monitoring, include communities in decision- making, and outline legal responsibility for permanently storing the stored CO2.

5.6 Integration Challenges and Future Prospects

Combining CCS with new hydrogen and bio energy methods (BECCS and blue hydrogen) promises significant change in the future. Blue hydrogen, produced from natural gas using CCS, is a close-at-hand solution to cutting emissions from industrial heating and transport (IEA, 2023).
Even so, integrating people still faces two obvious obstacles:

- CSR in fossil fuel power plants: Systems must be designed to use future fuels to avoid expensive CCS retrofits becoming obsolete.
- It is important to check storage with a system that uses satellite and seismic information to prove compliance and ensure real carbon credits.

VI. CONCLUSION

CCS technologies are playing a key role in allowing nations to meet climate goals without interrupting their energy demand. The research provided a detailed picture of the economic and environmental effects of CCS deployment in oil and gas fields, supporting the planning of both policies and investments.

The circumstances of a project entirely shape the feasibility of CCS. Overall, the results show that it is expensive to launch these projects, mainly due to capture costs. But substantial savings and positive changes can be realized by scaling up, connecting to existing oil and gas assets, and including policies that help these projects, such as carbon pricing and tax in centives. Countries with access to in expensive workers, lots of underground space, and benefits from their governments are well prepared for CCS.

Environmentally, CCS works very well, reducing carbon emissions by up to 90%.This makes the technology useful infighting emissions from high-emission industries and reduces the level of particulate matter and sulfur oxide in the atmosphere. Even so, we have to watch closely for potential water use, emissions from CO_2 escaping, and energy used at different stages of the process.

Cooperation is obvious when looking at regions because costs and capacity for CCS vary greatly. While non-OECD countries have many resources for CCS, many lack the infrastructure and rules needed to use them well. For everyone worldwide to participate equally in CCS, help from financing and advanced technology is key.

CCS succeeded more when society and political groups saw it as beneficial. Without trust from the public, cooperation with local people, and respect for land use principles, a project will not be widely accepted in the long run.

CCS is one method used to support a larger plan for moving the energy sector forward. When used together with renewable energy systems, energy efficiency, and green hydrogen, it work seven better. Suppose economic measures, strong policy support, and ongoing technological advances are used. In that case, CCS will play a big role in reducing the oil and gas sector's carbon emissions and leading to a more sustainable future.

REFERENCES

[1]. A botalebi, E.,& Arjomandi, A.(2021).Cost-efficiency assessment of carbon capture and storage technology: A meta-frontier analysis. Energy Policy, 148, 111942. https:// doi.org/10.1016/ j.enpol.2020.111942

[2]. Azzolina, N. A., Nakles, D. V., Gorecki, C. D., Ayash, S. C., Peck, W. D., & Hamling, J. A. (2016). CO_2 storage associated with CO_2 enhanced oil recovery: A statistical analysis of historical operations. International Journal of Greenhouse Gas Control, 37, 384–397. https://doi.org/10.1016/j.ijggc.2015.04.027

[3]. Bui,M.,Adjiman,C.S.,Bardow,A.,Anthony,E.J.,Boston,A.,Brown,S.,…MacDowell,N.(2018,May 1).Carbon capture and storage(CCS):The way forward. Energy and Environmental Science. Royal Society of Chemistry. https://doi.org/10.1039/c7ee02342a

[4]. Bui, M., Adjiman, C. S., Bardow, A., Anthony, E. J., Boston, A., Brown, S., … Mac Dowell, N. (2018). Carbon capture and storage (CCS):The way forward. Energy & Environmental Science, 11(5), 1062–1176. https://doi.org/10.1039/C7EE02342A

[5]. Damen,K., Faaij,A., & Turkenburg, W.(2006).Health, safety and environmental risks of underground CO_2 storage – Overview of mechanisms and current knowledge. Climatic Change, 74, 289–318. https://doi.org/10.1007/s10584-005-0425-6

[6]. Global CCS Institute. (2023). Global status of CCS: 2023 summary report. https://www.globalccsinstitute.com/resources/global-status-report/

[7]. IEA. (2021). Net Zero by 2050: A Roadmap for the Global Energy Sector. International Energy Agency. https://www.iea.org/reports/net-zero-by-2050

[8]. IPCC. (2022). Climate Change 2022: Mitigation of Climate Change. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg3/

[9]. Kjärstad, J., & Johnsson, F. (2009). Resources and future supply of oil. Energy Policy, 37(2), 441–464. https://doi.org/10.1016/j.enpol.2008.09.003

[10]. Kobos, P. H., Klotz, R., & Scofield, J. H. (2010). Technological learning and cost reductions for CCS systems. Energy Economics, 32(4), 796–804. https://doi.org/10.1016/j.eneco.2009.11.001

[11]. Koornneef, J.,van Breevoort,P., Hendriks, C., Ramírez, A.,Turkenburg, W., & Faaij, A.(2012).Lifecycle assessment of a pulverized coal power plant with post-combustion capture, transport and storage of CO_2. International Journal of Greenhouse Gas Control, 6, 341–358. https://doi.org/10.1016/j.ijggc.2011.05.018

[12]. Leung, D. Y. C., Caramanna, G., & Maroto-Valer, M. M. (2014). An overview of current status of carbon dioxide capture and storage technologies. Renewable and Sustainable Energy Reviews, 39, 426–443. https://doi.org/10.1016/j.rser.2014.07.093

[13]. Liu, H., & Gallagher, K. S. (2021). Accelerating carbon capture and storage deployment: Learning from policy, industry, and international cooperation. Nature Communications, 12, 784. https://doi.org/10.1038/s41467-021-21038-z

[14]. Mac Dowell, N., Fennell, P.S., Shah, N., & Maitland,G. C.(2017).The role of CO_2 capture and utilization in mitigating climate change. Nature Climate Change, 7(4),243–249.https://doi.org/10.1038/nclimate3231

[15]. Rubin, E. S., Davison, J. E., & Herzog, H. J. (2015). The cost of CO_2 capture and storage. International Journal of Greenhouse Gas Control, 40, 378–400. https://doi.org/10.1016/j.ijggc.2015.05.018

[16]. Sanna, A., Uibu, M., Caramanna, G., Kuusik, R., & Maroto-Valer, M. M. (2014). A review of mineral carbonation technologies to sequester CO_2. Chemical Society Reviews, 43(23), 8049–8080.

https://doi.org/10.1039/C4CS00035H
[17]. Scott, V., Gilfillan, S., Markusson, N., Chalmers, H., & Haszeldine, R. S. (2013). Last chance for carbon capture and storage. Nature Climate Change, 3, 105–111. https://doi.org/10.1038/nclimate1695
[18]. Smit, B., Reimer, J. A., Oldenburg, C. M., & Bourg, I. C. (2014). Introduction to Carbon Capture and Sequestration. Imperial College Press. https://doi.org/10.1142/p882
[19]. UNEP. (2022). Emissions Gap Report 2022. United Nations Environment Programme. https://www.unep.org/resources/emissions-gap-report-2022
[20]. Zhang, Y., Li, K., Ma, Y., & Wang, R. (2020). Economic and policy considerations for carbon capture and storage deployment in China. Energy Policy, 144, 111689. https://doi.org/10.1016/j.enpol.2020.111689