Columbia University

School of International and Public Affairs (SIPA)

Capstone Workshop

How Can Carbon Sinks Be Used to Offset Emissions from Equinor's Production and Products?

Final Report for Equinor

Contents

Key Messages

- Equinor will likely need to purchase carbon credits to offset residual emissions.
- Equinor’s carbon offset strategy should focus on removing carbon dioxide from the atmosphere rather than avoiding emissions from elsewhere.
- Companies will continue announcing climate targets, increasing the demand for carbon offsets.
- Scrutiny towards companies that make false or inaccurate claims regarding their carbon footprint will increase
- Scrutiny towards low-quality offsets will increase, as well as criticism towards organizations that verify and sell these offsets.
- The best carbon offset solution in the long-term is Direct Air Capture with Carbon Storage (DACCS), but the current supply is low and scaling the technology will require large amounts of capital.
- Equinor will need to purchase carbon offsets from various solutions to meet its targets.
- Equinor should implement a portfolio approach to mitigate the risks associated with each of the solutions.
- Ahead of 2030, Equinor should focus on alleviating the constraints to implement its 2030 portfolio, mainly advancing DACCS, promoting high-quality NBS projects, and leveraging its influence to increase accountability in the oil sector.
- BECCS can also become an important part of Equinor’s portfolio if additionality and food-water and land nexus issues are properly addressed.
- Demand for carbon-neutral products exists at current prices. However, it is likely that the offsets used for these products are low-quality and do not reflect the true cost of carbon.
- We do not recommend Equinor enters the carbon-neutral product business because these products will not be competitive when incorporating the cost of high-quality offsets.

Executive Summary

Introduction

As emissions from industry and electricity continue to increase, IEA estimates that if the world does not pursue deep decarbonization efforts, our existing and planned infrastructure will consume 95 percent of our carbon budget for limiting global warming to 1.5 degrees Celsius.[1] In this context, corporations worldwide continue announcing efforts to become net-zero emitters by 2050. The difficulty of decarbonizing the economy implies that achieving a 1.5 degrees Celsius increase pathway will require capturing 5.6 Gigatons (Gt) of carbon dioxide per year by 2050.[2] A suite of nature-based and technology-based solutions will be crucial to remove carbon from the atmosphere.

Equinor targets carbon-neutral global operations by 2030 and becoming net-zero by 2050. Equinor relies on its expertise as a global energy major to reduce emissions from its products and achieve these goals. The company is also building out and purchasing renewable energy capacity to power its operations. However, Equinor will likely have to purchase carbon credits to offset residual emissions that will allow it to achieve its targets. As Equinor develops and implements a carbon offset strategy, it is imperative that they choose to remove carbon from the atmosphere rather than avoid emissions elsewhere. Carbon removal is increasingly becoming the only acceptable alternative to claim carbon reductions from existing emissions.

Overview of Carbon Offsets Sector

Carbon markets and carbon offsets are becoming increasingly important for two main reasons: 1) The number of companies announcing climate targets is increasing rapidly, 2) The world is on a path that will likely require fossil fuels to power at least part of the global economy by 2050. The world will need to remove carbon from the atmosphere to achieve a 1.5-degree pathway. Adequately pricing carbon and ensuring high-quality offsets will be key for achieving this.

Scrutiny against companies making inaccurate claims about their carbon footprint is increasing rapidly. Companies have failed to recognize the risks of adopting ambitious climate targets and have made mistakes when thinking about what carbon-neutral or net-zero really means. The clearest and most recent example is the backlash against investor and climate advocate Mark Carney for claiming that Brookfield Asset Management, the firm where he is Vice-Chair and Head of ESG and Impact Fund Investing[3], is net-zero. He based his claims on how Brookfield's large renewable energy generation fleet offsets their carbon emissions in other parts of their business.[4]

Similarly, criticisms about the quality of existing carbon offsets and existing verification mechanisms and registries have increased. Particularly, nature-based solutions have come under pressure as many argue they do not meet the additionality principle and are hard to verify. The increased attention over nature-based solutions recently put pressure on The Nature Conservancy's portfolio of projects, and the

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[1] HSBC Centre of Sustainable Finance. "CCUS for Paris Alignment: Supporting Carbon Neutrality in Heavy Industrials and Power", September 2020, Accessed April 13, 2020,

[2] Global CCS Institute. "Global Statues of CCS 2020". 2020. Accessed April 13, 2020.

[3] Brookfield Asset Management. Team. Accessed on April 12, 2021. https://www.brookfield.com/about-us/leadership/mark-carney

[4] Camila Hodgson. "Carney's stumble at Brookfield intensifies focus on 'net zero' claims". Financial Times. April 9, 2021. https://www.ft.com/content/2d96502f-c34d-4150-aa36-9dc16ffdcad2

organization will conduct an internal review after receiving criticism for its claims surrounding avoided deforestation projects.[5]

As more companies announce climate targets and the demand for carbon offsets increases, the scrutiny over companies' inaccurate claims and low-quality offsets will be recurring. To navigate this complex space, Equinor should continue to rely on the Science Based Targets Initiative (SBTi)[6] and The Oxford Principles for Net Zero Aligned Carbon Offsetting[7] to develop and implement their carbon offset strategy.

The remarkable growth in carbon offsets seen over the past years is explained by a mix of new entrants willing to purchase cheap offsets of questionable quality, more countries allowing offsets as part of the compliance burden for carbon taxes, and a market fragmentation that contributes to certifying new project types and technologies at a faster pace. This translated into cumulative issuances across the standards of close to 200 million credits in 2020. It is becoming inherently clear that the growth has outpaced the environmental integrity in parts of the market, and a number of initiatives are scrambling to address the level of centralization and standardization in the market, what to do about legacy credits, and justifying project lifetimes through a revised framework of environmental criteria.

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) provides a glimpse of what is to come by ICAO's decision to restrict offsets by standards, project start date, accounting method, and certain project types. Frameworks under development such as the Paris Agreement Article 6, the Taskforce on Scaling Voluntary Markets, and Science Based Targets Initiative are expected to create similar push and pull effects in the market, with no actor dominant enough to define a market-wide approach. A common denominator among the frameworks is the focus on shortening crediting periods while relying on recalibrated baselines for project renewals, favoring ex-post issuance of credits, avoiding double-counting, and differentiating credits with a vintage past 3-5 years of the neutralization year.

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[5] Ben Elgin. "A Top U.S. Seller of Carbon Offsets Starts Investigating Its Own Projects". Bloomberg. April 5, 2021, https://www.bloomberg.com/news/features/2021-04-05/a-top-u-s-seller-of-carbon-offsets-starts-investigating-its-own-projects
Ben Elgin. "These Trees Are Not What They Seem". Bloomberg. December 9, 2020, https://www.bloomberg.com/features/2020-nature-conservancy-carbon-offsets-trees/

[6] Science Based Targets Initiative (SBTi). https://sciencebasedtargets.org/

[7] The University of Oxford, "The Oxford Principles for Net Zero Aligned Carbon Offsetting", September 2020, https://www.sustainabilityexchange.ac.uk/files/oxford_offsetting_principles.pdf

Comparison of Carbon Offset Solutions

As an initial evaluation, Equinor should assess solutions and projects based on the categories and criteria below.

Table 1.1 Evaluation Criteria for Carbon Offsets

Category	Scaling	Environmental Integrity	Cost	Project Benefits	Carbon Accounting
Criteria	Readiness Available volume	Verifiability Permanence Additionality Leakage	Price in 2021 Price in 2050	Biodiversity Local community Greenwashing Target countries Synergies with Equinor	Timing Accounting

The table below shows the scoring of the solutions we evaluated in this report. A complete methodology, criteria definitions, and scoring rubric is provided in section four of this report.

Table 1.2 Project Types and Weighted-Average Scores

Project Sub-category	Project Type	Weighted Score (1-3)
Forestry and Land Use	Afforestation/reforestation	**2.04**
	Improved forest management	**1.71**
	REDD - Avoided planned deforestation	**1.71**
	REDD - Avoided unplanned deforestation	**1.71**
Ocean solutions	Mangrove	**2.30**
	Seaweed	**2.30**
Technology-Based Solutions	Direct Air Capture with Carbon Storage	**2.53**
	Bioenergy with Carbon Capture and Storage	**2.08**
	Biochar	**2.07**

Supply and Demand of Carbon Offsets

Demand for high-quality offsets is already higher than supply, and this will continue to occur. There are also not enough offsets of any solution to cover Equinor’s needs. Therefore, Equinor will likely need to purchase offsets from various solutions to achieve its 2030 and 2050 targets.

Most of the offsets available in the market are from avoided deforestation and improved land management projects. These offsets are priced at less than US$10/t$CO_2$. However, there are many concerns about their quality. Direct Air Capture prices are anywhere between US$200 and US$1000/tCO_2. However, several companies have started announcing large purchases directly from the project developers at prices around US$400 to US$600/tCO2. The table below summarizes the current price and capacity ranges for each of the technologies assessed in this report.

Table 1.3 Current Carbon Offset Prices and Capacity

Solution	Current		Future (2050)	
	Supply Cost (1)	Supply Capacity (2)	Supply Cost (3)	Supply Capacity (4)
	US$ / ton CO2	MTon CO2 per Year	US$ / ton CO2	GTon CO2 per year
AD/A/R	$3~10	80~100	$50~90	5.7-15.1
Ocean	$5~10	1~5	$10~100	0.50–1.38
ALM	$10~129	2~10	$0~100	2.0~5.0
DACCS	$200~600	<1	$46~146	0.5~10.0
BECCS	$100~400	1.5	$20~175	2.5~5.0

Recommendations for Equinor's Carbon Offset Strategy

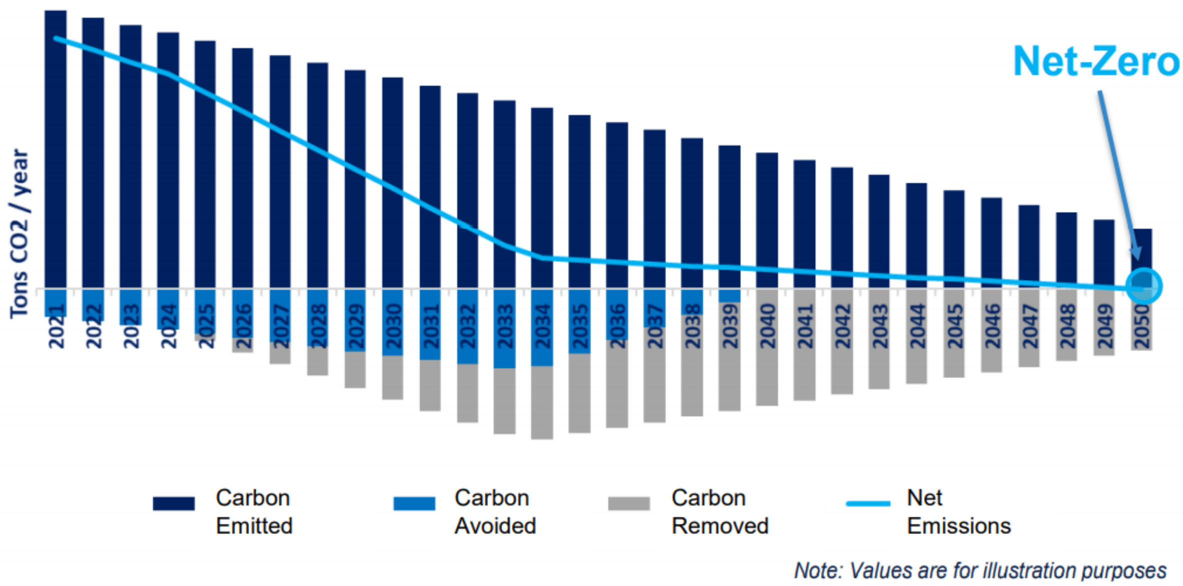
As the world continues to demand at least some oil and gas to power economic activity, Equinor will likely need to purchase carbon offsets to achieve its 2030 and 2050 targets. Equinor should build a strategy around carbon removal in the long-run. We believe that Direct Air Capture is the most appropriate solution to offset carbon emissions. However, there is not enough DAC capacity available for Equinor to only purchase DAC offsets. Therefore, we recommend that Equinor builds a portfolio of offset solutions to meet its 2030 and 2050 targets. Until 2030, Equinor should focus its efforts on investing and helping develop DACCS, which can be done by purchasing DAC capacity ahead of 2030 or partnering with companies to leverage Equinor's storage capabilities.

BECCS is also a promising solution given that it has many of the same benefits as DACCS but at a lower cost. For BECCS to be considered a negative emissions technology, the biomass needs to be grown with the purpose of creating these carbon offsets. An existing biomass plant later equipped with CCS represents emissions avoidance instead of removal. If this issue, as well as food-water-land nexus issues are solved, BECCS can become an important component of Equinor's portfolio.

Portfolio Approach

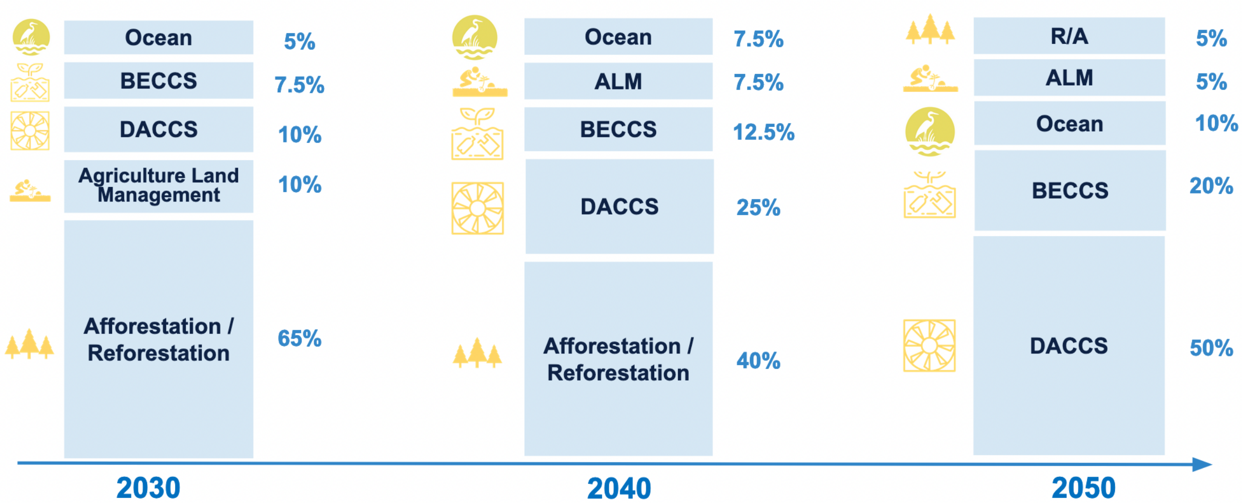
We believe that Equinor should apply a portfolio approach to managing its carbon offsets. This approach consists of diversifying the carbon offset solutions, geographic location, and project developers from which Equinor purchases offsets. A portfolio approach would allow Equinor to offset its residual emissions, help develop a market for direct carbon removal, and mitigate risks associated with the various offset solutions and projects. In addition, it would allow Equinor to rely on the currently available solutions, mostly nature-based solutions that avoid emissions, and transition towards carbon removal and technology-based solutions.

Figure 1.1 Indicative Role of Carbon Offsets in Equinor's Climate Strategy



We believe Equinor should pursue the offset portfolio portrayed below.

Figure 1.2 Recommended Portfolio for 2030, 2040, and 2050



Helping Develop DACCS from 2021 to 2030

Ahead of building a portfolio of offsets to meet 2030 targets, Equinor should now focus on helping scale DACCS. The main ways of doing this are:

- **Placing purchase orders for 2030:** Equinor can place orders with one of the DAC companies to purchase offsets starting in 2030. This type of order would likely require an agreement and down payment from Equinor and would secure larger amounts of offsets than those available now for Equinor to use to meet their targets 2030 and onwards. Most of the purchases made so far are forward purchase orders of this type that would begin providing offsets in 2024 or 2025.
- **Purchasing offsets now:** Equinor can also purchase lower quantities of DAC offsets now from the DAC providers. This would provide much-needed revenue for these companies to grow. However, the volumes available right now are low.
- **Investing in a DAC company:** Equinor could invest in a DAC company. This would directly help one of these companies scale up. There are only two companies operating DAC projects commercially, Climeworks and Carbon Engineering, and both seem to have strong financial backing already. However, the need for DAC is large, and there must be other smaller companies that need capital to commercialize their product.
- **Co-developing DACCS projects:** Equinor could co-develop DACCS projects together with DAC providers, with Equinor leveraging its transportation and storage capabilities, either through the Northern Lights JV or Equinor’s low-carbon solutions team. This option could help lower the cost of DACCS by scaling the storage part of the solution. The partnership between Northern Lights and Climeworks is a step in this direction.

We recommend Equinor proceeds by purchasing orders for 2030. This would allow them to start securing the DACCS offsets they need to achieve their 2030 targets. Equinor could also start purchasing earlier, for example, by 2025. If Equinor begins purchasing DACCS offsets before 2030, they could be used to offer carbon-neutral products. Equinor could invest in DAC companies or co-develop projects in addition to securing offsets for their 2030 portfolio.

Business Opportunities in Carbon-Neutral Products

The three main types of business opportunities in carbon offsets for Equinor to consider are: developing projects and selling carbon offsets, purchasing and selling carbon offsets on the market, and selling carbon-neutral products.

- **Opportunities in carbon offset project development:** One option for Equinor involves leveraging its carbon transportation and storage capabilities to develop carbon removal projects and sell carbon offsets of these removals. Equinor’s partnership with Climeworks represents a potential model for pursuing this type of opportunity, leveraging the potential synergies with Equinor’s capabilities. We believe that as demand for carbon offsets increases, Direct Air Capture with Carbon Storage (DACCS) will become attractive even at high prices. In addition, these opportunities can help Equinor diversify its revenue stream as it transitions into becoming a global broad energy major.
- **Opportunities in carbon offset trading:** Another potential opportunity involves purchasing carbon offsets to resell them or trade them. The potential for having a fully functioning carbon market increases as carbon pricing mechanisms improve how they reflect the cost of carbon. We’ve seen prices in the European Trading Scheme increase over the last few months, providing a positive signal in the right direction. Therefore, there are reasons to believe that carbon offsets

will gain value. The main risks in this opportunity are: current volumes are very low, existing carbon offsets might not be of good quality, and that they do not accurately reflect carbon cost. Therefore, trading credits from projects considered below acceptable to apply to Equinor's neutralization of its own credits represents a risk that could result in scrutiny from investors and the general public.

- **Opportunities in carbon-neutral products:** The third opportunity involves carbon-neutral products. The market for carbon-neutral LNG has grown notably in the past year. Most carbon-neutral LNG shipments to date were delivered to customers in Asia, but on March 8, 2021, Shell received the first carbon-neutral LNG shipment in Europe from Gazprom. The wide range of drivers of demand and the new actors and interest groups entering the space point towards continued interest in this product. Particularly, corporate and national CO2 targets, and downstream customer requirements will play an influential role in the coming years. The cost premium for carbon-neutral LNG is estimated to be 10-20% above standard LNG[8], but an analysis of the underlying credits used to neutralize the emissions revealed concerns about their quality. A total of 1.15 million credits were identified as directly linked to LNG transactions, and a majority of these would be excluded in the frameworks under consideration by the Science Based Targets Initiative and Taskforce on Scaling Voluntary Carbon Markets. In the coming years, there will likely be a readjustment for the types of offsets used towards carbon-neutral LNG, and from a business risk perspective it would be recommended to wait until the new frameworks are in place before entering the market. For the scale needed to offset a cargo of LNG, which is roughly 250,000 tons of CO2, Equinor would likely have to enter into long-term offset contracts with developers to drive down the price. And Equinor would have to compromise and deviate from the recommended projects here to remain cost-competitive with others in the industry. The risk of receiving public backlash and investing in an offset project that could be devalued under a new framework is not worth taking for a nascent product that still needs to figure out what is considered carbon-neutral. If Equinor decides to pursue this opportunity, the carbon offsets used for it should be from high-quality project types such as DACCS to prevent any backlash about the accuracy of the carbon-neutral label.

Other recommendations

With the recent leadership transition in OGCI's Executive Committee, Equinor is in a strong position to shape the oil and gas industry's approach to carbon offsets. OGCI's position paper on natural climate solutions provides a starting point for best practices among member companies but raises the ambition level that would enhance the organization and industry's credibility as a whole. This will bring positive ripple effects for corporate risk management strategies for investing in carbon offsets. First, OGCI could increase transparency by publishing a joint registry for tracking carbon offsets to reveal the exact project details among all members. This would increase the stakes of investing in cheap and low-quality offsets while developing a unified approach to report on carbon offsets.

[8] Markowitz, Kenneth & Procaccini, Gabriel, "Key Considerations for Carbon-Neutral Oil and LNG Transactions Using Carbon Offsets", https://www.jdsupra.com/legalnews/key-considerations-for-carbon-neutral-3494413/

Second, creating a dedicated climate investment sub-group for investments related to carbon markets. In this group, companies ranging from scaling new solutions that are likely to provide further benefits in the carbon markets to monitoring technologies and software platforms can be grouped together. Given the magnitude of companies likely to enter the carbon markets to purchase offsets in the coming years and pressure to increase these markets' environmental integrity, OGCI can claim that the investment fund contributes to shaping tomorrow's carbon markets in a positive way. Lastly, OGCI can take a more active role in the carbon removal industry, as there will likely be a sharper divide between carbon removal and carbon avoidance in the coming years. Organizing workshops and creating an environment for potential pilot projects are the first steps worth considering to grow closer to participants in this sector.

1. Introduction

Equinor has the ambition to reach carbon-neutral global operations by 2030. The main priority will be to reduce greenhouse gas emissions from own operations. The remaining emissions will be compensated either through quota trading systems, such as EU ETS, or high-quality offset mechanisms. By setting this ambition, Equinor demonstrates its long-standing support to carbon pricing and the establishment of global carbon market mechanisms as outlined in the Paris Agreement.

In addition, customers are requesting O&G companies to provide carbon-neutral products. Equinor is currently focusing on forest credits mechanisms as an offset option but wants to assess other carbon sink offset options as well.

Within this context, a team of students from Columbia University's School of International and Public Affairs aimed to analyze how carbon sinks can be used to offset emissions from Equinor's production and products. The main objectives of this assignment are:

- Map and assess carbon sink offset opportunities
- Assess verification methodologies
- Analyze the future demand and supply for carbon offsets
- Estimate the future price of carbon sinks (USD/tonnes CO2e) towards 2030 and 2050
- Recommend an offset strategy and implementation plan for Equinor, including an evaluation criteria tool.

This report is the final deliverable for this assignment. In the report, we first provide an overview of the fight against climate change and current efforts 30 and 2050.

We would like to thank Equinor for the opportunity to take part in their quest towards Net-Zero and particularly, Ann-Cathrin Vaage, for all her guidance and support during the process. We also want to express our utmost gratitude to our Capstone Advisor, Jason Bordoff. His continued guidance and thoughtfulness were key to achieving our goals. We would also like to thank all the experts that gave in the oil and gas industry. Then, we briefly describe Equinor's climate strategy and targets. Third, we provide an overview of carbon markets and the role of carbon offsets in fighting climate change. Then, we assess the different carbon offset solutions that are currently feasible and provide a framework and criteria for assessing their risks and adequacy. In the next section, we outline how other companies are using carbon offsets in their climate strategy. We then assess potential business opportunities for Equinor in the carbon offsets sector, including carbon-neutral products. Then we explain the Monte Carlo simulation model and results. Finally, we provide recommendations for Equinor.

As companies continue to announce climate targets, we believe the role of carbon offsets will continue to increase. Companies are failing to take into account the risks associated with purchasing offsets. We believe this report can help Equinor lead the way in developing a robust carbon offset strategy, purchasing high-quality carbon removal offsets to achieve their climate targets by 20us their time to ask questions and whose inputs were invaluable for our assignment. Finally, we want to thank Torre Lavelle and Daniel Propp for all their support throughout the semester.

2. Overview and Trends in Climate Change and Net Zero Targets

2.1. Climate change and net-zero

Climate change is the defining environmental issue of the 21st century. As the potential environmental, economic, and social impacts of climate change can no longer be ignored, policymakers and business leaders at all levels are responding. Mitigation efforts are rapidly developing to reduce the emissions of greenhouse gases or to enhance their removal from the atmosphere by sinks. However, it is not easy to achieve the goal stated in the Paris Agreement, in which governments agreed to keep global warming well below 2 degrees Celsius and to make efforts to keep it below 1.5°C. The Intergovernmental Panel on Climate Change (IPCC) found in 2018 that to limit global warming to 1.5°C, "Global net human-caused emissions of carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050."[9]

"Net-zero emissions" refers to reducing greenhouse gas emissions with the goal of balancing greenhouse gas emissions produced and emissions removed from the atmosphere. The concept of net-zero emissions is akin to "carbon-neutral." One key difference, however, is carbon-neutrality can be achieved at the domestic level with offsets from other jurisdictions, while net-zero emissions do not have the same connotation. Carbon neutrality also does not imply a commitment to reduce overall GHG emissions.[10] In many sectors of the economy, such as aviation, abating emissions is currently difficult, and there will be residual emissions that need to be balanced by removing CO2 from the air. To achieve the net-zero target, it is important to utilize offsets through natural-based solutions such as forest and improved land management. Negative emissions technologies such as Direct Air Capture (DAC) and Bioenergy with Carbon Capture and Storage (BECCS) will also need to play a role.

2.2 Oil & Gas sector's impact and common strategies

The oil & gas industry's operations account for 9 percent of all human-made greenhouse gas emissions. In addition, the fuels it produces create another 33 percent of global emissions.[11] Therefore, if the world is to achieve its climate target, the oil & gas industry will have to play a big role. Oil and gas companies are facing a critical challenge as the pressure to act on climate change increases. Shareholders and investors are increasingly conscious of environmental issues. Renewable technologies have also been getting cheaper. Failures to address growing concerns to reduce greenhouse gas emissions would therefore threaten the profitability and social acceptability in the long run. Many oil and gas companies have adopted strategies that can substantially decarbonize operations—for example, reducing fugitive

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[9] Intergovernmental Panel on Climate Change, "Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments", October 2018, https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/

[10] Herbert Smith Freehills, "Carbon-Neutral and Net-Zero Carbon: What's the Difference – and Why Does It Matter?", December 2020, https://www.herbertsmithfreehills.com/carbon-neutral-and-net-zero-carbon-whats-the-difference-and-why-does-it-matter

[11] McKinsey & Company, "The future is now: How oil and gas companies can decarbonize", January 2020, https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-future-is-now-how-oil-and-gas-companies-can-decarbonize

emissions by improving leak detection and repair (LDAR) and installing vapor-recovery units (VRU); replacing gas boilers with electric steam-production systems.[12] Some companies are also diversifying their energy operations to include renewables. Another common strategy is to implement initiatives that offset emissions by tapping into carbon sinks, and assessing how carbon sinks can be used to offset emissions is the main focus of our study.

2.3. Carbon Avoidance vs. Carbon Removal

There are differences between carbon avoidance and carbon removal. Avoided emissions are those that might have occurred but do not. Emissions avoidance can be achieved through conventional mitigation techniques, including energy efficiency improvement and displacing fossil fuels with renewable energy. One key disadvantage of carbon avoidance is that quantifying GHG emissions avoidance will depend on the baseline, which can be controversial. Carbon-removal strategies, on the other hand, remove carbon dioxide from the atmosphere and store it through various means. Removal approaches that employ trees and soil to absorb carbon have been used at a large scale for decades; other strategies that rely more on technology are also rapidly developing.

Emission avoidance efforts are critically important. Yet the science has shown that they will not be enough on their own to meet the goals of the Paris Agreement.[13] Net-zero commitments, plus a growing recognition of the importance of negative emissions, are pushing more interest in carbon removal offsets. Given the huge potential of carbon removal in the long run and the fact that avoidance offsets fall short across several dimensions, we consider that Equinor's carbon offset strategy should focus on reliably removing and sequestering carbon from the atmosphere rather than avoiding emissions from elsewhere.

[12] ibid.

[13] McKinsey & Company, "The future is now: How oil and gas companies can decarbonize", January 2020, https://www.mckinsey.com/industries/oil-and-gas/our-insights/the-future-is-now-how-oil-and-gas-companies-can-decarbonize

3. Summary of Equinor’s Climate Roadmap

In 2020, Equinor announced they would attempt to become net-zero by 2050. Equinor based this and other climate goals on the Paris Agreements targets, the Sustainable Development Goals, and the Norwegian government's targets. The company shows a long-term commitment to its climate roadmap, built around Equinor's emissions, its possibilities for an efficient energy transition, and current rigorous solutions to achieve net-zero.

The company identified where it could change and adapt the quickest. It stated its commitment to reducing its products' emissions and later intervening to reduce scope three emissions. If Equinor fulfills the urgent emission reductions needed to confront the current climate crisis, it will continue to exist as a leader within the energy market. Equinor’s climate roadmap shown in this section is its core to success.

This section gathers information straight from Equinor’s sustainability report and climate roadmap. It includes the definitions the company uses, its specific actions, and the timeline to achieve them.

3.1. Climate Goals and Strategy

To achieve net-zero by 2050, Equinor aims at reducing absolute emissions and emissions intensity from production and final consumption of energy; this includes scope 1, 2, and 3 GHG emissions, where scope three emissions represent a calculation of indirect emissions from customers’ use of Equinor’s equity production volumes. The company has set a clear strategic direction and continued commitment to long-term value creation in support of the Paris Agreement.[14] The table below describes Equinor’s targets and provides context around the activities that will be undertaken to achieve them.

Table 3.1: Equinor’s Climate Goals

Ambitions	Boundary	Scope	Reference Year	Ambition Year	Description
Reduce absolute emissions in Norway • 40% reduction by 2030 • 70% reduction by 2040 • Near zero by 2050	Operational control 100% (including TSP role), Norway	Scope1&2 CO_2 & CH4	2005	2030, 2040, 2050	Includes offshore and onshore facilities. Will pursue energy efficiency measures, electrification projects, consolidation, digitalization, and CCUS and hydrogen.
Upstream CO_2 intensity <8kg CO_2/boe	Operational control 100%, upstream	Scope1 CO_2	NA	By 2025	Not including onshore gas processing in Norway (TSP role), refining, or LNG
Carbon-neutral operations globally by 2030	Operational control 100%	Scope 1 and 2 CO_2 & CH4	NA	2030	EU ETS quotas and natural sinks included.
Net-zero emissions by 2050 Reduce net carbon intensity by 100% by 2050	Scope 1 and 2 GHG emissions (100% operator basis) • Scope 3 GHG emissions from the use of sold products (equity production)	Scope 1, 2 and 3 CO_2 & CH4	2019	2050	Net GHG emissions (g CO_2 equivalents) divided by equity energy production (Megajoules, MJ). A detailed description of the net carbon intensity indicator is available at equinor.com.

[14] Equinor. “Equinor’s ambition is to reach net-zero emissions by 2050.” https://www.equinor.com/en/sustainability/climate.html

	• Energy production (equity)				
Eliminate routine flaring by 2030	Operational control 100%	CO_2 & CH4	NA	2030,2040	In support of the World Bank Zero Flaring by 2030 initiative. Not including onshore gas processing in Norway, refining, or LNG.
Keep methane emissions near zero	Operational control 100%	CH4	2016	2030	Upstream and midstream emissions (Equinor-operated, including TSP role). Equinor aims to maintain a low methane intensity (0.03% in 2019)
Increase renewable energy capacity to • 4-6GW by 2026 •12-16 GW by 2035	Equity basis	Installed capacity (GW)	2019	2026/2035	Installed capacity, Equinor share

3.2. Progress

3.2.1. Carbon-neutral global operations by 2030

Equinor says it is fully committed to reducing emissions from offshore oil and gas production.[15] Even in the most optimistic forecast scenarios, the world will likely still need oil and gas for a long time. It is therefore essential that the oil and gas that the world needs are produced with the lowest carbon footprint possible. Most of Equinor's offshore installations produce their own electricity using gas turbines, which account for a quarter of Norway's total emissions of both NO_X and CO_2.

3.2.2 Efficient oil and gas production

Equinor already has one of the industry's lowest upstream carbon intensities and aims to reduce this further. They are moving forward the 2030 ambition of <8kg CO_2 per barrel of oil equivalent (boe) to 2025. The 2021 global industry average is 18kg CO_2 per boe (IOGP). They also aim to keep methane emissions at near zero and to eliminate routine flaring by 2030.

3.2.2. Developing a high-value renewable business

Recognizing the unprecedented opportunities in renewable energy, Equinor has built a strong renewable portfolio in production and is leveraging its core competencies in managing complex oil and gas projects when growing in offshore wind. By 2026 Equinor expects to increase current installed capacity by ten times. Equinor recently added Dogger Bank (UK) and Empire Wind (US) to its offshore wind portfolio. Dogger Bank will be the world's largest offshore wind farm development with a total installed capacity of 3.6GW. Empire Wind will provide renewable electricity to New York City, with a capacity of 816MW, delivering power to one million homes. Up to 80 % of the world's offshore wind potential will likely require floating solutions, and Equinor is well-positioned to industrialize floating wind. They plan to commercialize it by 2030.

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[15] Equinor. "Electrification of Oil and Gas Operations." https://www.equinor.com/en/what-we-do/electrification.html

3.2.3. Developing low-carbon solutions

Equinor is promoting Carbon Capture, Utilization, and Storage (CCUS) and hydrogen solutions as these technologies can decarbonize hard-to-abate sectors of the economy, such as industry, maritime transport, heating, and power generation. This can only be done in close collaboration with governments and customers to establish a commercial framework and build new markets. Equinor is currently pursuing strategic partnerships with industry players to ensure safe, reliable, and cost-effective implementation.

Carbon Capture, Utilization, and Storage (CCS & CCUS)

Equinor is a leading pioneer in Carbon capture, utilization, and storage, or CCS/CCUS.[16] They are pursuing new business models to make CCS commercially viable in the decarbonized energy systems of the future, starting with Norway. The concept includes capturing CO_2 from various onshore industries, transporting it by ships, and injecting and permanently storing it 1000 – 2000 meters below the seabed.

Northern Lights is a Joint-Venture between Equinor, Shell, and Total. They are developing infrastructure on the Norwegian Continental Shelf for transport and storage of CO_2 from various onshore industries. The project involves transporting liquified CO_2 by pipeline to permanent offshore subsea storage. Northern Lights will have an initial storage capacity of 1.5 million tons CO_2 annually. The Norwegian government recently agreed on the investment decision. Other projects include the Technology Centre Mongstad, Sleipner West. Operational since 1996, Snøhvit LNG (2008), Algeria, In Salah (*2004)*.

Hydrogen

Equinor is looking into early-stage opportunities for converting natural gas to clean hydrogen while capturing and storing CO_2. In the journey to zero-carbon energy, many people believe that hydrogen should be considered the world's destination fuel. The carbon capture and storage part of this journey is the essential transitional step to facilitating a longer-term, sustainable, global hydrogen economy. Equinor recently signed an agreement with ENGIE to develop low-carbon hydrogen activities.[17] Projects include H 21 North of England and H2morrow steel, Germany.

3.2.4. Embedding climate decision-making

Equinor applies an internal carbon price and conducts rigorous sensitivity analysis to assess climate-related risks to their projects. The internal carbon price is at least USD 55 per ton of CO_2. In countries where the actual or predicted carbon price is higher, they apply the actual or expected cost, such as in Norway, where both a CO_2 tax and the EU ETS apply. Climate-related risks and opportunities are reported in line with the "Task Force on Climate-related Financial Disclosures (TFCD) recommendations.

3.2.5. Engaging with other sectors to accelerate decarbonization

Equinor is committed to working with all social sectors to reduce emissions. Their actions focus on the Sustainable Development Goals, 7,13, and 17. They have teamed up with 12 peer companies in the Oil

[16] Equinor. "Carbon Capture, Utilisation and Storage (CCS & CCUS):We're sending carbon back to where it came from". https://www.equinor.com/en/what-we-do/carbon-capture-and-storage.html

[17] Equinor. "ENGIE and Equinor join forces in the development of low-carbon hydrogen". https://www.equinor.com/en/news/20210218-join-forces-engie-hydrogen.html

and Gas Climate Initiative to shape the industry's climate response, including a USD 1 billion-plus investment fund on Climate Investments. They are also part of Climate Action 100+.

In addition, they assess their portfolio and new material capital expenditure investments towards a well below 2°C scenario, implement climate ambitions and remuneration for senior executives and employees, and review memberships in relevant industry associations with regards to indirect policy engagement.

3.3. Advantages and opportunities

The scale and composition of Equinor’s oil and gas emissions reduction, and the efficiency of its operations, will play a key role in achieving Equinor’s net-zero ambition. The carbon offsets ambitions play a smaller yet short-term solution to meet the goals. Also, a significant part of the Carbon efficient production of oil and gas will increasingly be a competitive advantage, and Equinor will seek to ensure a high-value and robust oil and gas portfolio.

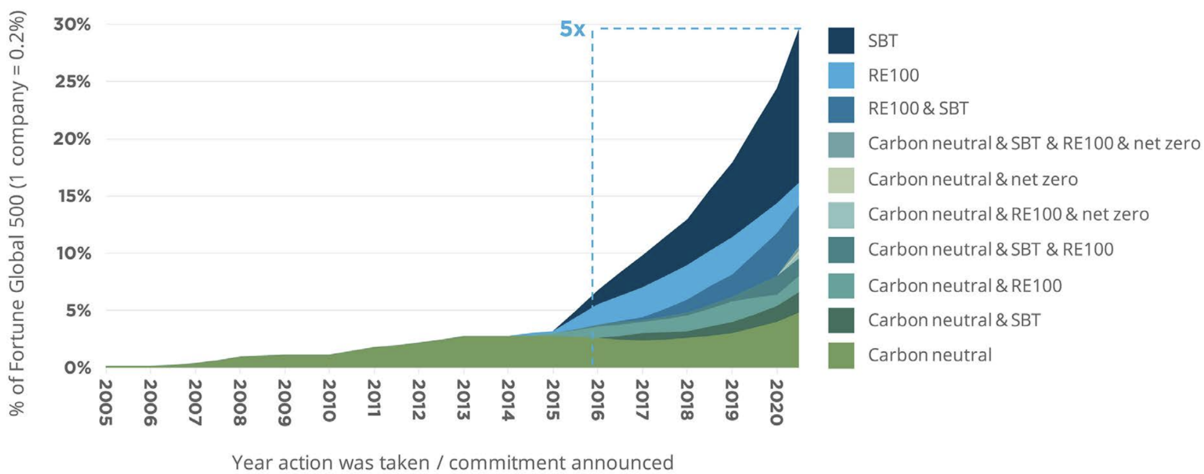
4. Overview of Carbon Offsets

4.1 Development of carbon offset initiatives

4.1.1 Growing importance of carbon offsets

Since the signing of the Paris Agreement in 2015, an increasing number of companies have announced net-zero pledges. Among Forbes 500 companies, the number of companies that announced their decarbonization goals increased five-fold between 2016 and 2021.[18] However, many experts have pointed out that reducing greenhouse gas (GHG) emissions alone is not enough and that it is necessary to sequestrate GHGs that have already been emitted.[19]

Figure 4.1: Percentage of Fortune 500 Companies Adopting Climate Pledges



For example, to reach the 1.5C target of the Paris Agreement, the amount of GHG emissions that the world can emit by 2050 is scientifically limited. This is also called the “carbon budget,” and it amounts to 570 Gt of carbon dioxide (CO_2). The figure below shows that the target can be somehow achieved by combining GHG emission reduction and GHG sequestration, in other words, carbon offset.[20]

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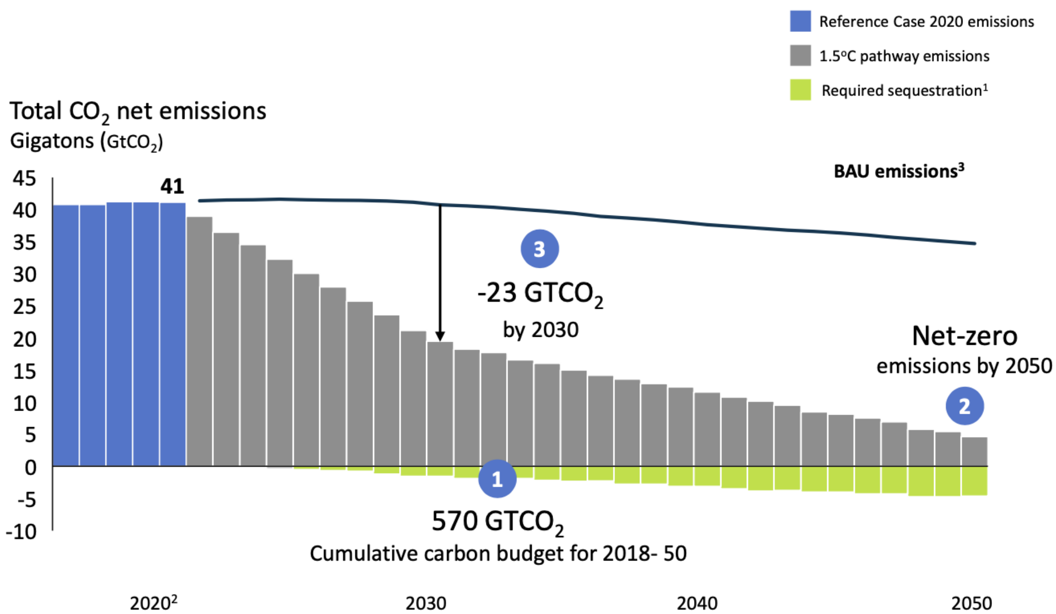
[18] Natural Capital Partners, “Response Required”, October 2020, https://www.naturalcapitalpartners.com/news-resources/response-required

[19] International Energy Agency, “Why carbon capture technologies are important”, July 2020 https://www.iea.org/reports/the-role-of-ccus-in-low-carbon-power-systems/why-carbon-capture-technologies-are-important

[20] The Taskforce on Scaling Voluntary Carbon Markets, “TVSCM Final Report”, January 2021, https://www.iif.com/tsvcm

Figure 4.2: Pathway to 1.5 degrees celsius



1. In order to reach 1.5 °C goal we must remain within the 570 $GTCO_2$ carbon budget
2. By 2050 all remaining emissions need to be fully offset by sequestration (net zero)
3. To set us on this path we must reduce net emissions by 23 $GTCO_2$ by 2030

4.1.2 Global initiatives to promote carbon offset

4.1.2.1 Governmental initiatives

United Nations

Under the United Nations' Kyoto Protocol, developed countries can invest in emission reduction projects in developing countries, and the credits associated with the reductions are transacted through the Clean Development Mechanism (CDM). The second commitment period under the Kyoto Protocol lasted from 2013-2020, which questioned the legality and ability to renew crediting periods for projects post-2020. In December 2020, the CDM Executive Board decided to temporarily extend the CDM issuances until COP26, as mechanisms such as CORSIA allow for the use of CDM credits. A historical analysis of the issuance success rate, which shows if projects were actually able to meet their estimated annual emissions reductions, reveals five project types were actually able to meet or exceed the estimated annual reductions - solar, reforestation, cement, HFCs and N20.[21]

[21] UNEP DTU, "CERs", April 2021, https://www.cdmpipeline.org/cers.htm

Figure 4.3: CDM Issuance Data: Issuance Success Rate by Project Type

National and regional compliance markets

Among the compliance carbon offset mechanisms, the European Union (EU) Emissions Trading Scheme (ETS) and California's cap-and-trade program are two of the most well-known and longest-running programs that accept carbon offsets. In recent years, developments to establish new compliance mechanisms and reforms to current standards have altered the overall acceptance and adoption of carbon offsets. Under phase 4 of the EU ETS, which lasts from 2021 to 2030, the use of international credits from CDM and Joint Implementation (JI) is no longer accepted.[22]

On the other hand, several countries have designed new mechanisms to include carbon credits as part of the compliance burden. These initiatives have recently been adopted to provide flexible alternatives for carbon taxes implemented in Colombia, South Africa, and Chile, while the Mexico ETS is under consideration. For companies operating in these countries, the use of offsets can reduce the overall tax burden. In the case of Colombia, the carbon tax is roughly equivalent to $6, which creates an incentive to purchase low-cost offsets to reduce the overall tax burden.

Another model under this category is the Joint Crediting Mechanism (JCM) in Japan, which is a bilateral mechanism between Japan and different partner countries. The structure of the program allows for emission reduction projects in the partner countries, and the Japanese government purchases JCM

[22] European Commission, "Start of phase 4 of the EU ETS in 2021: adoption of the cap and start of the auctions", November 2020, https://ec.europa.eu/clima/news/start-phase-4-eu-ets-2021-adoption-cap-and-start-auctions_en

credits to meet its reduction obligations.[23] This is a similar approach to what the Paris Agreement Article 6 envisions, and in 2019 Japan signed an MOU with the World Bank to use the JCM as a pilot for Article 6 carbon markets.

Industry

Ultimately, the appeal of carbon offsets under compliance mechanisms and voluntary markets to achieve corporate targets will be a function of future standards and directives. This already became apparent with the launch of CORSIA, the aviation industry's compliance program to address CO2 emissions in international aviation, where the International Civil Aviation Organization (ICAO) set eligibility terms for the use of carbon offsets. For the 2021-2023 compliance cycle, units are limited to more recent offsets by requiring the project's first crediting period to start January 1, 2016, or later.[24] Additionally, certain projects are excluded if the sustainable development contributions are not reported or use ex-ante accounting for future emissions reductions.

Besides ICAO, the International Maritime Organization (IMO) is in the process of revising the initial strategy published in 2018 to reach its climate targets for the shipping industry, which is expected to be finished by 2023. There is potential for the use of carbon offsets in the revised strategy, and shipping decarbonization survey conducted by Lloyd's Register showed that 20% of respondents expected marine fuels combined with carbon offsets to be used by 2030.[25]

4.1.2.2 Voluntary offset initiatives

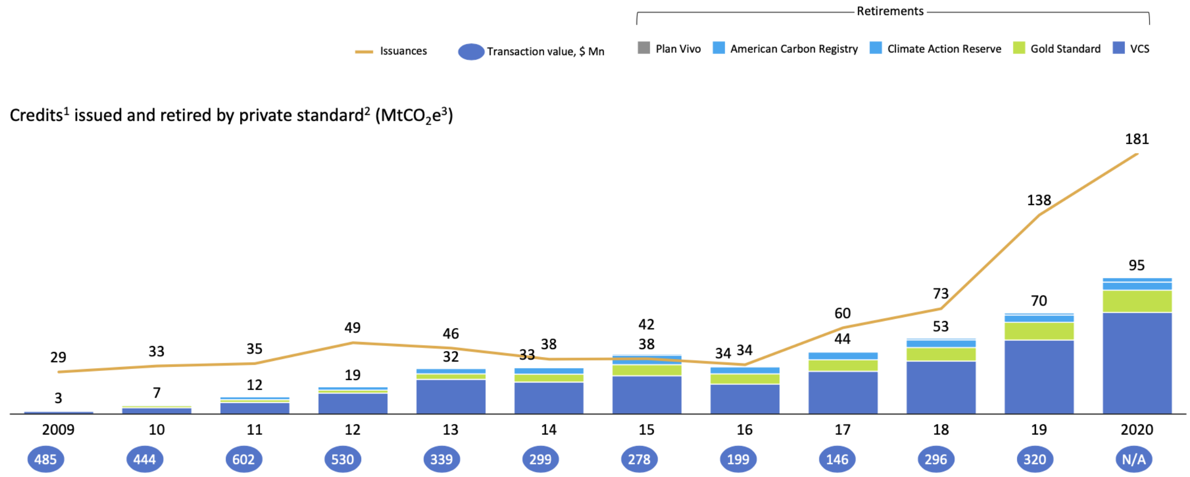
Led by the significant rise in companies setting ambitious net-zero targets and current carbon-neutral targets, voluntary carbon markets have gained momentum in the past years. As seen in the chart below, the number of credits issued across different standards increased by over 400% between 2016 and 2020.

[23] World Bank Group, "State and Trends of Carbon Pricing 2020" May 2020, https://openknowledge.worldbank.org/bitstream/handle/10986/33809/9781464815867.pdf?sequence=4&isAllowed=y

[24] ICAO, "CORISA Eligible Emissions Units", November 2020, https://www.icao.int/environmental-protection/CORSIA/Documents/TAB/TAB%202020/ICAO_Doc_CORSIA_Eligible_Emissions_Units_November_2020.pdf

[25] Lloyd's Register, "Regulation is key to shipping's green push, Lloyd's List survey finds", January 2021, https://www.lr.org/en/latest-news/regulation-is-key-to-shippings-green-push-lloyds-list-survey-finds/

Figure 4.4: Recent Growth in Voluntary Carbon Markets [26]



The growth spans a diverse set of industries and is not limited to niche companies such as Etsy, which aligns its carbon-neutral operations with its competitive advantage. Among the 250 largest companies based on revenue in the Fortune 500, 46% of the companies reported a net-zero target or science-based targets.[27] To underline the widespread reliance on carbon offsets across industries, one of the current top purchasers of carbon offsets is the Japanese pharmaceutical company Takeda, which purchased 4.3 million verified emissions reductions (VERs) to offset its FY2019 emissions.[28]

Credits from the voluntary offset markets are issued under private standards with their own methodologies and monitoring requirements. Compared to international mechanisms, these standards are far more flexible in developing new methodologies. This allows them to establish niche markets and adopt new technologies but at the risk of developing premature methodologies with quality concerns.

Case study: Verra

Verra was established in 2005 and has over the past years grown to become the dominant standard for offsets. In 2020, a record-setting 140 million credits were issued under the VCS program.[29] An analysis of the credits issued reveals a concentration of credits around a few methodologies. The top methodology, representing close to half of all issuances, is grid-connected electricity generation from renewable sources (large scale).

[26] Ecosystem Marketplace, press search, data from VCS, GS, CAR, ACR and Plan Vivo market registries, McKinsey Analysis

[27] KPMG, "Towards net zero", November 2020, https://assets.kpmg/content/dam/kpmg/xx/pdf/2020/11/towards-net-zero.pdf

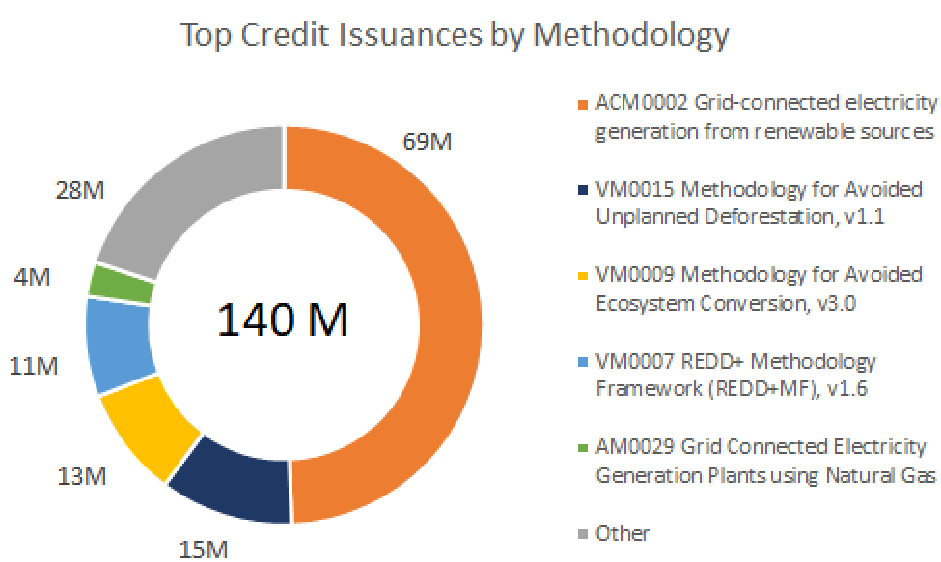
[28] Takeda, "2020 Sustainability Report", January 2021, https://www.takeda.com/48f1a6/siteassets/system/corporate-responsibility/sustainable-value-report/takeda2020sustainabilityreport_en.pdf

[29] Verra, "Data and Insights" Accessed on April 2021, https://verra.org/datainsights/data-and-insights-january-2021/

Although grid-connected electricity generation from renewable sources faces certain challenges for additionality, the growth rates over the past two years show a significant increase. The disconnect between what is considered high risk for additionality and the growth rates seen over the past years suggests the market is not fully valuing the quality of offsets, and this presents a risk for new buyers. In fact, the high demand for renewable energy offset credits is partially explained by the surge of new entrants in the market valuing price over quality and co-benefits.[30] Recently, verification standards have moved to restrict the applicability of renewable energy as offsets. As part of Verra's version 4 update in 2019, grid-connected electricity generation using wind, geothermal, solar power, or hydropower plants were excluded in non-LDC countries.[31] This is because of a general increase in scrutiny against projects that focus on avoiding emissions instead of capturing carbon from the atmosphere. In addition, the steep drop in the cost of solar and wind generation has cast doubt over the additionality of renewable energy offsets. We do not believe that renewable energy projects will continue to be accepted as carbon offsets by verification methodologies and third-party verification providers in the future. Therefore, this report does not consider renewable energy as an option for Equinor to purchase offsets.

In a similar way, avoided deforestation, household devices, waste disposal, energy efficiency, and transportation are also avoided emissions technologies. Although many of these solutions are still accepted under methodologies, registries, and third-party verification, we also believe that they will not be commonly accepted in the future as carbon offsets move towards focusing on carbon removal.

Figure 4.5: Top Credit Issuances by Methodology



[30] Steve Zwick, "Demand for voluntary carbon offsets holds strong as corporates stick with climate commitments''. Ecosystem Marketplace. September 2020, https://www.ecosystemmarketplace.com/articles/demand-for-voluntary-carbon-offsets-holds-strong-as-corporates-stick-with-climate-commitments/

[31] Verra, "Introduction to VCS Version 4", October 2019, https://verra.org/wp-content/uploads/2019/10/VCS-V4-Webinar_17OCT2019.pdf

Table 4.1: Top Growth Rates for Projects with more than 1M Credits Issued in 2020

Methodology Name	2018	2019	2020	Growth Rate '18-'20
ACM0002 Grid-connected electricity generation from renewable sources	10,805,316	37,218,311	69,309,508	541%
AR-ACM0001 Afforestation and reforestation of degraded land	188,302	1,382,619	3,135,615	1565%
AR-ACM0003 Afforestation and reforestation of lands except for wetlands	276,235	213,420	3,265,909	1082%
ACM0006 Electricity and heat generation from biomass	91,922	46,750	1,335,063	1352%
VM0006 Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects, v2.2	131,991	3,187,507	2,203,198	1569%

Lastly, by examining the pipeline of new projects, which consists of roughly 96 million estimated annual emission reductions, it seems like the current methodology profile is likely to continue. Close to ⅓ of new project issuances are linked to renewable energy and REDD+.

Figure 4.6: Current Issuance and Credits in Pipeline

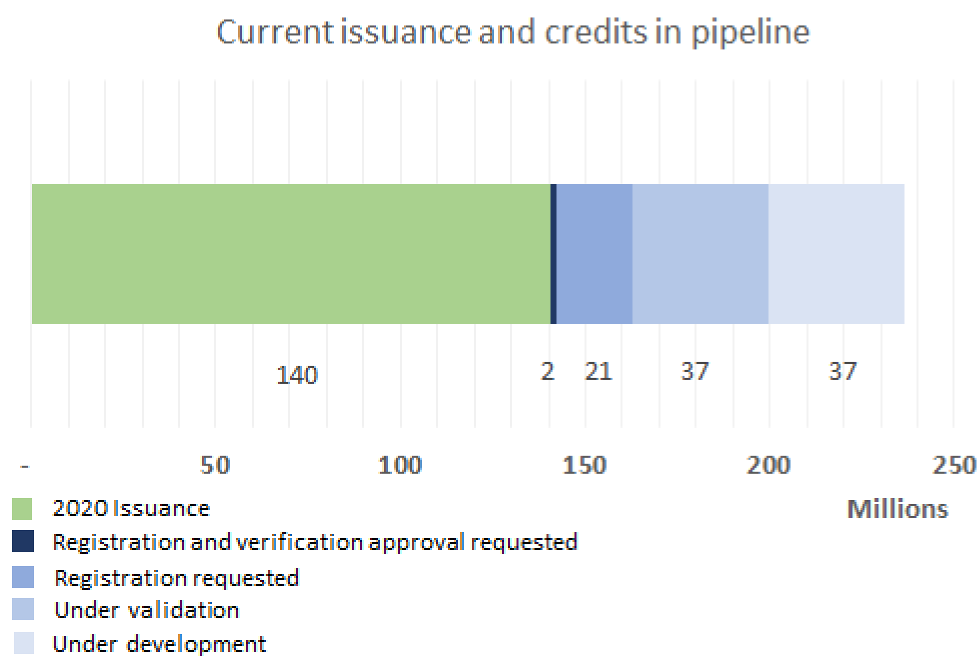


Table 4.2: Top Estimated Annual Emission Reductions by Methodology

Methodology	Pipeline
VM0015 Methodology for Avoided Unplanned Deforestation, v1.1	21,731,670
VM0007 REDD+ Methodology Framework (REDD+MF), v1.6	16,394,565
ACM0002 Grid-connected electricity generation from renewable sources	15,224,997
AR-ACM0003 Afforestation and reforestation of lands except for wetlands	6,737,093
AMS-II.G., VMR0006 Energy efficiency measures in thermal applications of non-renewable biomass	6,500,000
Remaining Projects	29,629,019
Total	**96,217,344**

Among the other standards, Gold Standard is the second largest with 34.4 million issuances in 2020.[32] The standard was established in 2003 by a team of international NGOs led by the World Wildlife Fund (WWF) and differs slightly from Verra in its exposure to forestry credits. The top issuing project types for 2020 are wind, energy efficiency, and biogas. The remaining standards are highly regionalized, with the Climate Action Reserve (CAR) and American Carbon Registry (ACR) focusing on projects in North America and compatible with California's cap-and-trade program. The standards issued 19.2 million and 2.5 million credits respectively in 2020. ACR was established in 1996 by Winrock, a company that also launched the Architecture for REDD+ Transactions (ART). The ART standard fits jurisdictional forest projects because it uses aerial and satellite data to monitor large forests' conditions and chronological changes. But aerial and satellite data are not relevant in monitoring Direct Air Capture (DAC). Therefore, the relevant methodology should be chosen according to the offset solutions.

4.1.3 Recent trends

Carbon Removal Marketplaces

A growing number of companies specializing in carbon removal marketplaces are contracting volumes with corporate buyers. In October 2020, Indigo Ag disclosed commitments from Barclays, JPMorgan Chase, and IBM for its carbon credits.[33] The credits are approved under Verra's methodology for improved agricultural land management, which was adopted around the same time.[34] Additionally,

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[32] Gold Standard, "Impact Registry". Accessed in April 2021, https://registry.goldstandard.org/credit-blocks/issuances?q=&page=1

[33] Indigo Agriculture, "Indigo welcomes publication of new methodology enabling European growers to earn income from carbon farming credits", October 2020, https://www.indigoag.eu/pages/news/indigo-welcomes-publication-of-new-methodology-enabling-european-growers-to-earn-income-from-carbon-farming-credits

[34] Verra. "VM0042 Methodology for Improved Agricultural Land Management, v1.0". Accessed on April 2021. https://verra.org/methodology/vm0042-methodology-for-improved-agricultural-land-management-v1-0/

companies such as Puro.earth and Nori offer their own type of credits (CORCs and NRTs) and worked with high-profile clients within the carbon removal environment, including Microsoft and Shopify.

Entrepreneurs' initiative

Prominent business leaders are now also targeting carbon offsets and carbon removal technologies. Bill Gates and Elon Musk have personally emphasized the importance of offsets, and offsets are becoming mainstream in the energy discussion[35]. Elon Musk has announced that he would donate $100 million towards a prize for the best technology that can capture carbon dioxide.[36] The prize in-of-itself is not the most important part. Instead, Elon Musk's involvement signals that carbon offsets and carbon removal are becoming part of the mainstream climate conversations.

4.1.4 Anticipating changes in the carbon market structure

In this section, we explore anticipated changes that will shape the future use of carbon offsets through government initiatives and private sector initiatives.

4.1.4.1 Government initiatives

A government-led mechanism based on the Paris Agreement Article 6 is expected to be finalized during COP26. At the moment, we see the parties converge around the following areas:

- The Supervisory Body will have the authority to develop and approve new methodologies, similar to the CDM structure.
- Crediting periods of maximum 5 years with a maximum renewal rate of two times, or a maximum of 10 years without the renewal option.
- Mitigate the risk of double-counting by including the option of corresponding adjustments (CAs), meaning countries apply an accounting approach where countries selling the Internationally Transferred Mitigation Outcomes (ITMOs) have to write down the emission reductions in their NDCs.
- Reforms to additionality are considered a key part of finalizing Article 6, and the current language in the proposal suggests a dual-track approach where projects in LDCs or small island developing states can use BAU baselines[37], while other states use more stringent methods such as a performance benchmark or positive lists.[38] It should be noted that positive lists in general are beneficial by providing certainty for scaling nascent technologies by automatically granting additionality to the technology, but can also work as a loophole when establishing international

[35] CBS News, "Bill Gates: How the world can avoid a climate disaster", February 2021, https://www.cbsnews.com/news/bill-gates-climate-change-disaster-60-minutes-2021-02-14/

[36] Sam Shead, "Elon Musk says he will donate $100 million to whoever invents the best carbon capture technology". CNBC. January 2021, https://www.cnbc.com/2021/01/22/elon-musk-tesla-ceo-donates-to-carbon-capture-technology-prize.html

[37] UNFCCC, "Draft text on matters relating to Article 6 of the Paris Agreement: Rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Paris Agreement". Accessed in April 2021, https://unfccc.int/sites/default/files/resource/CMA2_11b_DT_Art.6.4_.pdf

[38] Axel Michaelowa, Aglaja Espelage, and Benito Müller, "Negotiating cooperation under Article 6 of the Paris Agreement", European Capacity Building Initiative, November 2019, https://ecbi.org/sites/default/files/Article%206%202019_0.pdf

mechanisms based on consensus. In CDM, grid-connected solar PV and offshore wind are still included in the positive lists.[39]

As part of the process to align current practices with expected changes under the Paris agreement, the voluntary standards are conducting public stakeholder consultations to revamp their frameworks. In the case of the Gold Standard, a more dynamic review for additionality is expected. Previously, submitting information to demonstrate an ongoing financial need for carbon financing was requested by the standard, but it was not used as a determinant for evaluating if a project received a renewed crediting period. Additionally, in cases where countries opt to not use the corresponding adjustment mechanism, the Gold Standard is still prepared to transact these credits. These credits are unlikely to be applicable for corporate reduction targets, but rather claim active contribution to carbon financing and co-benefits.[40]

To date, there are 40 existing or planned Article 6 pilot projects. These initial projects aim to test the concepts envisioned in the Paris Agreement for carbon offset projects to prepare host countries and provide frameworks for future projects. Most projects relate to energy supply, energy demand, waste, transportation and land-use. From the project methodologies, no uniform method for determining the baselines is applied, but rather a wide range with the JCM opting for current CDM methodologies, the German BMU uses standardized baselines, while the Swiss Foundation for Climate Protection and Carbon Offset specify mitigation to go beyond the unconditional target.[41]

4.1.4.2 Private sector Initiatives

The private sector has made considerable progress in advancing the development of carbon offset solutions and frameworks for a global carbon market. We see the efforts at the company, sector, and public figure levels. In addition, the Taskforce on Scaling Voluntary Carbon Markets presents the most organized approach so far.

Taskforce on Scaling Voluntary Carbon Markets (the Taskforce)

In December 2020, COP26 Advisor and former Governor of the Bank of England, Mark Carney, launched the Taskforce on Scaling Voluntary Carbon Markets (the Taskforce) with a diverse set of stakeholders to scale up voluntary carbon offset markets. It includes consumers, suppliers, standards, and market intermediaries, and members include Shell, BP, Total, and Chevron. The taskforce claims that to reach the 1.5C target, the voluntary market needs to scale from the current 0.2 Gt/year to 3 Gt/year by 2030. Based on this goal, they are making various proposals for market expansion.

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[39] Clean Development Mechanism. "Methodological tool: Positive lists of technologies". Accessed in April 2021, https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-32-v2.0.pdf

[40] Owen Hewlett and Hugh Salway, "Technical consultation: Aligning Gold Standard-certified projects with the Paris Agreement", Gold Standard, March 2021. https://www.youtube.com/watch?v=CXE6MpU1UQc

[41] Sandra Greiner, Nicole Kramer, Federico De Lorenzo, Axel Michaelowa, Stephan Hoch, and Juliana Kessler, "Article 6 piloting: State of play and stakeholder experiences", Climate Focus, December 2020, https://www.climatefocus.com/sites/default/files/Climate-Finance-Innovators_Article-6-piloting_State-of-play-and-stakeholder-experiences_December-2020.pdf

The Taskforce proposes a set of "core carbon principles" (CCPs) to develop quality criteria to verify the emission reductions. These emphasize the accounting principles behind a ton of carbon, while other desirable features such as co-benefits and vintage are treated as additional attributes. The table below summarizes the description for each criterion:

Table 4.3: Offset Criteria Definition

Criteria	Description
Real	Verified ex-post credits
Additional	Conservative BAU scenario, and must be surplus to regulatory requirements. Jurisdictional programs must show additional reductions below the historical reference level.
Realistic and credible baselines	Must be conservative, and recalculated on a regular timeframe
Monitored, Reported and Verified (MRV)	Verified by an accredited, third-party entity at specified intervals.
Permanent	Can have reversal risk, but in that case must meet requirements for a multi-decadal term, have comprehensive risk mitigation in place, and means to replace units lost.
Leakage	Considering any potential increase in emissions outside the boundary, including taking appropriate deductions.
No double-counting	Only a single actor can account for the CO2 reductions
Do no net harm	Environmental and social risks must be considered, and appropriate mitigation measures in place to limit the harm.

For additional attributes, the taskforce defers any decision to put limits on vintage, as older vintages might be used to offset historical emissions. For co-benefits, it encourages the further development of existing programs such as the Blue Carbon Initiative, Black Carbon Quantification Methodology, SD Vista, Gold Standard for the Global Goals, and Climate, Community & Biodiversity (CCB) Standards.[42]

International Carbon Reduction & Offset Alliance (ICROA)

ICROA is a non-profit membership organization for promoting best practices within the voluntary carbon market, and its code of best practice is widely used among corporations to commit to credible international standards for sourcing and using carbon credits. In its response to the Taskforce report, it strongly discourages an independent third-party organization to audit voluntary carbon market standards, and would rather maintain the independence of the current standards. ICROA also warns

[42] The Taskforce on Scaling Voluntary Carbon Markets, "TVSCM Final Report", January 2021, https://www.iif.com/tsvcm

against using corresponding adjustments and exporting carbon reductions from the host country, as this can delay private investments in the voluntary markets.[43]

Science Based Targets Initiative (SBTi)

The initiative counts a total of 1,274 corporate targets and commitments, and is a joint initiative by the Carbon Disclosure Project (CDP), the United Nations Global Compact (UNGC), the World Resources Institute (WRI), and World Wildlife Fund (WWF). At the moment, the organization is working on publishing a set of net zero criteria and guidance applicable to the targets ahead of COP26 in November 2021. Previously, carbon offsets could not count towards these targets, but in the most recent public consultation report, it suggests high quality carbon credits as an eligible compensation action. Criteria include measurability, additionality, durability, unique retirement, verified impact, ex-post issuance, and vintage must be no further than 3 years from the neutralization year.

4.2 Forecast of carbon offset markets

In this section, we provide an overview of what the literature expects the supply and demand of carbon offsets to look like by 2050.

4.2.1 Supply

Currently carbon offsets account roughly for 100 MTCO2 per year but they have the potential to grow up 8~12 GTCO per year by 2030[44] and up to 11.2~36.5 GTCO per year by 2050.[45] Supply costs vary significantly by offset solutions. Below are the reference cost ranges of offset solutions that we examine in this report. It is important to highlight that numbers vary widely according to different sources; this study attempted to choose, combine, estimate or compare the most logical estimations according to expert opinion.[46]

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[43] International Carbon and Offset Alliance, "Icroa`s Response to the Task Force on Scaling Voluntary Carbon Markets", December 2020 https://www.icroa.org/resources/ICROA%20Papers%20-%20Reponses/ICROA%20Response%20to%20TSVCM%20Consultation%20Document.pdf

[44] Christopher Blaufelder, Cindy Levy, Peter Mannion, and Dickon Pinner, "A blueprint for scaling voluntary carbon markets to meet the climate". McKinsey & Co., January 2021 https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

[45] Added amount of values per solution in the table below.

[46] These would be input values for the model in section 8.

Table 4.4: Supply and Prices for Carbon Offset

Solution	Current Supply		2050 Supply		Comments
	Cost (1)	Capacity (2)	Cost (3)	Capacity (4)	
	US$ / ton CO2	MTon CO2/year	US$ / ton CO2	GTon CO2/year	
AD/A/R	$3~10	80~100	$50~90	5.7-15.1	1,4 Ecosystem Marketplace[47] 2 State of Voluntary Carbon Markets[48] 3 Goldman Carbonomics[49]
Ocean	$5~10	1~5	$10~100	0.50–1.38	1 Shell Indonesia[50] 2 Blue Carbon Initiative & Other Projects[51] 3,4 American University[52]
ALM	$10~20	2~10	$0~100	2.0~5.0	1,2 Norway, Australia,Brazil & US Projects[53] 3,4 American University[54]
DACCS	$200~600	<1	$46~146	0.5~10.0	1 Carbon180[55] 2,4 NCS for US & IEA[56] 3 Rhodium Analy Groups[57]
BECCS	$100~400	1.5	$20~175	2.5~5.0	1 Goldman Carbonomics & GCC Institute[58] 2,4 ICEF BiCRS[59] 3 GCC Institute: Ethanol[60]

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[47] Donofrio, et al., "State of the Voluntary Carbon Markets 2020: The Only Constant is Change", Ecosystem Marketplace, Dec. 2020, https://www.forest-trends.org/publications/state-of-the-voluntary-carbon-markets-2020-the-only-constant-is-chang

[48] Donofrio, J., Maguire, P., Zwick, S., Merry, W. et al. "Financing Emissions Reductions for the Future". Ecosystem Marketplace. December 2020, https://www.forest-trends.org/wp-content/uploads/2019/12/SOVCM2019.pdf

[49] Estimation assuming higher standards lead to higher forest offset costs. Michele Della Vigna, Zoe Stavrinou, Nikhil Bhandari, Neil Mehta & Brian Singer, "Carbonomics: The Future of Energy in the Age of Climate Change". Goldman Sachs, December 2019 https://www.goldmansachs.com/insights/pages/gs-research/carbonomics-f/report.pdf

[50] Estimation based on Shell`s Peatland Restoration project in Indonesia https://wrm.org.uy/articles-from-the-wrm-bulletin/section1/driving-carbon-neutral-shells-restoration-and-conservation-project-in-indonesia/

[51] Estimation based on current projects ocean offset projects of the "Blue Carbon Initiative" https://www.thebluecarboninitiative.org/ and Shell`s Peatland Restoration project in Indonesia (See footnote 50)

[52] American Univ, "Fact Sheet: Blue Carbon", https://www.american.edu/sis/centers/carbon-removal/fact-sheet-blue-carbon.cfm

[53] Estimation based on the projects in the aforementioned countries, see section 5.3.3.4

[54] American University. "Fact Sheet: Soil Carbon & Biochar", 2018 https://www.american.edu/sis/centers/carbon-removal/upload/icrlp_fact_sheet_soil_carbon_biochar_181006.pdf

[55] Conservative range from Carbon180. "Factsheet: Direct Air Capture", April 2020

[56] Range compiled from: Joseph Fargione, et. al, "Natural climate solutions for the United States". Science Advances, November 2018 https://advances.sciencemag.org/content/4/11/eaat1869 & the IEA https://www.iea.org/reports/direct-air-capture

[57] "Capturing Leadership: Policies for the US to Advance Direct Air Capture Technology," Rhodium Group, May 2019, P.28.

[58] Conservative range compiled from: "Carbonomics: The Future of Energy in the Age of Climate Change" (See footnote 49) & Christopher Consoli, "Bioenergy and capture capture and storage", Global CCS Institute, 2019 https://www.globalccsinstitute.com/wp-content/uploads/2019/03/BECCS-Perspective_FINAL_18-March.pdf

[59] David Sandalow. "Biomass Carbon Removal and Storage Roadmap", Innovation for Cool Earth Forum, January 2021 https://www.icef-forum.org/pdf/2020/roadmap/roadmap.pdf

[60] Estimating BECCS technologies get as efficient as Ethanol today or won't be significant. Christopher Consoli, "Bioenergy and capture capture and storage", Global CCS Institute, 2019 https://www.globalccsinstitute.com/wp-content/uploads/2019/03/BECCS-Perspective_FINAL_18-March.pdf

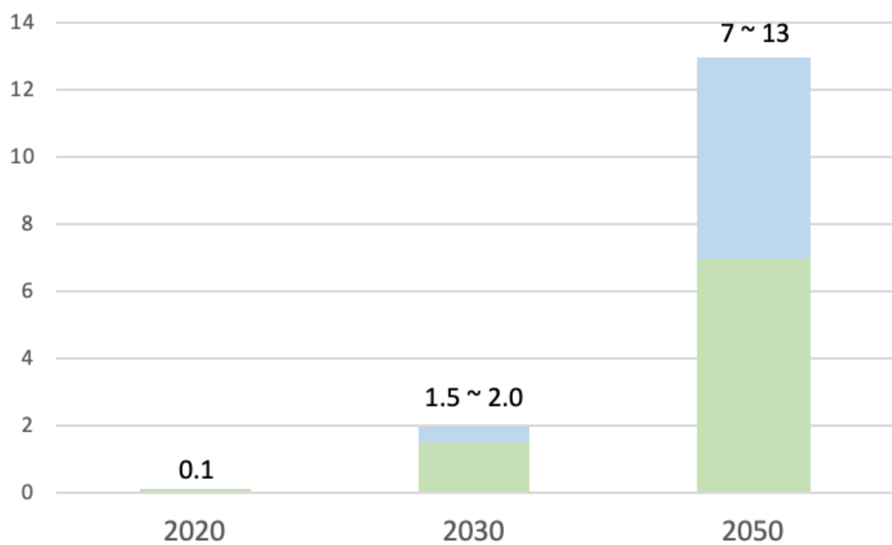
In terms of prices, Nature-Based Solutions (NBS) are the cheapest solutions, and Technology-Based Solutions (TBS) tend to be the most expensive. For example, our estimation is that currently, most NBS are less than US$20 per ton of CO2, while most TBS are more than US$100. Therefore, investment and trading in Nature-Based Solutions (mainly forest-based) are now dominant in the offset market because they can assure higher quantities and lower prices than Technology-Based Solutions.[61]

It seems that this tendency will change in the future. Technology-based solutions will become cheaper when scaling up due to an increase in demand, and Nature-Based Solutions will become more expensive as a higher emphasis on removal and quality is made.

4.2.2 Demand

Regardless of aiming towards the 1.5 C goal or 2.0 C goal, demand for carbon offsets exceeds supply. The Taskforce estimates that the carbon offset market must expand by 15 times more than the current level by 2030 and up to 100 times by 2050 to achieve the 1.5C goal.[62]

Figure 4.7: Voluntary Demand Scenarios for Carbon Credits, Gigatons per year



4.2.3 Carbon credits price

Predicting carbon credit prices is complicated given demand and supply dynamics and the cost curves of the different solutions. Demand is expected to increase as corporate commitments increase, pushing prices up. Supply is also expected to increase, responding to the increase in demand and higher prices.

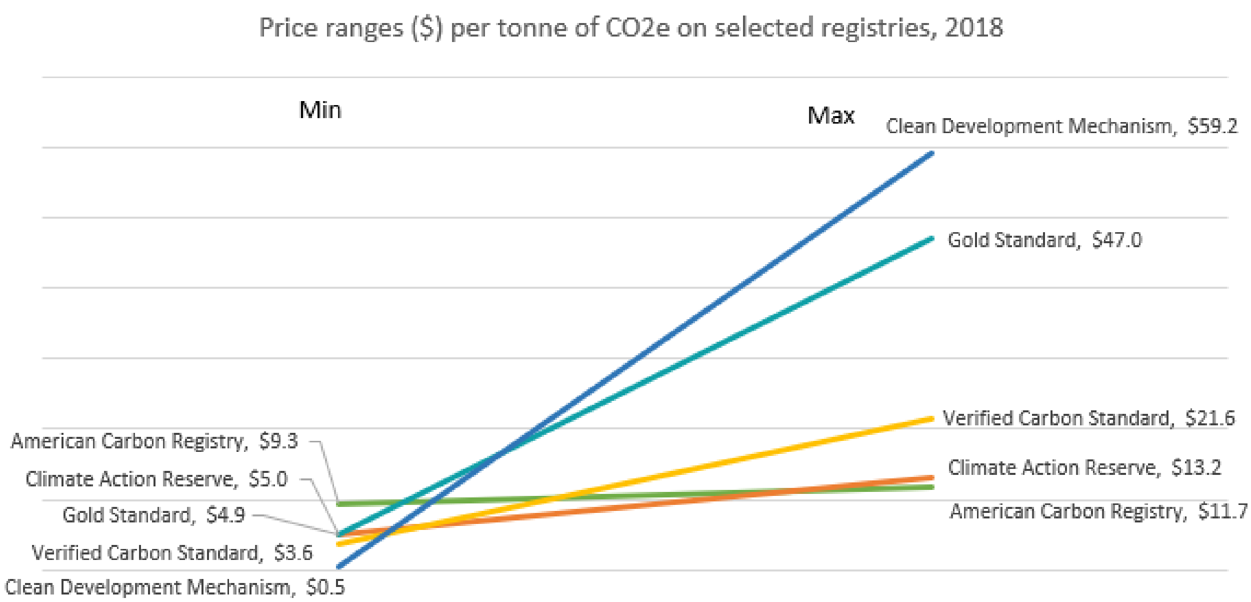
[61] Gross, Anna. "Carbon Offset Market Progresses during coronavirus". Financial Times. https://www.ft.com/content/e946e3bd-99ac-49a8-82c9-e372a510e87c

[62] Christopher Blaufelder, Cindy Levy, Peter Mannion, and Dickon Pinner. "A blueprint for scaling voluntary carbon markets to meet the climate", McKinsey & Co., January 2021 https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

For example, a senior official at a verification institution maintains that future carbon sink capacity will significantly depend on price.[63] However, supply is more constrained given the capital-intensive nature of Technology-Based Solutions and the time it takes to develop and verify offset projects.

Supply is also constrained by external factors. Take forestry as an example; forests are affected by comparing the opportunity cost of agriculture. If producing crops is more profitable, landowners wouldn't stop deforestation and turn their forests into croplands. Therefore, offset prices should be more attractive and competitive pricing than agriculture. On the other hand, replacing agriculture with forestry might disrupt the food supply, particularly in less-developed countries. As seen in the chart below, prices can vary significantly depending on the standard.[64]

Figure 4.8: Variation in Offset Prices by Registry



Prices will also change based on policy decisions. If major countries enact carbon pricing or carbon border taxes, carbon prices will react to those policy changes. In addition, EU-ETS prices will continue to vary based on initial allocations and allowance expirations. For example, EU-ETS sets allowance expiration dates depending on the duration of the market. However, if allowances that have not been used within the specified period are carried over to the next period, allowances will be temporarily oversupplied in the next period.[65] In 2007, allowance prices actually plummeted and did drop again in 2013 due to overallocation.

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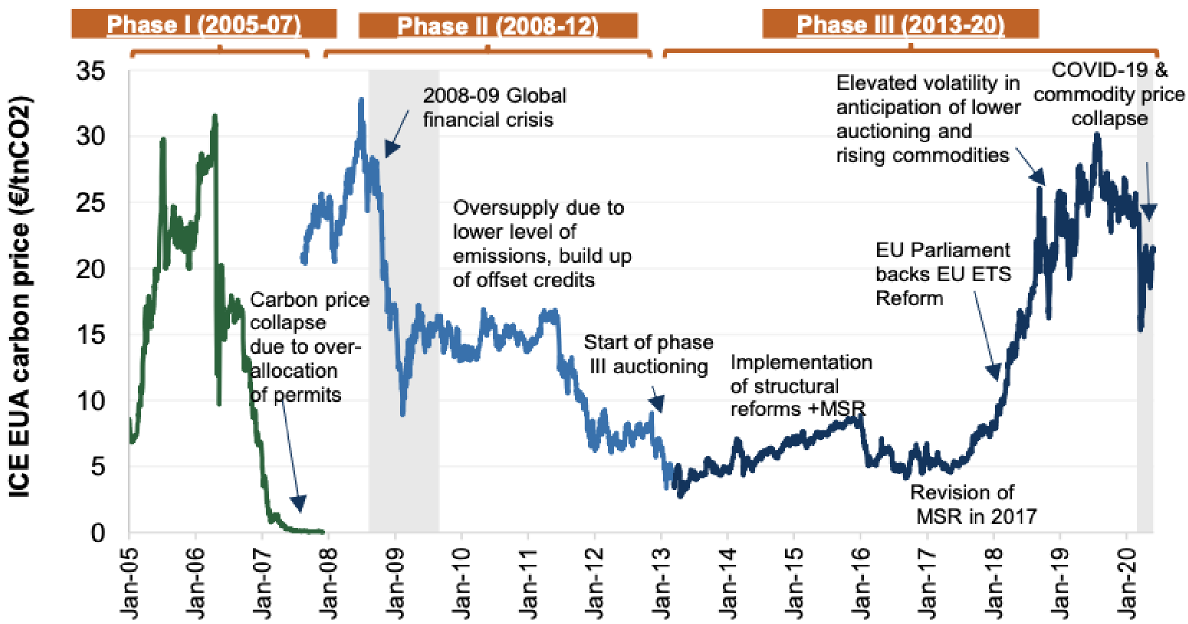
[63] Interview with American Carbon Registry, March 19, 2021

[64] Gross, "Carbon Offset Market Progresses during coronavirus", https://www.ft.com/content/e946e3bd-99ac-49a8-82c9-e372a510e87c

[65] Goldman Sachs, "Carbonomics: The Green Engine of Economic Recovery", https://www.goldmansachs.com/insights/pages/gs-research/carbonomics-green-engine-of-economic-recovery-f/report.pdf

Carbon prices will also change based on macroeconomic performance. Carbon prices, just like any other prices, will respond to recessions. It took five years for the EU ETS to recover after the 2008 economic crisis. The figure below shows the EU ETS carbon prices and their response to economic shocks.

Figure 4.9: ICE EUA Carbon Price, 2005 - 2020 (EUR/ton CO2)[66]



Below we present some indicative figures of carbon prices (USD/tons CO2e):

- $3-42: EU-ETS's EUA price during phases II and III (2008–2021)
- $37: social cost of carbon, 2020 Baseline Scenario (William Nordhaus, 2017)[67]
- $45: social cost of carbon, Central Estimate (US Interagency Working Group, 2017)[68]
- $52: social cost of carbon, Near Term to Net Zero approaches, benchmark scenario with a completion target of 2050 (Noah Kaufman, 2020)[69]

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[66] ICE, Thomson Reuters Datastream, Goldman Sachs Global Investment Research

[67] Nordhaus, "Revisiting the Social Cost of Carbon", Proceedings of National Academy of Sciences, 114(7) , January 2017

[68] Interagency Working Group on the Social Cost of Carbon, United States Government, "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866", February 2010, https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf

[69] Kaufman, "A Near-Term to Net Zero Alternative to Social Cost of Carbon for setting Carbon Prices" https://www.energypolicy.columbia.edu/research/article/near-term-net-zero-alternative-social-cost-carbon-setting-carbon-prices

5. Carbon Offset Mechanisms

5.1 Screening Criteria for Offset Solutions

To assess each offset solution, we developed a list of criteria with input from Equinor. These criteria represent the most important aspects to analyze when determining which solutions are the most adequate for Equinor to purchase. Based on these criteria, we will evaluate potential offset solutions for Equinor. The table below shows the screening criteria and the definitions.

Table 5.1: Screening Criteria for Offset Solutions

Category	Criteria	Definition and Scoring Methodology
Scaling	**Readiness**	Whether the solution is proven in today's market and there are offsets available to purchase. A purchase of more than 50,000 tCO2 is possible (3). A purchase between 50,000 tCO2 and 10,000 tCO2 is possible (2). Purchases below 10,000 tCO2 are possible (1).
	Available volume	Expected growth in delivering offset volumes in 2030 and 2050. A purchase of more than 500,000 tCO2 is possible by 2030 (3). A purchase between 500,000 tCO2 and 100,000 tCO2 is possible by 2030 (2). Purchases below 100,000 tCO2 are possible by 2030 (1).
Environmental integrity	**Verifiability**	Whether the project or solution is continuously verified by a third party. The project is verified by different certified third-party organizations over its lifetime with annual verification intervals (3). The project is verified by a certified third-party organization with verification intervals above 1 year (2). The project is not verified, or there are concerns about the verification body or interval (1).
	Permanence	Length of time that the solution stores carbon and the probability of reversals. Solution stores carbon for more than 200 years and probability of reversals is low (3). The solution stores carbon for more than 100 years and the probability of reversals is moderate (2). The solution stores carbon for less than 100 years or the probability of reversals is high (1).
	Additionality	An offset is additional if it had not occurred in the absence of a market for carbon credits. The possibility to sell carbon offset credits must play a decisive role, as it must face financial and technological barriers. Also, projects need to pass a regulatory surplus test to ensure it's not mandated to cut emissions. The project's offsets are definitely additional (3). There is some uncertainty about the offsets' additionality (2). It is hard to

		determine if the offsets are additional (1).
	Leakage	The project offsetting the emissions does not cause the emissions to occur elsewhere, and the project accounts for its effect on GHG emissions elsewhere. Estimated leakage emissions are close to 0 per year (3), <100,000 tCO2 per year (2), >100,000 tCO2 per year (1)
Cost	**Price in 2021**	The price of purchasing a credit to offset 1 ton of CO2 with this technology in 2021. <US$50/ton CO2 (3), <US$100/ton CO2 (2), <US$150/ton CO2 (1).
	Price in 2050	The price of purchasing a credit to offset 1 ton of CO2 with this technology in 2021. <US$100/ton CO2 (3), <US$150/ton CO2 (2), <US$200/ton CO2 (1).
Project Benefits	**Biodiversity (Co-benefits)**	Whether the offsets have the possibility of improving the local biodiversity in net terms. The solutions have potential high co-benefits for local biodiversity (3), the solution will not harm local biodiversity (2), the solutions could harm local biodiversity (1)
	Local Community (Co-benefits)	Whether the offsets have the possibility of improving the local community in net terms. The solution has potential high co-benefits for local communities (3), the solution will not harm local communities (2), the solutions could harm local communities (1).
	Greenwashing Risk	Whether the offset contributes to building a positive communication strategy for Equinor and whether it creates the risk of 'Greenwashing'. The offset contributes to Equinor's communication strategy and Greenwashing risk is low (3). The offset's contribution to communication strategy is low and Greenwashing risk is moderate (2). The offset does not contribute to communication strategy or Greenwashing risk is high (1).
	Target countries	Is the offset project in the U.S., U.K., Brazil, or Norway. It's available in at least the U.S. and Brazil (3). It's available in at least one country (2). It's not available in any of the countries (1).
	Synergies with Equinor	Does the project complement or create synergies with Equinor's current products and services? This could be taking advantage of Equinor's renewable energy fleet or its CO2 transport and storage

		value-chain. There is large synergy potential with Equinor's operations (3). There are some synergies with Equinor's operations (2). There are no synergies with Equinor's operations (1).
Project-Level Considerations Regarding Carbon Accounting	**Timing**	Ability to provide a vintage between 1-4 years prior to the emissions intended to be canceled out. Older vintage credits could have been generated under less stringent requirements, and are more likely to trade at a lower price, which could lead to "greenwashing" accusations.
	Accounting	Low risk of inflating credit values, and relies on ex-post credit issuance. Credits issued at an ex-ante basis signals a significant time between the project start date and the actual emission reductions, and would constitute an unnecessary risk of reversal.

5.2 Carbon Offset Solution Comparison

Based on the criteria presented above, we are building a tool to help us visualize an overall comparison of the offset solutions currently available. At this moment, we only included the solutions that we are exploring in this report. However, we can add other technologies to this visualization.

The tool creates a weighted-average score for each offset solution. Each of the criteria above received a weighting that can be modified to correctly reflect Equinor's objectives. Then, based on our research we gave a score of one (1), two (2), or three (3) to each solution for each of the criteria. Three is the best and one is the worst. The last column calculates the weighted average score for each technology, with a minimum of one and a maximum of three.

For the final report, we plan on improving this table by providing a methodology for scoring each of the criteria, modifying the weights of the criteria based on Equinor's comments, and adding more technologies. Initial results show that Direct Air Capture with Carbon Storage (DACCS) and reforestation and afforestation have the best scores. However, as we improve the methodologies the results could change. The table below shows an initial assessment of the technologies that we have researched so far.

Table 5.2: Comparison of Offset Solutions

	Criteria	Readiness	Potential Volume	Verifiability	Permanence	Additionality	Leakage	Current Cost per CO2 Ton	2050 Cost per CO2 Ton	Biodiversity Co-benefits	Local Communities Co-benefits	Greenwashing Risk	Availability in Targeted Countries	Synergies with Equinor´s Capabilities	Final Score
	Weight (1-10)	5	4	10	7	8	6	7	6	5	5	8	4	6	NA
Project Sub-category	**Project Type**														
Forestry and Land Use	Afforestation/reforestation	3	3	1	2	2	2	3	3	3	3	1	3	1	**2.04**
	Improved forest management	3	3	1	2	1	1	3	3	2	2	1	3	1	**1.71**
	REDD - Avoided planned deforestation	3	3	1	2	1	1	3	3	2	2	1	3	1	**1.71**
	REDD - Avoided unplanned deforestation	3	3	1	2	1	1	3	3	2	2	1	3	1	**1.71**
Ocean solutions	Mangrove	2	3	2	2	2	2	2	3	3	2	1	2	3	**2.3**
	Seaweed	2	3	2	2	2	2	2	3	3	2	1	2	3	**2.3**
Technology-Based Solutions	Direct Air Capture with Carbon Storage	2	3	3	3	3	3	1	2	2	2	3	2	3	**2.53**
	Bioenergy with Carbon Capture and Storage	2	3	2	3	2	3	1	2	2	2	2	2	2	**2.08**
	Biochar	1	3	3	2	3	2	1	2	2	2	2	2	1	**2.07**

The weights presented in the table above reflect what we have observed in existing literature and the market. However, Equinor will be able to adjust these weights based on their objectives. Below we justify the weights we provided for each criterion.

Readiness

Readiness is important for ensuring that Equinor invests in solutions that are proven. Most of the solutions in this analysis are proven and therefore score high in this category. The initial weight for readiness is 5. This weight reflects that this criterion is not one of the most decisive ones given that technologies evolve over time and a solution that scores low on readiness now might score well on it in the future.

Potential Volume

Potential volume is important to inform Equinor's view of the solution in the future. The initial weight for potential volume is 4. This weight reflects that potential volume should not stop Equinor from purchasing offsets from this solution if their potential volumes are not expected to increase. It's likely that many solutions will be needed to achieve Equinor's climate targets and even small amounts of a good offset can make a difference.

Verifiability

Verifiability is important because Equinor wants to make sure their offsets are correctly accounted for and that a third party provides an independent opinion. The initial weight for verifiability is 10 given that transparency and an accurate assessment of the offset are key for achieving climate goals while maintaining good societal standing.

Permanence

Permanence reflects the length of time the solution stores carbon but also the probability of reversals. The initial weight for permanence is 7, reflecting mostly the importance of the probability of reversals. Ideally, the length of time that carbon is stored is long but if it's not very long then it can be solved by purchasing more offsets when the lifecycle ends.

Additionality

Ensuring the offsets are additional is one of the most important aspects. The initial weight for additionality is 8. Although it is one of the most important criteria, it is hard to prove. Therefore, a higher weight could penalize even great projects. A weight of 8 reflects its importance but understands that it is hard to assess the additionality of an offset. There are different ways to define and measure additionality, but most focus on demonstrating financial and technological barriers, while passing a regulatory surplus test.[70]

Leakage

In a similar way than additionality, leakage is difficult to assess. Therefore, it's weight of 6 reflects its importance without penalizing potential good projects. In addition, the scoring methodology for it

[70] World Bank Group, Partnership for Market Readiness. "Carbon Credits and Additionality: Past, Present, and Future
https://openknowledge.worldbank.org/bitstream/handle/10986/24295/K8835.pdf?sequence=2%26isAllowed=y

focuses on the uncertainty reflected in assessing leakage. Projects for which it is very certain that leakage is not an issue will score better than projects in which the effect of leakage is uncertain.

Price in 2021
Prices are important but are not the decisive factor. This is reflected in their weight of 7. In particular in 2021, some solutions might have high prices but purchasing might still be encouraged to increase scale and reduce future prices.

Price in 2050
2050 prices are important but are not the decisive factor. This is reflected in their weight of 6. This criterium is weighted lower than prices in 2021 because of the uncertainty around what prices will be in 2050.

Co-benefits
Beyond the carbon accounting, offsets can deliver positive outcomes for corporate ESG criteria. Each program often allows for specific standards that certify sustainable development impacts. In the case of the Gold Standard, it aligns it with the SDG under the "global goals" standard, where projects seeking validation must contribute to at least 3 SDGs, and one of them must be SDG 13 climate action.[71] A comprehensive list of co-benefits standards is found below. For the purpose of the comparison, biodiversity and local communities are split, as these might be weighted differently. Currently, both are weighted as a 5. Co-benefits are useful in aligning specific projects with ESG focus areas, but should have lower priority than the reliability of the project to drive down emissions.

Table 5.3: Certifications and Co-benefits

Program	Certification	Areas
Gold Standard	Gold Standard for the Global Goals	SDG 13 - emission reductions & black carbon reductions SDG 7 - renewable energy certificate labels SDG 6 - water benefit SDG 5 - gender equality SDG 3 -improved health outcomes
VCS	Climate, Community & Biodiversity Standards (CCB)	Contains sub-sections for climate, community and biodiversity.
VCS	Sustainable Development Verified Impact Standard (SD VISta)	Aligns co-benefits with SDGs within the Verra registry.

[71] Axel Michaelowa, Igro Shishlov, Stephan Hoch, Patricio Bofill, and Aglaja Espelage. "Overview and comparison of existing carbon crediting schemes". Nordic Environment Finance Corporation. February 2019 https://www.nefco.int/wp-content/uploads/2019/05/NICA-Crediting-Mechanisms-Final-February-2019.pdf

Women Organizing for Change in Agriculture (WOCAN)	W+	SDG 13 - Climate action SDG 5 - Gender equality
The Ecológica Institute	SOCIALCARBON	Social, human, financial, natural, biodiversity and carbon aspects.

Greenwashing Risk

Greenwashing risk has become increasingly important as more companies announce climate targets and some companies start making claims about their carbon footprint. The initial weight for greenwashing risk is 8, which reflects the importance of Equinor maintaining good standing and being able to lead the oil sector in climate efforts.

Target Countries

Ideally, Equinor would purchase offsets from projects in the countries where they operate. However, not all offsets are available in these countries. The initial weight of 4 reflects that this is a preference rather than a required characteristic.

Synergies with Equinor

There are several opportunities for Equinor to contribute their experience in deploying projects in the carbon removal supply chain. The initial weight for synergies with Equinor capabilities is 6, given that it is also a preference and not a requirement. However, the score is slightly higher given the need for deploying these technologies.

5.3 Nature-Based Solutions

This section analyses the main types of Nature-Based Solutions available, deforestation, reforestation, afforestation, improved land management, mangroves, and seaweed.

5.3.1 Deforestation, Reforestation, Afforestation

Forests cover one quarter of the world's landmass and hold as much carbon as the atmosphere, making them the most important ecosystem for the global carbon cycle.[72] Currently, there are three different project types that are eligible to produce carbon offsets: afforestation or reforestation, avoided conversion, and improved forest management (IFM).[73]

- **Afforestation/Reforestation (A/R):** Carbon is sequestered and offsets generated through the creation or re-establishment of forests.
- **Avoided Conversion (AC):** Preventing the conversion of forested land to non-forested land, and the avoided carbon dioxide emissions through this conservation effort yield offsets. Under the

[72] Ni, Y., Eskeland, G.S., Giske, J. et al. "The global potential for carbon capture and storage from forestry". Carbon Balance Manage 11, 3 (2016), https://doi.org/10.1186/s13021-016-0044-y

[73] The Climate Trust, "Forest Carbon Projects". February 2018, https://climatetrust.org/forest-carbon-projects-faq/#:~:text=A%20%E2%80%9Cforest%20carbon%20offset%2C%E2%80%9D,compensate%20for%20emissions%20occurring%20elsewhere.

Verified Carbon Standard, Reduced Emissions from Deforestation and Degradation (REDD) is similar to AC.

- **Improved Forest Management (IFM):** Projects involve land management activities that increase or at a minimum maintain the current level of carbon stocking.

5.3.1.1 Costs

Forest carbon offsets prices are dynamic and can vary from compliance market to voluntary market, from project to project, and over time. There is a wide range of factors that influence the price of carbon credits, including type and location of projects, additional project benefits, marketing, and others. As corporate demand continues to grow, the A/R offset volume has been increasing dramatically. In 2018, issuances of A/R offset transactions rose by 342%. Currently, most forestry offsets on the voluntary market fall roughly within the range of $3 to $10 per ton of CO2. Avoided unplanned deforestation, avoided planned deforestation, and A/R projects credits are transacted with average prices of $3.65, $4.21, $7.69 per ton of CO2, respectively.[74] With the excess supply selling off, prices on the voluntary carbon market are expected to rise as companies vie for quality projects.[75]

High carbon prices would lead to more removals. One research estimates that CO2 removals from tropical reforestation between 2020–2050 could be increased by 5.7 $GtCO_2$ to 15.1$GtCO_2$ if prices increase.[76] In terms of the different regional potential, Latin America comprised 40% of low-cost removals from reforestation between 2020 and 2050 at US$20 per ton, followed by Africa (36%) and Asia (24%). Latin America also comprised 48% of low-cost reductions in emissions from deforestation, followed by Asia (29%) and Africa (23%). Specifically, Brazil ranks top among all other nations in terms of the potential for increased removals from tropical reforestation and reduced emissions from deforestation between 2020 and 2050. [77]

5.3.1.2 Co-benefits and communication strategy

Voluntarily purchasing forestry carbon offsets has become increasingly attractive to corporates who are looking to showcase green credentials. With a wide range of co-benefits including supporting biodiversity and helping communities thrive, forest carbon offset can be a cost-effective way for Equinor to reach carbon neutrality goals, demonstrate commitments to protecting the environment, and corporate social responsibility.

5.3.1.3 Jurisdiction vs. Project

There is debate over the appropriate scale of crediting for emissions reductions from the forest sector. The jurisdictional approach and project-based approach have different advantages and risks.

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[74] Donofrio, J., Maguire, P., Zwick, S., Merry, W. et al. "State of the Voluntary Carbon Markets 2020: The Only Constant is Change,. Ecosystem Marketplace, December 2020. https://www.forest-trends.org/publications/state-of-the-voluntary-carbon-markets-2020-the-only-constant-is-chang

[75] CJ Clouse, "Conserving and restoring forests won't be cheap and easy after all", Greenbiz. February 2020. https://www.greenbiz.com/article/conserving-and-restoring-forests-wont-be-cheap-and-easy-after-all

[76] Busch, J., Engelmann, J., Cook-Patton, S.C. et al. "Potential for low-cost carbon dioxide removal through tropical reforestation", Nat. Clim. Chang. 9, 463–466 (2019), https://doi.org/10.1038/s41558-019-0485-x

[77] ibid.

Jurisdictional approach: Government authorities themselves take the lead in designing and implementing forest protection strategies. In theory, the jurisdictional approach can generate huge volumes of high-quality credits at a scale. Concerted government actions regulate land use and address a broad range of deforestation drivers through relevant policies. The jurisdictional approach is effective in addressing potential leakage inside a country as it can spread carbon accounting and control across entire jurisdictions. Political leadership is key to advancing a jurisdictional approach, but it is also a primary risk. For example, recent reversals in the trajectory of forest loss in Brazil are linked to rollbacks in national government policy.[78] Therefore, corporate buyers should pay attention to whether the approach is designed to be resilient to political change and policy reversals.

Project-based approach: One major advantage of purchasing project-scale emission reduction credits is that activities centered on specific areas lend themselves to communications of easy-to-understand objectives associated with iconic wildlife, protected areas, and specific communities.[79] It is also easier to link to existing local activities for the company or the customer i.e., the buyer of a carbon-neutral LNG cargo. However, project-based REDD is particularly subject to the leakage problem. Project-scale interventions cannot effectively address deforestation that is displaced to another location.

5.3.1.4 Advantages and disadvantages

Advantages: Forest can be competitive offset solutions given their relatively low credit prices and the wide range of potential co-benefits. Forests provide a range of ecosystem services that forest sector offset projects can maintain and expand. These may include increased local livelihoods, maintaining ecosystems and biodiversity, local farm productivity (pollination and precipitation services), limiting runoff, and water filtration.

Disadvantages: Forestry projects have a number of characteristics that could disadvantage them in generating meaningful CO2 reduction.

- **Additionality:** Determining baseline activity, which may be highly site-specific, is particularly challenging for forest projects. Since the baseline determines how much carbon storage is additional, this makes additionality uncertain.
- **Permanence:** There is considerable risk that forest carbon will not be stored permanently. CO2 sequestered by trees can be re-released into the atmosphere due to harvesting, fire, or disease.
- **Leakage:** Forestry projects are particularly prone to leakage, which is difficult to quantify. Significant leakage risk can occur from displacement of harvesting or land-use development.
- **Social and environmental harms:** Poorly-designed forestry projects that do not sufficiently engage local communities and indigenous peoples can have major negative impacts, including livelihood restrictions and even community displacement.

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[78] Rhett A. Butler. "Despite COVID, Amazon deforestation races higher". April 11, 2020. https://news.mongabay.com/2020/04/despite-covid-amazon-deforestation-races-higher/

[79] Frances Seymour, "INSIDER: 4 Reasons Why a Jurisdictional Approach for REDD+ Crediting Is Superior to a Project-Based Approach", World Resources Institute, May 05, 2020, https://www.wri.org/blog/2020/05/insider-4-reasons-why-jurisdictional-approach-redd-crediting-superior-project-based

It should be noted that location matters when it comes to the carbon-removal capacity of forests. Forests in the tropics have comparative advantages since they grow more rapidly and therefore capture more carbon. Tropical forestry projects also lead to a positive change such as the formation of clouds which then reflect the sunlight and cool the planet, whereas forests in high latitudes can cause the earth's surface to grow darker and absorb more heat. [80]

5.3.1.5 Policy

Within the UNFCCC, REDD+ initiatives support developing countries in their efforts to reduce emissions from deforestation and degradation, and to conserve forest carbon stocks. The launch of initiatives such as the Architecture for REDD+ Transactions (ART) and its associated jurisdictional TREES standard would facilitate transactions for companies to purchase jurisdictional-scale credits.

The Paris Agreement stated that countries should protect and enhance forests in order to maintain and create carbon sinks. REDD+ initiatives are currently not covered under the Paris Agreement Article 6. As the negotiations are not yet finalized, REDD+ could eventually be integrated into Article 6 cooperative approaches.[81]

5.3.1.6 Model for Equinor

Equinor should purchase forestry offset credits that meet high-quality verification standards and are diligently monitored. It is also important to target regions where funds from trading carbon offsets will have the greatest impact. Tropical forests should be the main focus given their larger impact on climate compared to forests in other locations. Equinor should also consider prioritizing forestry offsets in Latin American countries, specifically in Brazil, considering the huge potential of low-cost removal and the possible linkage with Equinor's local operations. In addition, Equinor should pay attention not to overestimate co-benefits in justifying forestry offset projects since generating real and meaningful CO2 reduction is the primary goal.

5.3.1.7 Risks to Equinor

Corporates may face criticism for using forests as a greenwashing tool that distracts from generating meaningful CO2 reduction. In the jurisdictional approach, rollbacks in government policies and failures to enforce existing regulations could affect the quality of offset credits and result in price fluctuations.

[80] Ben Guarino. "Climate Solutions: The Audacious Effort to Reforest the Planet" The Washington Post. January 22, 2020.
https://www.washingtonpost.com/graphics/2020/climate-solutions/trillion-tree-reforestation-climate-change-philippines/

[81] Greiner, S., Chagas, T., Krämer, N., Michaelowa, A., et al. "Moving Towards Next Generation Carbon Markets Observations from Article 6 Pilots", June 2019,
https://www.climatefinanceinnovators.com/wp-content/uploads/2019/06/Moving-toward-next-generation-carbon-markets_update-june-2019-1.pdf

5.3.2 Ocean Carbon Capture and Storage Solutions

Over the past 200 years, oceans alone have taken up to 39% of the total anthropogenic emissions (IPCC, 2018)[82]. Oceans are crucial for nature-based solutions because they embody massive carbon capture and long-term storage, containing between 50 and 80%[83] of life on earth and 70%[84] of the planet's surface. Oceans are home to complex, interconnected, and interdependent ecosystems capable of sequestering and storing carbon efficiently and providing many co-benefits.[85]

Nevertheless, coastline ecosystems are being degraded at up to four times that of rainforests. Almost 2-7% of carbon sinks generated by ocean ecosystems are lost annually to anthropogenic damages.[86] As much as 1.02 billion tons of CO2 are being released annually from degraded coastal ecosystems. This is equivalent to 19% of emissions from tropical deforestation globally.[87] Investing in blue carbon, such as seagrass, mangrove, and salt marshes should consider the following information as part of the Equinor carbon offset strategy. The figures below show the multiple spaces of natural carbon capture and storage available in the oceans.

[82] "IPCC Special Report on Carbon dioxide Capture and Storage", 2018 https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_chapter6-1.pdf

[83] UNESCO World Oceans, 2017 http://www.unesco.org/new/en/oceans-day

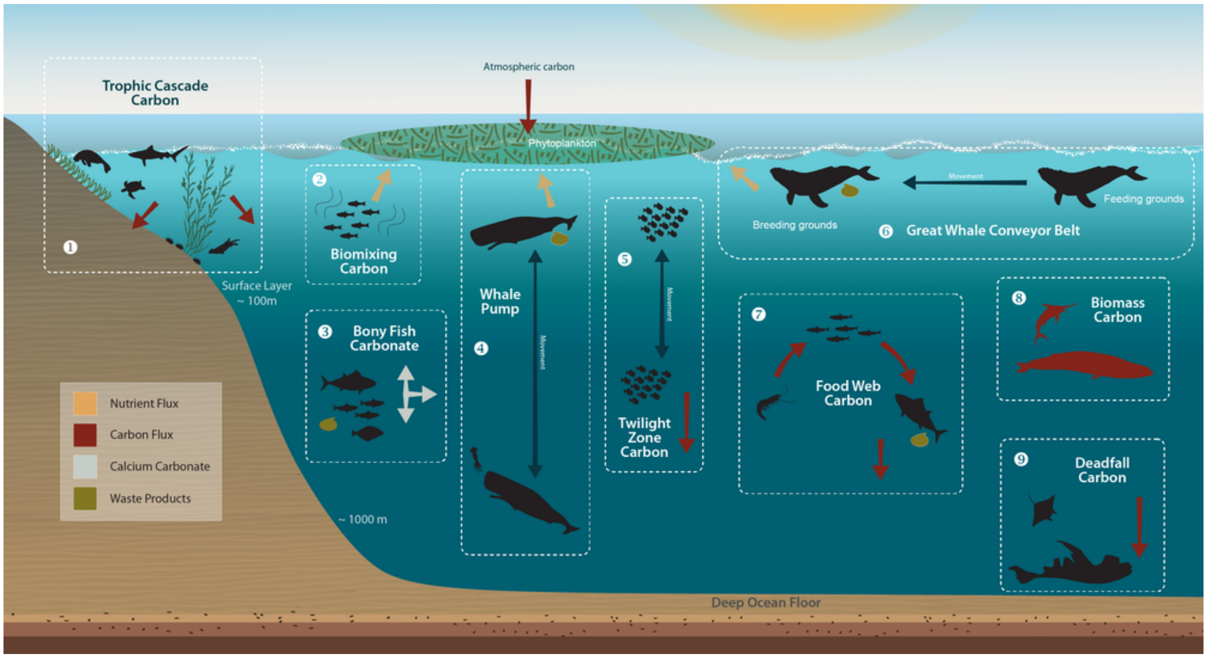
[84] "IFCC 2018 Special Report on Carbon dioxide Capture and Storage", 2018, pg 279

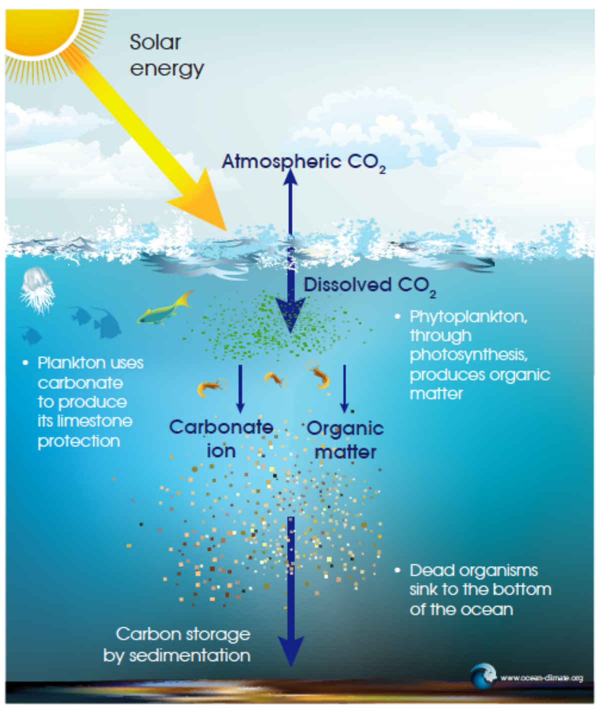
[85] Howard, J., Hoyt, S., Isensee, K., Pidgeon, E., Telszewski, M. (eds.) (2014). "Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows" Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Virginia, USA.

[86] The Institute for Carbon Removal Law and Policy, an initiative of the School of International Service at American University, "Blues Carbon Fact Sheet" https://www.american.edu/sis/centers/carbon-removal/fact-sheet-blue-carbon.cfm

[87] The Blue Carbon initiative. "Mitigating climate change through coastal ecosystem management". Accessed on March 31, 2020. https://www.thebluecarboninitiative.org/

Figure 5.1: Ocean's Carbon Capture and Storage Systems [88]





5.3.2.1 Costs

Blue Carbon is the carbon stored in the sediments and plants in wetlands (peatlands and coastal wetlands, including mangroves, tidal marshes, and seagrasses). Below are some sample costs of blue carbon solutions:

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[88] Lutz, Pearson, Vatter, Bhakta, "Oceanic Blue Carbon", Arendal, 2018

- Degraded coastal wetlands: 29 million hectares with each hectare sequestering an average of 12.1 tons of CO2 per year. Costs found are as low as $10–100 per ton of CO2.
- Degraded peatland: 46 million hectares with uncertain carbon removal benefits.
- Mangroves are estimated to be worth at least US$1.6 billion each year in ecosystem services that support coastal livelihoods and human populations around the world.

5.3.2.2 Co-benefits and communications strategy

The protection and restoration of these ecosystems provide valuable benefits in sequestration and maintaining carbon stocks in soils and vegetation. Restoration also yields co-benefits to communities (e.g., providing habitat for fish, supplying food, reducing the impact of extreme weather). Seaweed aquaculture offers significant potential for developing low-carbon alternatives for food, feed, and many other applications.[89]

The storage of carbon in the seabed has the enormous theoretical potential to divert carbon from the atmosphere. Still, it currently faces significant technical, economic, and sociopolitical challenges (e.g., environmental safety) that must be taken into the risk calculations.

5.3.2.3 Advantages and disadvantages

The main advantages are the following:

- **Biodiversity** protection.
- **Water quality**: wetlands and peatlands filter water
- **Flood control**: wetlands and peatlands reduce flooding and protect coasts against storms.
- Restored mangroves continue to sequester carbon for more than a century.
- Carbon markets tend to focus on carbon offsets achieved through restoration, with much less attention on optimizing the efficiency of existing ecosystems.[90] Blue Carbon has an advantage over other NBS because it has efficient solutions with positive domino effects:
    - Reducing nutrient inputs, avoiding unnaturally high bioturbation levels, and restoring natural hydrology (freshwater flows and tidal exchange) will maximize blue carbon sequestration and minimize blue carbon losses.

The main disadvantages are the following:

- **Saturation**: Seagrass meadows and tidal marshes would saturate in about half a century.
- **Reversibility**: blue carbon can be released if coastal ecosystems are degraded again; societies would need to maintain appropriate wetland management practices indefinitely. Coastal wetlands may also be vulnerable to sea-level rise.
- **The difficulty of measurement**: monitoring and verifying carbon removal via blue carbon is difficult and costly.

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[89] Hoegh-Guldberg, ‘‘The Ocean as a Solution to Climate Change: Five Opportunities for Action’’, Washington, DC: World Resources Institute, http://www.oceanpanel.org/climate

[90] Macreadie , Nielsen et al, 2017 “Can we manage coastal ecosystems to sequester more blue carbon?” https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.1484

- **Non-CO2 greenhouse gases**: some peatlands emit potent non-CO2 greenhouse gases, such as methane, which can offset the climate benefits of carbon removal.[91]
- **Land costs**: some conservation or restoration of coastal blue carbon ecosystems is excessively costly (land uses for tourism and ports) or sufficiently lucrative, and carbon alone is not sufficient motivation for conservation.[92]

5.3.2.4 Policy

The following is a summary of vital recommendations[93] researchers from the World Resources Institute have made for advancing in policy, research, and technology to accelerate the potential of ocean carbon capture and storage. All of the actions selected can be promoted, carried, or invested in by Equinor.

Coastal and Marine Ecosystems (2020–2025):

Policy

- Provide incentives for restoration of blue carbon ecosystems through payments for ecosystem service schemes, such as carbon and nutrient trading credits.
- Protect coral reefs as essential and integrated coastal defense to protect coastal blue carbon ecosystems.
- Enhance and adopt carbon accounting methodologies for mangroves, seagrasses, and salt marsh within national GHG inventories (IPCC 2013).
- Improve methods for monitoring mitigation benefits to enable accounting within national GHG inventories and biennial transparency reports (BTRs).

Research

- Undertake Equinor's projects location-based mapping of blue carbon ecosystems.
- Address biophysical, social, and economic impediments to ecosystem restoration to develop restoration priorities, enhance incentives for restoration.
- Help develop legal mechanisms for the long-term preservation of blue carbon.
- Understand the impacts of climate change on rates of carbon capture and storage.
- Undertake global-scale map of seaweed ecosystems.
- Develop IPCC-approved methodological guidance for seaweed ecosystems.
- Develop methods to fingerprint seaweed carbon beyond the habitat.

Tech

- Advance biorefining techniques, allowing sequential extraction of seaweed products
- Develop and pilot offshore and multiuse sites, including seaweed aquaculture, in open ocean

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[91] The Institute for Carbon Removal Law and Policy, an initiative of the School of International Service at American University, Blues Carbon Fact Sheet https://www.american.edu/sis/centers/carbon-removal/fact-sheet-blue-carbon.cfm

[92] The Blue Carbon Iniciative https://www.thebluecarboninitiative.org/about-blue-carbon

[93] Hoegh-Guldberg, ''The Ocean as a Solution to Climate Change: Five Opportunities for Action'', Washington, DC: World Resources Institute, http://www.oceanpanel.org/climate

Seabed Carbon Storage Priorities 2020–2025

Policy

- Invest in pilot projects to further explore potential environmental impacts
- Incentivize public/private partnerships
- Develop national strategies and targets
- Develop regulatory frameworks to ensure environmental impact assessments and associated precautions are put in place.

Research

- Map global geophysical potential and understand the impacts of long-lasting containment of CO2 in a deep seafloor environment.
- Understand the impacts of long-term storage on marine ecosystems.
- Explore the integrity of long-term storage technologies (leakage).

Tech

- Few major technical advances are required as seabed storage is already deployed at an industrial scale.
- Scale-up technologies in ways that are economically feasible.

Ideas and Proposals:

1. **Large-scale seaweed farming** or ranching of free-floating sargassum can remove the carbon stored in plant biomass by sinking it to the ocean floor or by locking it up in long-lived bioproducts.
2. **Artificial fertilization.** In nutrient-poor waters, the export of carbon into deep oceans or oceans sediments can be boosted by artificial fertilization of phytoplankton either directly with the help of ships or planes or by artificial upwelling of deeper nutrient-rich waters. (enhancing the use of seaweed).
3. **Protecting and restoring** blue carbon ecosystems would prevent emissions associated with ecosystem degradation and increase organic carbon storage in marine soils.
4. **Enhancing ocean alkalinity**[94] leads to increasing the ocean's absorptive capacity of CO2 and counteracting ocean acidification:
    a. Alkalinity added to beaches or the open ocean.
    b. Accelerated weathering of limestone or silicate rock in controlled reactors
    c. Electrochemical seawater treatment facilities
5. **Liquid CO2 Storage:** liquid CO2 from emissions captured on-land could be stored in subsurface geological formations or on the deep oceans.
    a. Solutions include finding ways to increase water density at the poles to accelerate the downward transport of CO2 to the deep ocean.

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[94] The Institute for Carbon Removal Law and Policy, an initiative of the School of International Service at American University. Ocean Alkalinization Fact Sheet https://www.american.edu/sis/centers/carbon-removal/fact-sheet-ocean-alkalinization.cfm

5.3.2.5 Model for Equinor

The ocean plays a protagonist role in the worldwide climate change mitigation strategy for five ocean-based activities: renewable energy, transport, food production, ecosystems, and carbon storage. All areas have significant co-benefits and potential for reducing the emissions gap[95] by up to 21% on a 1.5°C pathway and by about 25% on a 2.0°C pathway by 2050.[96]

According to experts, using all five ocean-based mitigation options could reduce global GHG emissions by nearly 4 billion tons of carbon dioxide equivalent (CO2e) per annum in 2030 and by more than 11 billion tons per annum in 2050, relative to projected business-as-usual emissions.[97] Equinor's advantage in knowledge and usage of oceans and locations for production creates key synergies that have already been explored (Northern Lights).

Carbon storage in the seabed (direct injection into the deep ocean, alkalinity addition, and iron fertilization) has a promising future with --theoretical-- high benefit solutions. Nevertheless, there are economic, technical, and political barriers to be solved and unknown risks or damage to ocean ecosystems for the future.

Up until now, the ocean-based annual mitigation potential in 2050 to keep in mind for building Equinor's portfolio is:

- Coastal and marine ecosystems are expected to have a 0.32–0.89 GtC02e/year (Gigatons of equivalent CO2 Per year) mitigation potential for 2030 and a 0.50–1.38 GtC02e for 2050 mitigation potential
    - **Mangroves:** 0.18–0.29 GtC02e
    - **Seaweed Farming:** 0.05–0.29 GtC02e
    - **Salt Marshes:** 0.05–0.10 GtC02e
    - **Seagrasses:** 0.22–0.70GtC02e
- Carbon storage in the seabed: 0.25–1.0 GtC02e/year in 2030 and 0.50–2.0 in 2050

5.3.2.6 Risks to Equinor

There are no particular higher risks for Equinor compared to other solutions. Equinor should include ocean-based as part of their offsets portfolio since oceans can be tied to the companies' offshore wind and offshore oil products and their current carbon storage projects. Equinor could even work with project developers to implement blue carbon projects in Equinor's coastal properties and offshore leases.

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[95] UNEP, 2018, Emissions Gap Report 2018

[96] Hoegh-Guldberg, ''The Ocean as a Solution to Climate Change: Five Opportunities for Action'', Washington, DC: World Resources Institute, http://www.oceanpanel.org/climate pg4.

[97] Hoegh-Guldberg, ''The Ocean as a Solution to Climate Change: Five Opportunities for Action'', Washington, DC: World Resources Institute, http://www.oceanpanel.org/climate

5.3.3 Agriculture Land Management

Historically, the agricultural sector has been a major source emitter of carbon dioxide, with 10% of total emission in the US. But, recently, with new technologies and methodologies, by improving land management, the agricultural sector sees potential to become a carbon removal provider.

With the following methods, croplands can increase their ability to absorb carbon dioxide emissions.[98]

- Reducing soil disturbance
- Altering planting schedules or rotations
- Grazing livestock in an organized way
- Introducing compost or crop residues usage

Also, agriculture sector has potential to store carbon in soil with the following mechanism:[99]

- Changes in tillage practices
- Crop rotations
- Conversion of acreage to grasslands
- Afforestation: planting of trees or seeds to change open land into forest or woodland.

A recent expert assessment estimates that soil carbon sequestration could be scaled up to sequester 2–5 $GtCO_2$ per year by 2050, with a cumulative potential of 104–130 $GtCO_2$ by the end of the century.

5.3.3.1 Costs

- Supply costs differ significantly by land management methodologies. Also, the location of cropland is a key element of supply cost[100]. Generally, costs are higher than forests management.
    - **Conservation tillage:** \$12.97/TCO_2 (USA), \$19.31/TCO_2 (Central USA), \$10.84/GtC02 (Australia) and \$25/TCO_2 (India)
    - **Continuous cropping:** \$20.34/TCO_2 (Montana, USA)
    - **Crop rotation:** \$129.71/TCO_2 (Senegal) * Semi-arid mixed agriculture and \$20.34/TCO_2 (Australia) * Dryland grain production system

- However, compared to TBS, it’s fair to say that improved agricultural managements is cheaper and more competitive

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[98] The Institute for Carbon Removal Law and Policy, an initiative of the School of International Service at American University. Soil Carbon Sequestration Fact Sheet https://www.american.edu/sis/centers/carbon-removal/fact-sheet-soil-carbon-sequestration.cfm

[99] Luis Ribera, Bruce McCarl, “Carbon Markets: A Potential Source of Income for Farmers and Ranchers”, https://agrilifeextension.tamu.edu/library/agricultural-business/carbon-markets-a-potential-source-of-income-for-farmers-and-ranchers/

[100] Kai Tang, Marit E. Kragt, Atakelty Hailu, and Chunbo Ma. “Carbon farming economics: What have we learned?” Journal of Environmental Management. Volume 172, 2016 https://www.sciencedirect.com/science/article/pii/S0301479716300494

5.3.3.2 Co-benefits and communications strategy

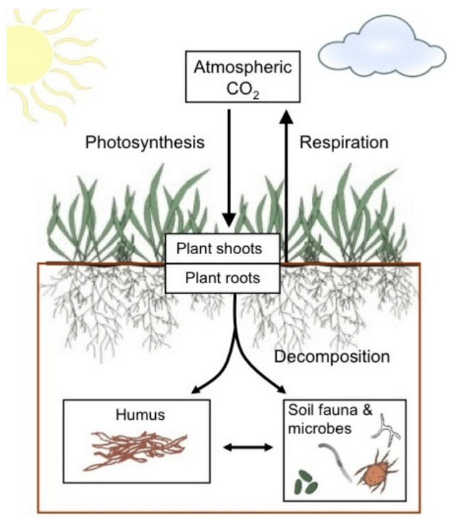
Improved soil management can bring co-benefits to farmers. Not only do carbon sequestration methods increase farmers' income, these methods can reduce vulnerability to soil erosion and nutrient loss including growing green manure crops and cover crops, crop residue retention, reduced/zero tillage, and maintenance of ground cover.[101]

Besides, land degradation in the agriculture system can be prevented. This is ecologically and socioeconomically important for farmers and communities.

5.3.3.3 Advantages and disadvantages

Advantages: Soils hold three times the amount of carbon currently in the atmosphere or almost four times the amount held in living matter.[102] By nature, soils are equipped with carbon sequestration mechanisms through the vegetation.[103] When properly managed, enormous amounts of carbon sequestration potential can be unleashed.

Figure 5.2: Soil Sequestration Cycle



Disadvantages: Similar to the other solutions in this section, monitoring and verifying carbon offset is a difficult task. Solid conditions can change over time, and advanced monitoring solutions such as satellites are not able to provide the same quality verification as seen with forests. Besides, soils are more vulnerable to weather conditions and natural disasters.

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101 IPCC "Report on climate change and land"
https://www.ipcc.ch/site/assets/uploads/sites/4/2020/02/SPM_Updated-Jan20.pdf

102 The Institute for Carbon Removal Law and Policy, an initiative of the School of International Service at American University. Blues Carbon Fact Sheet
https://www.american.edu/sis/centers/carbon-removal/fact-sheet-blue-carbon.cfm

103 Ontl, T. A. and Schulte, L. A. "Soil Carbon Storage". Nature Education Knowledge 3(10):35, 2012
https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/

Also, transforming the conventionally-managed agricultural lands methods to new carbon-friendly ones will require a certain amount of upfront costs.[104]

5.3.3.4 Policy

There is growing political support for agricultural decarbonization and carbon sequestration globally.

US: A law called The Growing Climate Solution Act of 2020 was submitted in 2020, and is under deliberation. The purpose of this law is to (1) issue offset credits through agriculture and (2) assist farmers in making money through offset trading.[105]

Norway: A voluntary agreement between the government and farmer's organizations was signed in June 2019 to reduce as much as five million tons of GHG from the agricultural business between 2021 and 2030 and cooperate toward decarbonization and carbon offsetting in the agricultural sector.[106] This agreement is still aimed for carbon reduction, but this government-farmer cooperation could expand to carbon offset activities in the foreseeable future.

Brazil: The Brazilan government is supporting the Low-Carbon Agriculture (ABC) Plan that includes a credit initiative called the ABC program. This plan provides low-interest loans for sustainable low-carbon agricultural practices such as no-till agriculture, restoration of degraded pasture, integration of crops, livestock, and forest, planting of commercial forests, biological nitrogen fixation, and treatment of animal wastes. The plan also emphasizes extending integrated crop-livestock-forest (ICLF) systems by a further 5 million hectares by 2030, which represents a 43% increase from current levels.[107]

Australia: To accelerate carbon sequestration on farms and further develop the related carbon markets, Carbon Farmers of Australia (CFA) launched the world's first soil carbon industry group in 2020. CFA also concluded a contract with Australia's Emission Reduction Fund to supply over 3 million tonnes of soil carbon sequestration over the next ten years.[108]

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[104] Dufranse, Gilles & Lickel, Sara & Castagné , Manon & Ritter, Tara. "Carbon Markets and Agriculture", Institute for Agriculture & Trade Policy, https://www.iatp.org/carbon-markets-and-agriculture

[105] Fisher, Deb. Fischer Cosponsors Growing Climate Solutions Act of 2020. https://www.fischer.senate.gov/public/index.cfm/2020/11/fischer-cosponsors-growing-climate-solutions-act-of-2020

[106] United States Department of Agriculture, Foreign Agricultural Service. "Government of Norway Publishes Comprehensive Climate Report" https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Government%20of%20Norway%20Publishes%20Comprehensive%20Climate%20Report_The%20Hague_Norway_03-12-2021

[107] Brazilian Farmers, The Brazilian Way: Environmentally-friendly & low-carbon farming. http://www.brazilianfarmers.com/tropical-agriculture-explained/environmentally-friendly-low-carbon-farming/

[108] Hein, Treena, "Soil Carbon Market Could Grow Quickly Globally", https://www.futurefarming.com/Smart-farmers/Articles/2020/12/Soil-carbon-market-could-grow-quickly-globally-691091E/

5.3.3.5 Model for Equinor

There is increasing government support and initiatives for carbon offsets in the agricultural sector in the four countries where Equinor is operating. Therefore, Equinor should follow these trends and participate in offsets in the agricultural sector in these four markets. Also, there is a multinational carbon farming project by Norway, Netherlands, and Germany.[109]

5.3.3.5 Risks to Equinor

In particular, there are no major risks for Equinor. However, it should be noted that many farmers are not familiar with the decarbonization and offset mechanism, as agricultural offset mechanisms are still a new trend. In order to fill this gap, the intermediaries are expected to play an active role, but Equinor needs to carefully follow the process so that the intermediaries can properly organize and proceed with the carbon removal in an effective way and on a meaningful scale.

5.4 Technology-Based Solutions

In this report, we explore the two main technology-based solutions available at the moment: Direct Air Capture with Carbon Storage (DACCS) and Bioenergy with Carbon Capture and Storage (BECCS).

5.4.1 Direct Air Capture with Carbon Storage (DACCS)

Direct Air Capture with Carbon Storage (DACCS) consists of capturing CO2, the Direct Air Capture (DAC) component, and removing carbon dioxide from the atmosphere, and injecting it into geological storage, the storage component. Although the technology is proven, costs are still high. The potential for removing carbon dioxide from the atmosphere is around 10MtCO2/year by 2030.[110] Costs are expected to decrease as deployment increases.

DACCS is the ideal solution to aspire in the long-term. Its technology ensures additional and permanent CO2 capture and storage. Investing early on in DACCS offsets will help scale the technology and help decarbonize hard-to-abate sectors of the economy. In addition, DACCS is aligned with Equinor's efforts in leading the oil and gas industry in low-carbon technologies.

5.4.1.1. Overview

Technology

Direct Air Capture takes CO2 directly from the air. The captured CO2 can then be safely stored underground or used as an input for producing fuels or other products. To be used as an offset, the CO2 captured by the project must be permanently stored, usually underground.

The two main approaches to capturing CO2 directly from the air are using solid or liquid systems. Solid systems use filters that chemically bind with CO2; when these filters are heated, they release CO2 which can then be captured. Liquid systems pass air through chemical solutions, such as a hydroxide-based solution, which removes the CO2 and returns the leftover air back into the atmosphere. The solution is

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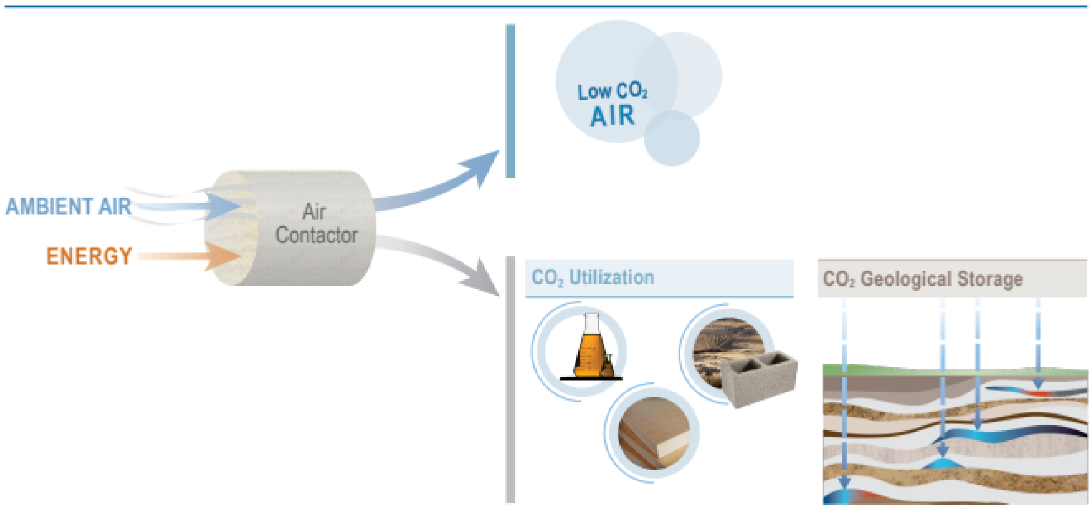
[109] European Regional Development Fund, "Carbon Farming," Interreg North Sea Region Carbon Farming, https://northsearegion.eu/carbon-farming/what-is-carbon-farming/about-the-project/

[110] International Energy Agency. "Direct Air Capture". Accessed March 15, 2021, https://www.iea.org/reports/direct-air-capture

then reused to continue the process. The figure below shows a simple example of how the technology works.

Figure 5.3: Direct Air Capture Process



DACCS requires energy from a clean energy source to be a negative emissions technology. It is well-positioned to benefit from low-cost renewable electricity. It's modular technology and the availability of CO2 around the world would allow developers to site DACCS plants close to their energy source. Its sitting capabilities also enable developers to reduce CO2 transportation costs by sitting the project close to the storage location.

Potential and Scale

DAC can remove 0.5 to 10 $GtCO_2$ annually by 2050 and as much as 40 $GtCO_2$ annually by the end of the century.[111] All decarbonization scenarios show that we will need to remove carbon from the atmosphere, including 9.67$MtCO_2$ / year by 2030.

There are currently 15 Direct Air Capture plants operating worldwide and capturing more than 9,000 tCO2/year.[112] There is also a 1MtCO2/year plant in advanced development in the United States. Of these plants some are paired with permanent storage and others use the CO2 for carbonation or other uses. The figure below shows the existing DAC plants around the world.[113]

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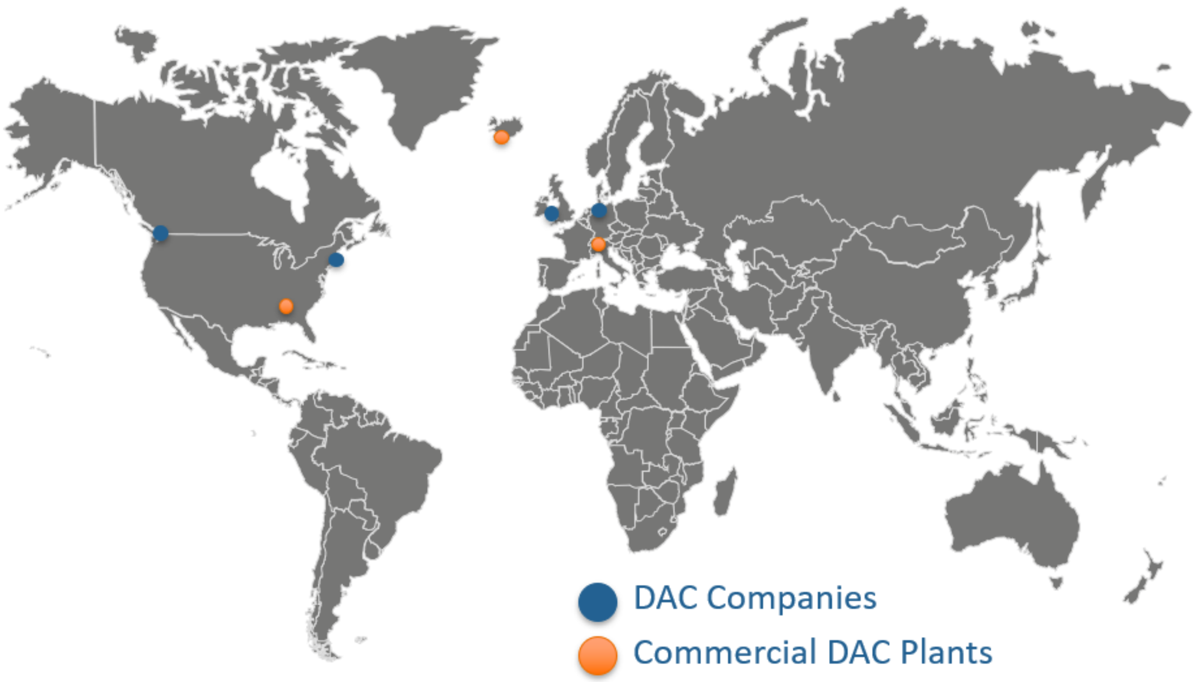
[111] Fargione, J. et al, "Natural climate solutions for the United States", Science Advances; Vol 4, No. 11; November 2018; Accessed February 13, 2021. http://advances.sciencemag.org/content/4/11/eaat1869

[112] International Energy Agency. "Direct Air Capture". Accessed March 15, 2021. https://www.iea.org/reports/direct-air-capture

[113] Carbon180. "The DAC Map". Carbon Brief. Accessed March 1, 2021, https://carbon180.org/dac-mapp

Figure 5.4: DAC Plants Around the World



Among the many DACCS industry players, three companies lead with technology and capital deployment: Climeworks, Carbon Engineering, and Global Thermostat. The three companies have strong financial backing from other oil majors, financial investors, and technology companies. Climeworks is the largest and the one with the most commercial sales so far. Carbon Engineering also has commercial projects and is increasing its scale. Global thermostat only has demonstration projects and reportedly has had several issues with its leadership, contractors, and retaining its staff.[114] The table below shows a comparison of the three companies.

[114] Leslie Kaufman and Akshat Rathi. "A Carbon-Sucking Startup Has Been Paralyzed by Its CEO". Bloomberg. April 9, 2021. Accessed April 13, 2021, https://www.bloomberg.com/news/features/2021-04-09/inside-america-s-race-to-scale-carbon-capture-technology?sref=uFaJcogC

***Table 5.4: Comparison of Direct Air Capture Companies*[115]**

	Climeworks	**Carbon Engineering**	**Global Thermostat**
Location	Switzerland	Canada	United States
System Type	Solid sorbent	Liquid solvent	Solid sorbent
Thermal Energy Needs	80-120 Celsius	900 Celsius	80-100 Celsius
Thermal Energy Sources	Non-fossil energy sources (geothermal, waste heat, etc.)	Natural gas with Carbon Capture and Storage	Any energy resource
Projects	Commercial operation with 16 plants globally with a collective capacity of 2,000 tons of CO2 captured from the air per year	Pilot plant in British Columbia. In the process of building a facility in the Permian Basin that will be capable of 1 million tons of CO2 per year	Pilot plants in Oklahoma and Colorado
Investments	Raised US$170 million since 2009. A new investment of an undisclosed amount by Microsoft's Climate Fund was announced in February 2021. Investors include Zurich Cantonal Bank, Horizon 2020, and others	Raised around US$102 million since founding in 2009. Investors include BHP, Chevron, Bill Gates, Oxy Low Carbon Ventures and others	Raised around US$5 million since founding in 2010. Partnered with companies including ExxonMobil, NRG, BASF. It has raised debt from Goldman Sachs and received various grants from the State of New York and NYSERDA.

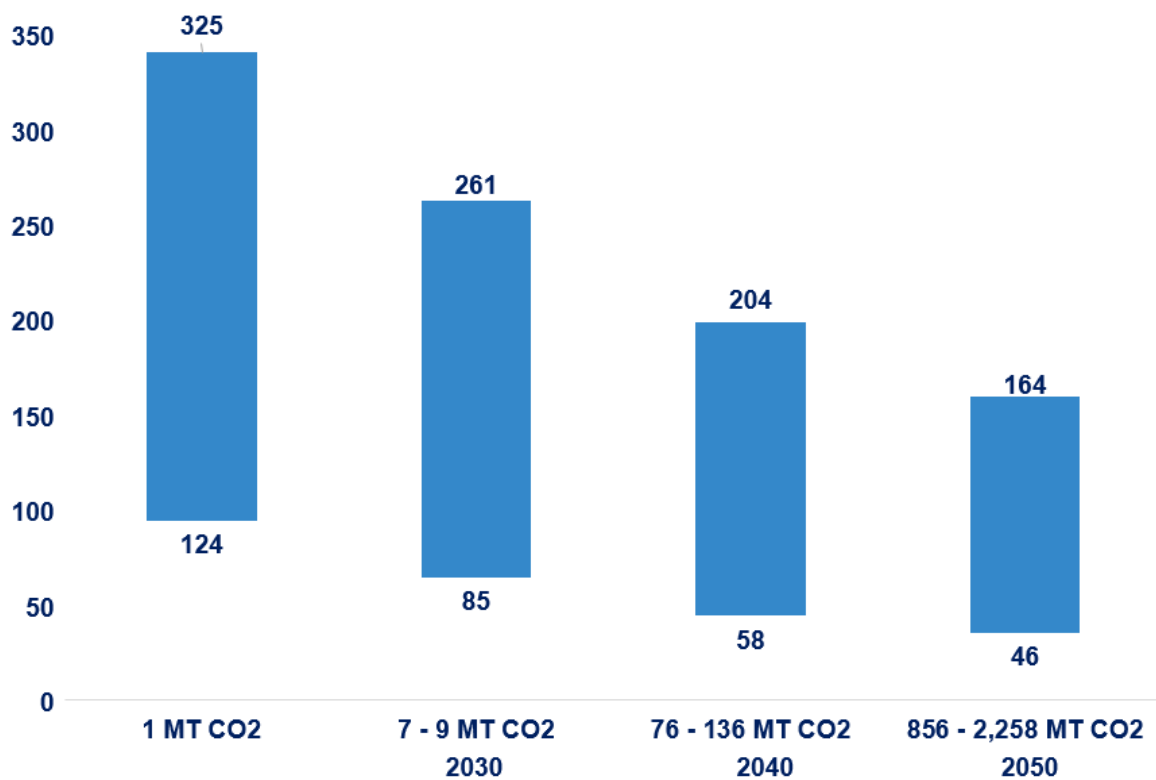
5.4.1.2 Costs

The cost of Direct Air Capture and Carbon Storage currently ranges between US$200 and US$600 per ton of Co2.[116] Costs are expected to fall to around US$200 - US$300 per ton of CO2 by 2024 and drop under US$100 per ton of CO2 by 2050. The United States presents one of the most competitive landscapes for

[115] Katie Lebling, Noah McQueen, Max Pisciotta, and Jennifer Wilcox, "Direct Air Capture: Resource Considerations and Costs for Carbon Removal." World Resources Institute. Accessed March 1 2021, https://www.wri.org/blog/2021/01/direct-air-capture-definition-cost-considerations
Pitchbook. Searches for Climeworks, Carbon Engineering, and Global Thermostat.
[116] Carbon180, "Factsheet: Direct Air Capture",Accessed in April 2020

DACCS, given their low-cost supply chains and carbon capture and storage tax credits. The figure below shows a projection of DACCS costs up to 2050[117] in the United States.

Figure 5.5: DAC Costs Projections in the United States (US$ / Metric ton of CO_2)



5.4.1.3 Co-benefits and communications strategy

Strongly relying on DACCS to offset carbon emissions would be viewed favorably by investors and environmental groups. DACCS represents an additional and easily verifiable technology. Although it does not result in biodiversity co-benefits or benefits to local communities, helping scale up the technology can have rippling effects in decarbonizing hard-to-abate sectors, like aviation and industrial processes. In addition, investing in this technology signals that the company is serious about fighting climate change in the long-term.

Including DACCS in Equinor's carbon offset strategy strongly aligns with Equinor's leadership in other low-carbon technologies. Equinor is already a leader in scaling low-carbon technologies. The Northern Lights joint-venture with Shell and Total for a Carbon Capture and Storage network and their partnership with Engie to pursue opportunities in low-carbon hydrogen put Equinor at the forefront of the energy transition. Establishing a carbon offset strategy consistent with Equinor's technological ambitions will show that Equinor's efforts to remove carbon from the atmosphere are honest.

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[117] Rhodium Group, "Capturing Leadership: Policies for the US to Advance Direct Air Capture Technology", May 2019, P.28.

5.4.1.4 Advantages & disadvantages

The main advantages of utilizing offsets from DACCS projects are:

- **Permanence and leakage**: DACCS can capture and store CO2 for thousands of years. The risk of reversal through this technology is low once the developer has thoroughly studied the storage site. In addition, the risk of reversal falls as time goes by. DACCS has no leakage risk because CO2 is not shifted elsewhere.
- **Verifiability and Accounting**: DACCS makes it easier to quantify the amount of CO2 captured and stored, making third-party verification easier too.
- **Additionality**: Each unit of CO2 captured and stored with DACCS is additional. Additionality is built into DACCS plants because if the plant is not built, those units of CO2 would not be captured and stored.
- **Timing**: The timing of each unit of CO2's capture and storage is accurate, making it easier to measure captured amounts more accurately.

The main disadvantages of utilizing offsets from DACCS projects are:

- **Price**: The price of DACCS offsets is currently high. Although costs are expected to fall. Short-term purchases will be expensive.
- **Readiness:** The technology is not fully scaled. This may lead to supply bottlenecks as demand for DAC plants increases.
- **Volume**: The volume of DAC offsets is low. Until supply increases, an offset portfolio would rely primarily on lower-quality offsets.
- **Verifiability**: There are currently no verification methodologies available, and most registries do not include DACCS as part of the solutions they cover. In the meantime, third-party verification must be arranged between the project developer and buyer.

5.4.1.5 Policy

Supporting policies that support DACCS and encouraging the adoption of clear international standards for DACCS is crucial for scaling the technology and encouraging effective carbon offsets. There are currently no clear verification methodologies for DACCS offsets, and most offset registries focus on Nature-Based Solutions. Companies that are already purchasing DACCS offsets, such as Microsoft, Shopify, and Stripe, are doing so by arranging third-party verification on their own when purchasing directly from the project developer.[118] Equinor should work with other companies, governments, and international organizations to encourage the creation and adoption of clear methodologies for DACCS.

5.4.1.6 Model for Equinor

Northern Lights recently signed a partnership with Climeworks to explore a full-chain CO2 capture and removal project. This partnership is promising for Equinor's ambitions. An advantage of seeking a partnership directly with a company is that Equinor can leverage its business to reduce carbon removal costs. For example, Equinor can explore partnerships to site DACCS plants next to one of their renewable energy generation plants to reduce electricity costs. Equinor can also explore the possibility of

[118] Microsoft, "Microsoft Carbon Removal: Lessons from an Early Corporate Purchase", Accessed in April 2020

companies sitting their DACCS plants next to one of their carbon capture and storage plants, such as their Northern Lights plant.

Equinor can also pursue an aggressive purchase of DACCS offsets through a general portfolio RFP. In any way that Equinor goes forward with DACCS, we would expect it to start purchasing low amounts of offsets beginning in 2025 and increasing annually until 2050. So far, the largest DACCS offset purchase was recently made by Shopify[119], at around 10,000 tons of CO2/year starting in 2024 from Carbon Engineering. On the other hand, Microsoft has contracted 1,400 tons of CO2 per year from Climeworks starting in 2021.[120]

5.4.1.7 Risks to Equinor

The main risks associated with DACCS relate to scalability and price. Prices of DACCS offsets are currently high and, although costs are expected to fall as deployment increases, prices might stay high if demand for offsets continues to increase without adequate supply. Building DACCS supply will require capital investments of 100 times the current amount. Investing early on in DACCS offsets would contribute to scaling the technology, lowering costs, and increasing the supply of offsets.

Another risk involves DACCS replacing serious efforts in reducing emissions and transitioning to clean energy alternatives and how this might be perceived by investors, environmental activists, and the general public. Relying on DACCS without committing to serious emissions reductions, real paths to achieving them, and transparent accounting and reporting run the risk of facing scrutiny and earning a 'greenwashing' label. However, if Equinor continues setting ambitious goals and communicating transparently, the company should not face serious backlash.

5.4.2 Bioenergy with Carbon Capture and Storage (BECCS)

5.4.2.1 Overview

Bioenergy with carbon capture and storage (BECCS) is a technology that integrates biomass conversion to heat, electricity, or liquid or gas fuels with carbon capture and sequestration (including biochar).

1. **Potential Biomass Feedstocks:** woody biomass (harvested wood products and wood harvest residue), worn grain, waste biomass (municipal solid waste and manure), agricultural residues & energy crops (switchgrass & miscanthus)
2. **Conversion Pathway:** Combustion (biomass is oxidized completely for power and/or heat production), Pyrolysis (biomass is heated in the absence of oxygen, producing liquids and/ or biochar) & Gasification (biomass is partially oxidized under oxygen-starved conditions for the production of syngas)
3. **Energy:** heat, electricity, liquid fuels (ethanol, biodiesel & long-chain hydrocarbons)

[119] Carbon Engineering, "Carbon Engineering launches new carbon dioxide removal service, with Shopify as its first customer" Accessed in March 2021, https://carbonengineering.com/news-updates/carbon-dioxide-removal-service/

[120] Microsoft, "Carbon Removal Portfolio", Accessed March 2021, https://app.powerbi.com/view?r=eyJrIjoiOGM2MGFlNGYtMGNlNy00YzY5LWEyMTAtOTA0ODEyNzEzYTczIiwidCI6ImMxMzZlZWMwLWZlOTItNDVlMC1iZWFlLTQ2OTg0OTczZTIzMiIsImMiOjF9

4. **Sequestration:** Geologic storage (saline aquifers and depleted hydrocarbon reservoirs) & Biochar (used as a soil amendment)

Potential and Scale[121]

The most widely used range for BECCS potential is 2.5-5.0 GtCO2/year.[122] Currently, five facilities around the world are actively using BECCS technologies. Collectively, these facilities are capturing approximately 1.5 million tons per year (Mtpa) of CO2.

The only large-scale BECCS facility is the Illinois Industrial CCS facility that captures up to 1 Mtpa of CO2. This facility produces ethanol from corn, producing CO2 as part of the fermentation process. The CO2 is stored in a dedicated geological storage site deep underneath the facility. The remaining four BECCS facilities operating today are small-scale ethanol production plants, using most of the CO2 for enhanced oil recovery (EOR):

1. Kansas Arkalon (USA): 200,000 tons of CO2 per year
2. Bonanza CCS (USA): 100,000 tons of CO2 per year
3. Husky Energy CO2 Injection (Canada): 250 tons per day (tpd)
4. Farnsworth (USA): Over 600,000 tons of CO2 was compressed from an ethanol plant (Kansas) and fertilizer plant (Texas) and piped to Farnsworth oil field for EOR (now ceased)

There are three additional planned BECCS projects:

1. Mikawa Power Plant (Japan): The retrofit of a 49-megawatt unit power plant in Omuta (Fukuoka Prefecture) to accept 100 percent biomass with a CO2 capture facility.
2. Drax Power Plant (UK): Biomass power generation pilot in North Yorkshire with the potential to develop CO2 capture and storage
3. Long Ship Norwegian Full-Chain CCS (Norway): BECCS integration into waste-to-energy and cement plants:
    a. Klemetsrud waste-to-energy plant: Plans to capture 400,000 tons of CO2 per year.
    b. Norcem Cement plant: Currently co-fires up to 30 percent biomass and plans to capture up to 400,000 tpa of CO2. Both plants will use the Northern Lights JV to transport and store their CO2.

[121]Christopher Consoli, "Bioenergy and capture capture and storage", Global CCS Institute, 2019 https://www.globalccsinstitute.com/wp-content/uploads/2019/03/BECCS-Perspective_FINAL_18-March.pdf

[122] David Sandalow, "Biomass Carbon Removal and Storage Roadmap", Innovation for Cool Earth Forum, January 2021 https://www.icef-forum.org/pdf/2020/roadmap/roadmap.pdf

Figure 5.6: BECCS Projects Worldwide

5.4.2.2 Costs

The cost of implementing BECCS technology varies widely. A review of the entire literature on BECCS found a current cost range between US$100-400 per ton of CO2 avoided depending on the sector.[123] After scaling up some potential future price values can be:

- Combustion: 88-288 US$/tCO2
- Ethanol: 20-175 US$/tCO2
- Pulp and paper mills: 20-70 US$/tCO2
- Biomass gasification: 30-76 US$/tCO2

5.4.2.3 Co-benefits and communications strategy

Moderately, relying on BECCS to offset carbon emissions would be viewed favorably by investors and environmental groups if used in a limited amount and avoiding water/food/land competition.

- BECCS represents an additional and easily verifiable technology
- Although it does not result in biodiversity co-benefits or benefits to local communities, helping scale up the technology can have rippling effects in helping decarbonize hard-to-abate sectors, like aviation and industrial processes
- In addition, it can be a good option to dilute the high costs of DAC in the medium term without the negative impact of nature-based technologies.

5.4.2.4 Advantages & disadvantages

The main advantages of utilizing offsets from BECCS projects are:

- **Permanence and leakage:** BECCS can capture and store CO2 for thousands of years. The risk of reversal through this technology is low once the developer has thoroughly studied the storage

[123] Fuss et al. (2018); NAS (2018)

site. In addition, the risk of reversal falls as time goes by. BECCS has no leakage risk because CO2 is not shifted elsewhere.

- **Verifiability and accounting:** BECCS makes it easier to quantify the amount of CO2 captured and stored, making third-party verification easier too
- **Additionality:** Each unit of CO2 captured and stored with BECCS is additional if the biomass growth is factored into the BECCS process. This increases the cost of BECCS, but ensures additionality.
- **Timing:** The timing of each unit of CO2's capture and storage is accurate, making it easier to measure captured amounts more accurately.
- **Readiness:** Biomass production and carbon capture and storage are proven technologies.

The main disadvantages of utilizing offsets from BECCS projects are:

- **Volume:** There are not enough projects in operations selling offsets for BECCS to be a significant portion of an offset portfolio.
- **Negative Co-benefits due to Water-Food-Energy Nexus:** BECCS main disadvantage relates to the amount of land required to grow the biomass. This may put pressure on forest land, food crop production, and water use.
- **Price:** The price of BECCS is dependent on the feedstock and can be very high given the current amount and type of feedstocks available.
- **Additionality:** Adding CCS to existing bioenergy plants might be considered avoidance and not removal. So, additionality can be an issue if not appropriately planned.

5.4.2.5 Policy

Supporting policies that support BECCS:

- There are currently no clear verification methodologies for BECCS offsets, and most offset registries focus on Nature-Based Solutions.
- Companies that are already purchasing BECCS offsets, such as Microsoft, Shopify, and Stripe, are arranging third-party verification on their own.
- Equinor should work with other companies, governments, and international organizations to encourage the creation and adoption of clear methodologies for BECCS.

5.4.2.6 Model for Equinor

- The strategy recommended for BECCS is for it to be a secondary carbon sink to dilute the cost of DACCS.
- Equinor can take advantage to reduce costs of synergies with this technology, particularly in the geological storage step
- Both US and Brazil have promising projects in Bioethanol from which the client can leverage from

5.4.2.7 Risks to Equinor

BECCS risks are similar to those of DACCS. In addition, the main risk to Equinor is the potential harm that BECCS could cause on local communities and local biodiversity. The impact feedstock growth can have on local forests and food security, as well as water usage, is significant. Equinor needs to make sure that

BECCS projects adequately examine these risks and ensure the project causes no harm to communities and biodiversity.

5.5 Other Less Developed Solutions

In this section we briefly describe the potential of other solutions that are still under development.

5.5.1 Biochar

Biochar is a type of charcoal produced by burning biomass. In a similar way to BECCS, biochar can be considered a carbon removal solution if biomass growth is considered part of the biochar production process. This charcoal is buried in the soil and is able to keep the carbon sequestered for centuries under the right conditions. However, more research is needed to understand its efficacy across different types of soils and over time.

Biochar's potential is uncertain. It ranges between 1.1 - 3.3 Gt by 2030[124] and 0.5 - 2 Gt of CO2 by 2050.[125] Currently, there are economically viable biochar applications with prices ranging between US$20 - 30 per ton of CO2. However, since biomass production needs to be incorporated to consider biochar production a negative emission or carbon removal technology, prices that incorporate this process range between US$60 - 120 per ton of CO2.[126] However, prices can vary widely and be much higher depending on the type of feedstock. In a similar way to BECCS, the most important challenge to biochar is the availability of land for biomass and the nexus with the food system.

5.5.2 CO2 Mineralization

Mineralization of CO2 is a process that reacts alkaline material with CO2 to form solid carbonate minerals to safely store CO2 in the long-term. This process occurs naturally. However, the objective is to accelerate the timeline for purposes of carbon removal and storage. Therefore, this technology needs to be paired with some form of carbon capture like DAC or BECC to be considered a negative emissions technology. Currently, Carbfix is the main proponent of this technology and it's currently being tested paired with Climeworks DAC technology in Iceland.[127] CO2 has capacity to store up to 1.5 GtCO2 per year based on current alkaline material production and possibly more than 3 GtCO2 per year by 2050.[128] The cost of storing CO2 from air using carbon mineralization ranges between US$20 and US$100 per ton of CO2 but more technical research is needed to mitigate technology risks.

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[124] Jennifer Wilcox, Ben Kolosz, Jeremy Freeman, "Carbon Dioxide Primer", Accessed April 13, 2021, Foreword • Carbon Dioxide Removal Primer (cdrprimer.org)

[125] American University - Center on Carbon Removal Law and Policy. "Factsheet: Biochar", Accessed April 2021, Fact Sheet: Biochar | American University, Washington, DC

[126] Jennifer Wilcox, Ben Kolosz, Jeremy Freeman, "Carbon Dioxide Primer", Accessed in April 2021, Foreword • Carbon Dioxide Removal Primer (cdrprimer.org)

[127] Climeworks, "Climeworks, Power and Carbfix lay the foundation to scale up carbon dioxide removal significantly to 4000 tons per year", August 2020, https://climeworks.com/news/climeworks-has-signed-groundbreaking-agreements-with

[128] Jennifer Wilcox, Ben Kolosz, Jeremy Freeman, "Carbon Dioxide Primer", Accessed in April 2021, Foreword • Carbon Dioxide Removal Primer (cdrprimer.org)

6. Companies' Carbon Offset Strategies

Many large companies have set short-term and long-term climate goals, including other oil companies. This section presents various companies' climate goals and what they are doing to achieve those. The table below shows a comparison of oil companies' climate targets and carbon offset use.

Table 6.1: Comparison of Oil Companies

Company	bp	Shell	equinor
Target	Net Zero by 2050	Net Zero by 2050	Net Zero by 2050
Emissions	(Scope I, II & III - Op. Control - 2019): 415M tons CO2	(Scope I, II & III - Op. Control - 2019): 656M tons CO2	(Scope I, II & III - Op. Control - 2019): 276 M tons CO2
Offset Portfolio	0.85M tons CO2 (2019)	2.7M tons CO2 (2019)	Near 0 tons CO2 (2019)
Strengths	Co-benefits aligned with SDGs	carbon-neutral products and strong trading arm	Low-carbon technologies pilot projects

Technology companies have some of the most ambitious climate targets. The table below shows a comparison of technology companies' climate targets and carbon offset use.

Table 6.2: Comparison of Technology Companies

Company			
Target	Carbon Negative by 2030	Net zero by 2040	Carbon free by 2030
Emissions	(Scope I, II & III - 2020): 11M tons CO2	(Scope I, II & III - 2019FY): 51M tons CO2	(Scope I, II & III - 2018): 15M tons CO2
Offset Portfolio	(2020): 1.3M tons CO2	No data available	(2018): 1.2M tons CO2
Strengths	RFP & Carbon removal focus	Forestry	Renewable energy procurement

6.1 Shell

Shell standards are assessed by PricewaterhouseCoopers and are verified by Carbon Standard, Gold Standard and the American Carbon Registry.

Portfolio 2019 (2.7M tCO2e per year)[129]:

- Carbon Capture and Storage, Canada: Since 2016, 1,936,186 credits have been issued. Average is 484,046 tons of CO2e per year
- Forest Management, Perú: In 2019, volume reach 134,081 tCO2e
- Forest Conservation, Perú: In 2019, 1,030,179 tCO2e
- Peatland Conservation & Restoration, Indonesia: In 2019, 361,170 tCO2e (last year in portfolio)
- Forest Conservation, Guatemala: In 2019, 163,176 tCO2e
- Coal mine/bed CH4, US: In 2019, 59,904 tCO2e
- Ozone Depleting Substances: n 2019, 100,000 tCO2e
- Forest, US: In 2019, 275,000 tCO2e

And other minor forest-related projects in China and UK

[129] Shell, "Nature-Based Solutions," Renewables and Energy Solutions, https://www.shell.com/energy-and-innovation/new-energies/nature-based-solutions.html#iframe=L3dlYmFwcHMvMjAxOV9uYXR1cmVfYmFzZWRfc29sdXRpb25zL3VwZGF0ZS8

6.2 BP

BP has been offsetting emissions since 2006. Their credits are purchased through United Nations Clean Development Mechanism (UN CDM) and the Verified Carbon Standard (VCS) and apply the ICROA code of best practice for procurement and retirements.

Expected portfolio 2021 (470K+ tCO2e per year)[130]:

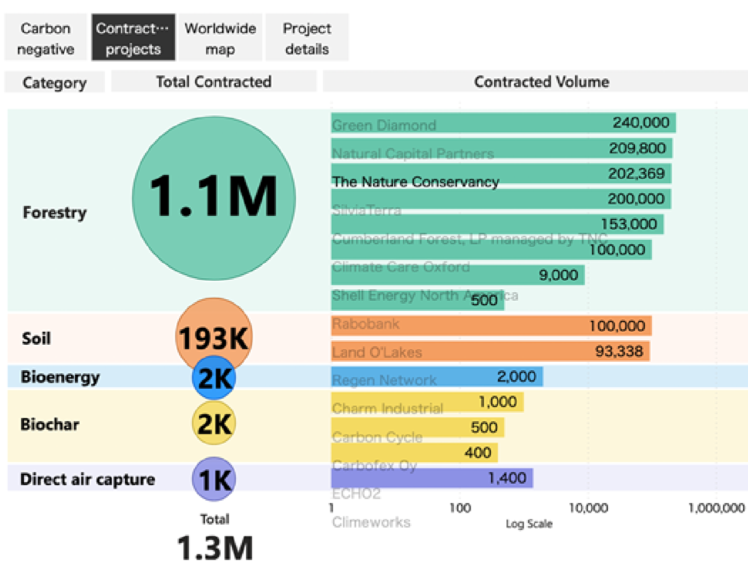
- Biogas, India: Issued 134,963 credits since 2016. Average of 11,247 tons of CO2e per year
- Cookstoves, Mexico: 284,464 tCO2e credits issued to date. In 2019, volume reach 91,000 tCO2e
- Forest management, Zambia: 943,469 tCO2e credits issued, averaging 180,000 tCO2e per year
- Hydropower, China: no information of emission reduction/carbon offset.
- Wind energy, China: 187,841 tCO2e mitigated on average annually

Projects in previous portfolios: Clean energy, Biogas, Biomass, Fuel Switching, Treadle Pumps, Reforestation, Composting Facility, Livestock.

6.3 Microsoft

Microsoft is implementing an aggressive carbon offset portfolio strategy focusing on carbon removal and technology-based solutions. In 2020, Microsoft issued an RFP for removing 1 million metric tons of CO2. They received proposals for removing 55 million metric tons from 189 projects across 79 applicants in more than 40 countries. Although only about 1000 of the 1.3 million tons of CO2 in their 2021 offset portfolio comes from DACCS, Microsoft aims on transitioning to purchasing mostly offsets from technology-based solutions. To do this, Microsoft is investing in new carbon reduction and removal technology through a US$1 billion Climate Innovation Fund.

Figure 6.1: Microsoft 2021 Carbon Offset Portfolio



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[130] BP, "BP Target Neutral Expands 2019 Carbon Offset Portfolio", https://www.bp.com/en_gb/target-neutral/home/news/2019-carbon-offset-portfolio.html

6.4 Amazon

Amazon aims on neutralizing residual emissions with carbon offsets from nature-based solutions. To do this, Amazon created the Right Now Climate Fund, a US$100 million fund that aims to remove or avoid carbon emissions by supporting nature-based climate solutions. So far, Amazon has invested in two projects: 1) a US$10 million investment to conserve, restore, and support sustainable forestry, wildlife and nature-based solutions across the Appalachian Mountains, in collaboration with The Nature Conservancy, 2) a US$4.07 million investment towards an Urban Greening program in Berlin, which uses nature-based solutions to help cities become more climate-change resilient.

6.5 Google

Google has been carbon-neutral since 2007 through improved operating efficiency, purchasing renewable energy, and carbon offsets. Between 2007 and 2019, Google partnered with close to 40 carbon offset projects and purchased more than 19 million tons of carbon offsets. Google aims to become carbon free by 2030.

6.6 Shopify

Shopify business and operations are carbon-neutral. They rely on carbon offsets for offsetting emissions from deliveries. Shopify pledged US$1 million per year to sequester carbon from the atmosphere. To purchase offsets, Shopify assesses the offsets based on additionality, permanence, scalability, monitoring and verification, and ensuring no double-counting.[131] Shopify recently agreed to purchase 10,000 tons of CO2 offsets from Carbon Engineering starting in 2024.[132] This is the largest Direct Air Capture purchase so far. Shopify had already purchased 5,000 tons of CO2 from Climeworks last October.[133]

6.7 Stripe

Stripe pledged to spend at least US$1 million per year to directly sequester carbon from the atmosphere and develop a carbon market[134]. They purchased 322.5 million tons of CO2 at a price of US$775 per ton from Climeworks.[135] Stripe also pursued an RFP process to get proposals for carbon removal projects, of which they picked four technology-based solutions projects.[136]

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[131] Shopify, "Carbon Offsets: A Field Guide to Shopify's Selection Process", May 2020, https://www.shopify.com/blog/carbon-offsets#:~:text=Shopify%20has%20adopted%20carbon%20offsets,Offset%20all%20remaining%20emissions.

[132] Ben German. "Shopify becomes carbon removal startup's first customer". Axios. March 9, 2021. https://www.axios.com/shopify-carbon-removal-38ee674e-69ff-409c-9995-d907120d586c.html

[133] Corbin Hiar, "Direct Air Capture of CO2 Is Suddenly a Carbon Offset Option", Scientific American, March 2021 https://www.scientificamerican.com/article/direct-air-capture-of-co2-is-suddenly-a-carbon-offset-option/

[134] Ryan Orbuch. "Stripe's first carbon removal purchases", Stripe, May 2020. https://stripe.com/blog/first-negative-emissions-purchases

[135] Ibid.

[136] Robinson Meyer, "The Weekly Planet: A Start-Up's Unusual Plan to Suck Carbon Out of the Sky", The Atlantic, November 2020, https://www.theatlantic.com/science/archive/2020/11/stripe-climate-carbon-removal/617201/

7. Business Opportunities in Carbon Offsets

There are business opportunities in carbon offsets for Equinor to consider. The three main opportunities analyzed in this report are the following: opportunities developing projects and selling carbon offsets, opportunities purchasing and selling carbon offsets on the market, and opportunities selling carbon-neutral products.

7.1 Opportunities in carbon offset project development

One option for Equinor involves leveraging its carbon transportation and storage capabilities to develop carbon removal projects and sell carbon offsets of these removals. Equinor's partnership with Climeworks represents a potential model for pursuing this type of opportunity. Demand for offsets will increase, and DACCS has become attractive even at current high prices.

As carbon offset supply is limited and demand continues to increase, focusing on selling offsets instead of first securing the offsets Equinor needs to achieve its climate goals presents various risks. Equinor's carbon transport and storage capabilities are currently in Norway, where costs are higher than the rest of the world. There might be enough demand for this type of project now, but there might not be in the future when costs fall elsewhere.

On the other hand, this strategy could help Equinor diversify its revenue streams as it transitions to becoming an energy company. In the Northern Lights project, Equinor already has the capacity to transport and store carbon dioxide. Therefore, there are cost reduction synergies that could arise from developing DACCS plants next to the Northern Lights storage facility.

7.2 Opportunities in carbon offset trading

Another potential opportunity involves purchasing carbon offsets to resell them or trade them. This opportunity is based on the assumption that the value of carbon offsets will increase over time. Companies with strong trading arms are exploring this opportunity, mainly Shell.

As carbon pricing mechanisms improve how they reflect the cost of carbon, the potential for having a fully-functioning carbon market increases. We've seen prices in the European Trading Scheme increase over the last few months, providing a positive signal in the right direction. Therefore, there are reasons to believe that carbon offsets will gain value.

The main risk in this opportunity is that existing carbon offsets might not be of good quality and do not accurately reflect carbon cost. Therefore, purchasing existing carbon offsets to resell them involves purchasing low-quality offsets. This might result in scrutiny from investors and the public in general.

7.3 Opportunities in carbon-neutral products

The market for carbon-neutral LNG has grown notably in the past year. Most carbon-neutral LNG shipments to date were delivered to customers in Asia, but on March 8, 2021, Shell received the first carbon-neutral LNG shipment in Europe from Gazprom. The LNG cargo of 70,000 tons delivered to the UK was estimated to emit approximately 240,000 tons of CO_2e by using DEFRA conversion rates for

Scope 1, 2, and 3.[137] Another development in this market is the set of new actors entering. Recently, Tokyo Gas established the carbon-neutral LNG Buyers Alliance, a group of 15 Japanese companies working to promote this solution. Additionally, trading companies Vitol and Mitsui now offer green LNG cargoes. The cost premium for carbon-neutral LNG is estimated to be 10-20% above standard LNG[138], and demand for carbon-neutral LNG is driven by corporate CO2 targets, compliance mechanisms, downstream customer requirements, positive media coverage and gaining experience with neutral carbon transactions.[139]

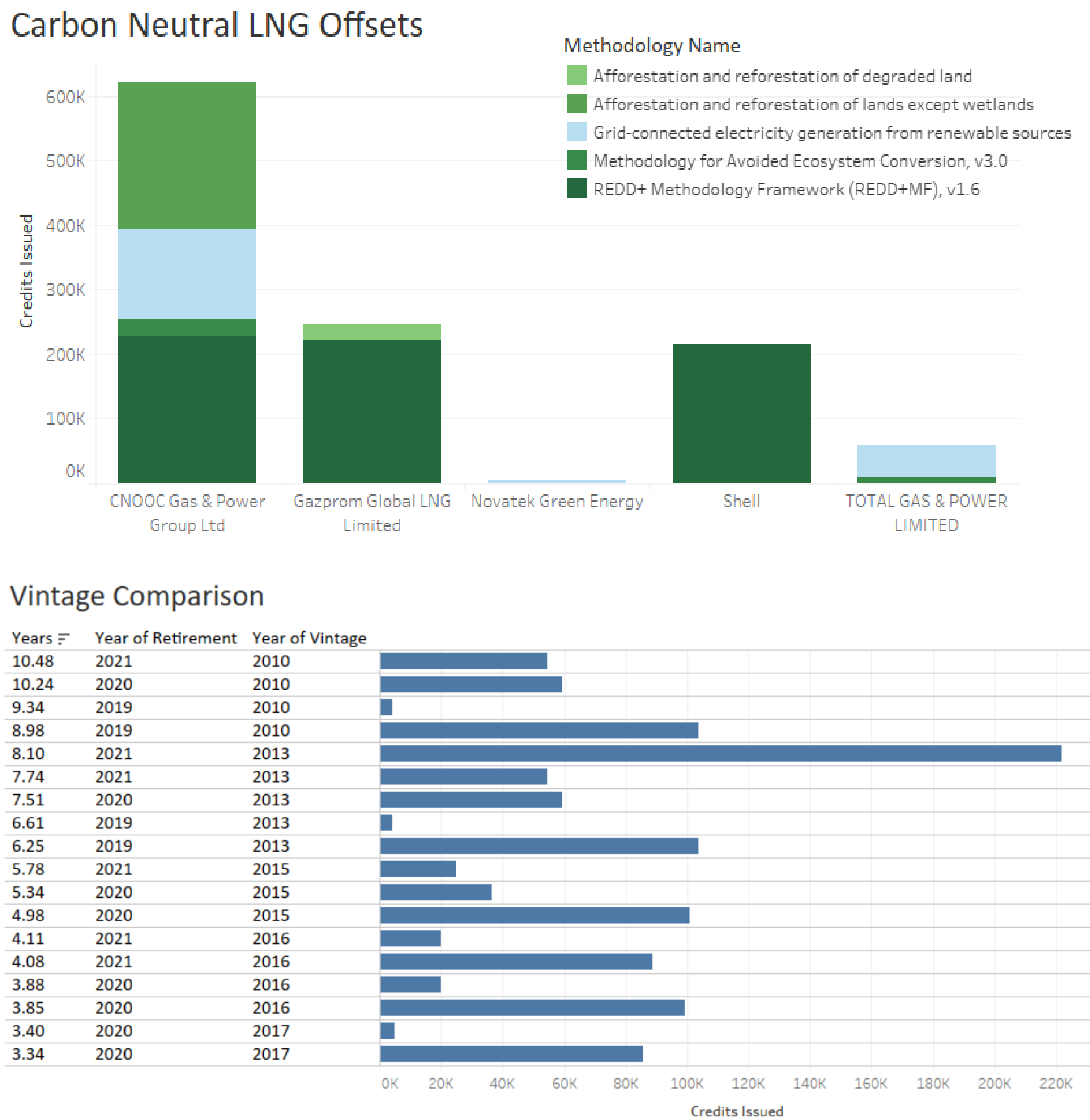
An overview of the carbon offsets associated with carbon-neutral LNG deliveries is shown in the table below. The credits total 1.15 million tCO2, and there are several indicators pointing towards the use of cheaper, at-risk credits for these transactions. First, the time between the vintage and retirement is above the 3-5 years range in many cases, particularly for the larger offset retirements. One of the top contributing projects is a deforestation project named "Cordillera Azul National Park REDD Project" and is criticized for receiving status as a protected national park before becoming a carbon offset project. Also, the issued credits for this project totaled 14.5 million tCO2 in 2019 alone, while ex-ante GHG emission reductions estimated for the period 2008-2018 equals 15.75 million tCO2. This irregular issuance pattern is another cause for concern about the integrity of this project.

[137] Shell, "First Carbon Neutral LNG Cargo Delivered in Europe", March 2021, https://www.shell.com/business-customers/trading-and-supply/trading/news-and-media-releases/first-carbon-neutral-lng-cargo-delivered-in-europe.html

[138] Kenneth Markowitz and Gabriel Procaccini. "Key Considerations for Carbon-Neutral Oil and LNG Transactions Using Carbon Offsets", JDSUPRA, February 2021, https://www.jdsupra.com/legalnews/key-considerations-for-carbon-neutral-3494413/

[139] S&P Global Platts, "Market Movers Europe, Mar 22-26: Steel price hike, UK hydrogen strategy in the spotlight". Webinar. Accessed April 2021, https://www.spglobal.com/platts/en/market-insights/videos/market-movers-europe/032221-aramco-covid-steel-coil-green-hydrogen-uk-grain-freight

Figure 7.1: Carbon Offsets Associated with carbon-neutral LNG Deliveries, 2019 - 2021



8. Equinor's Offset Portfolio Model

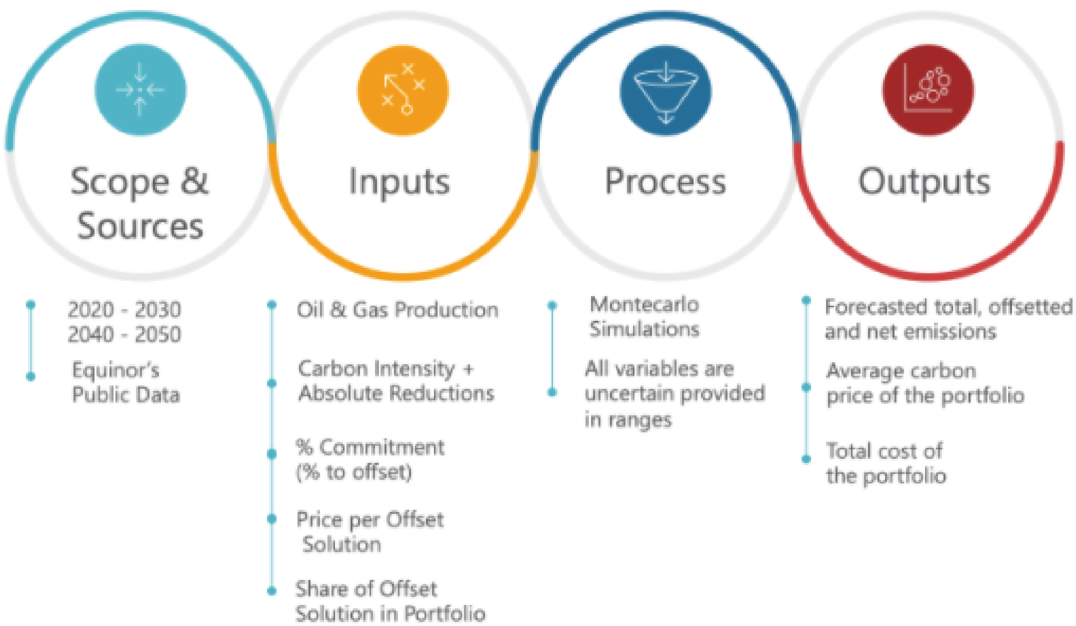
A simple analysis of Equinor`s potential portfolio today, in 2030, 2040, and 2050 was performed, in order to obtain:

- Total emissions of Equinor
- Emissions Equinor needs to offset
- Average portfolio price per ton
- Total offset portfolio cost

Key Facts about the model:

- Most of the inputs used belong to publicly available reports from Equinor
- A probabilistic approach was used to take into account uncertainties (Montecarlo SImulation); each input is assigned lower and upper bounds, random values within those ranges are obtained per variable in 1000 iterations. Outputs are probabilistic distributions, not deterministic values
- The objective of the model is to be a tool to check assumptions and potential scenarios; it is not thought as a roadmap. The model will be given to the client as a final deliverable[140]

Figure 8.1: Model Stages



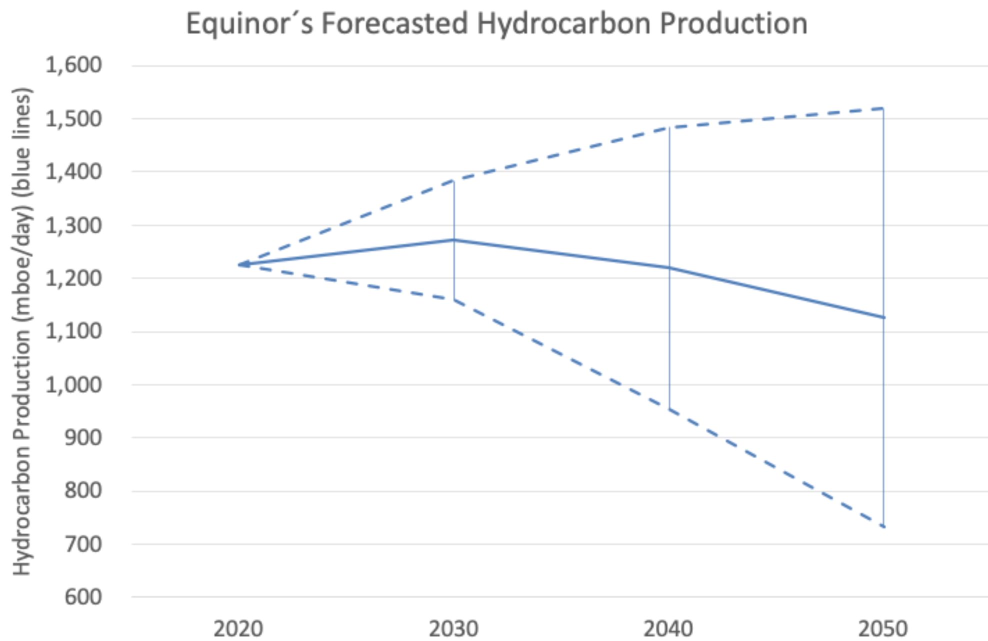
8.1 Hydrocarbon Production

The Energy Perspectives 2020[141] report and database were used to estimate Equinor's oil and natural gas

[140] This section explains qualitatively the model. If the quantitative assumptions are required please check the actual model file

[141] Equinor, "Energy Perspectives 2020 (Data Appendix)", 2020, https://www.equinor.com/content/dam/statoil/image/how-and-why/energy-perspectives/2020/energy-perspectives-2020-data-appendix-i.xlsx

__Figure 8.2: Equinor´s Forecasted Hydrocarbon Production__



production in the following decades, assuming that the company production will vary between the maximum and minimum scenarios ("Rivalry" and "Rebalance") keeping its share of global production within certain limits.

8.2 Carbon Intensity and Total Emissions

The Equinor CDP 2020[142], was used to obtain current scope 1, 2, and 3 emissions. Current carbon intensity was obtained by dividing these emissions by current production in operated fields.

The Climate Roadmap 2020[143] was used to estimate the pathway to reduce the carbon intensity. Scope I and II absolute emissions will be reduced 5, 9 and 12.5 M tons of CO2 for each decade in the future. It is assumed that the absolute carbon intensity of scope 3 emissions in 2050 would be 50% of what it is today. It assumed that scope 1, 2, and 3 total emissions are proportional to hydrocarbon production and carbon intensity. The ambitions are considered the maximum achievable.

8.3 Equinor Commitments

The following guidelines were provided by Equinor to estimate the offsetting commitments in the following decades:

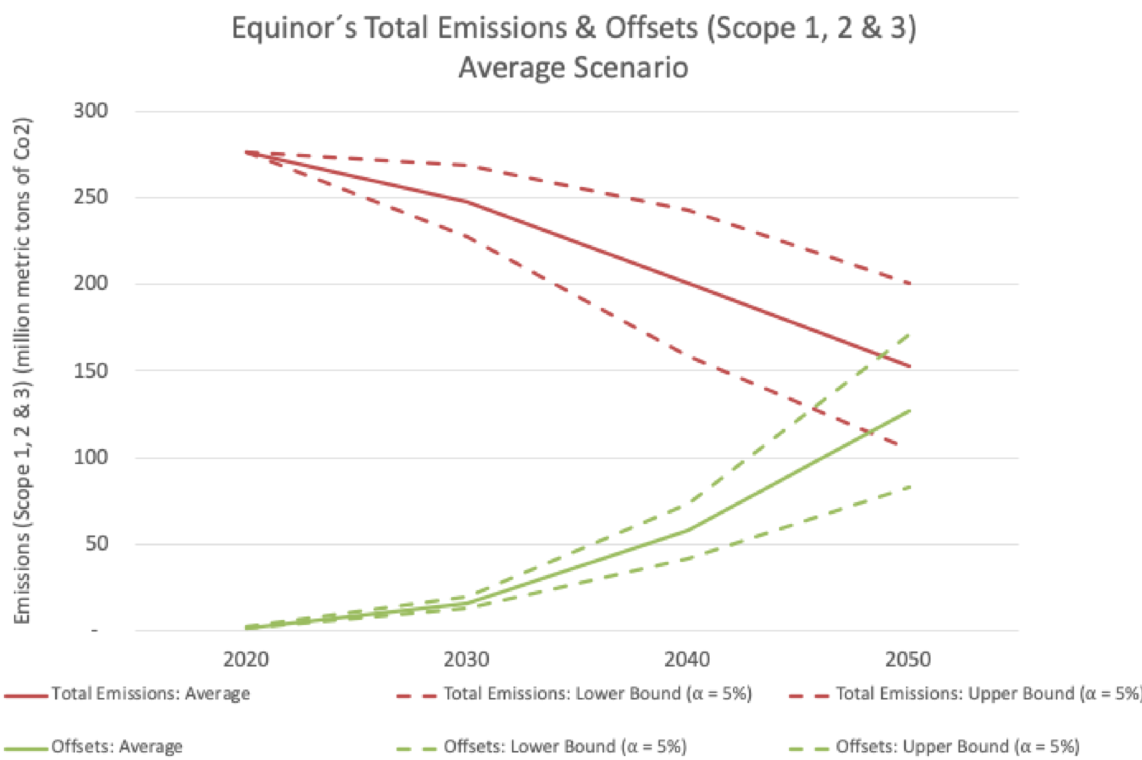
- Up to 2030, only Scope 1 and 2 emissions from Brazil & UK should be considered to be offset
- The current production in these countries will likely double in the next ten years

[142] Equinor, "CDP Climate ChangeQuestionnaire 2020", 2020, https://www.equinor.com/content/dam/statoil/documents/sustainability-reports/equinor-cdp-response-2020.pdf

[143] Equinor, "Climate Roadmap 2020", 2020, https://www.equinor.com/content/dam/statoil/documents/climate-and-sustainability/climate-roadmap-2020-2.pdf

● The net-zero ambition covers scope 1 and 2 GHG emissions on an operational control basis (100%) and scope 3 GHG emissions (use of products, category 11, on an equity share basis)

Figure 8.3: Equinor´s Total Emissions and Offsets



8.4 Carbon Offsets Weight and Prices per Solution Type

Price averages and ranges were estimated for the 6 main solutions: forest, ocean, improved land management, DAC, BECCS and others, based on the analysis performed in section 4.2.

For the weight of each solution in the portfolio per decade the values chosen express the conclusions of this team after reviewing extensive research and performing interviews with experts. The main theme is a gradual transition from cheap nature-based solutions to technology-based solutions focusing on removal rather than avoidance.

Figure 8.4: Modeled Portfolio Prices per Solution

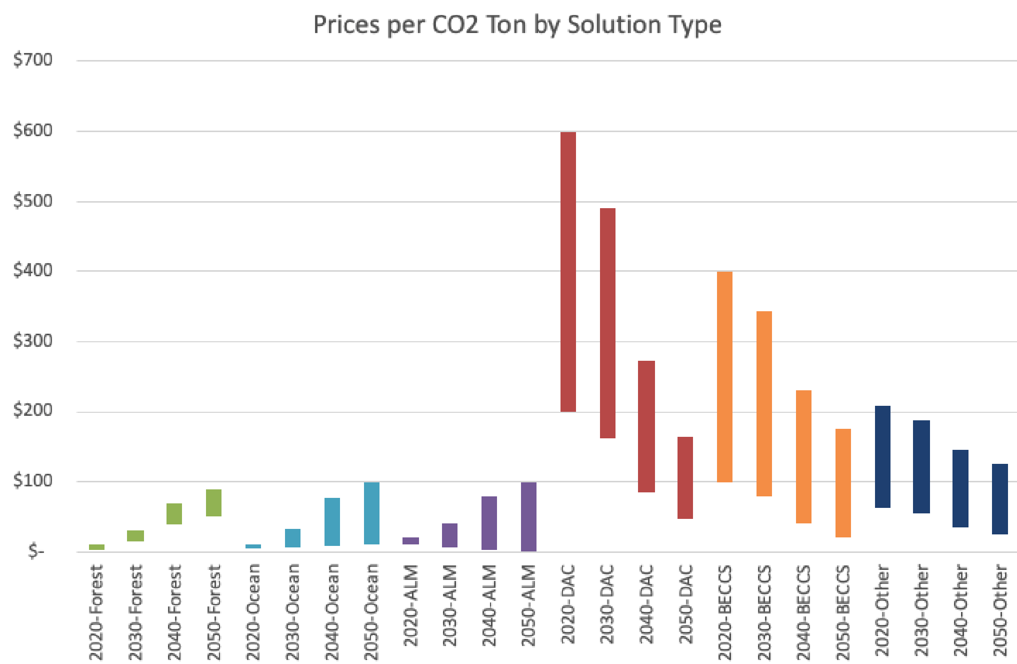
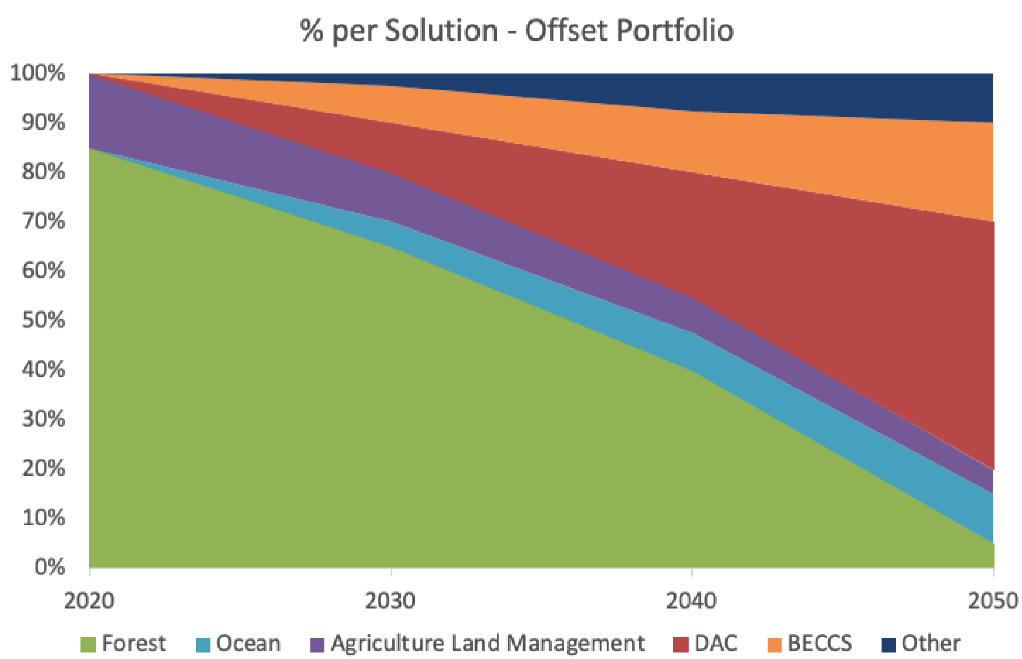


Figure 8.5: Modeled Portfolio Share per Solution



8.5 Results

On average, Equinor`s production of oil and natural gas will peak in 2030 to slightly decrease after that. Nevertheless, due to a decrease in carbon intensity total emissions since the present. Net emissions are the difference between total emissions and emissions offset. The offset portfolio mostly targets scope 3 emissions after 2030, therefore the net emissions are drastically reduced after that moment, almost reaching zero by 2050 following Equinor`s main Ambition.

Figure 8.6: Equinor´s Total Emissions and Offsets by Scope

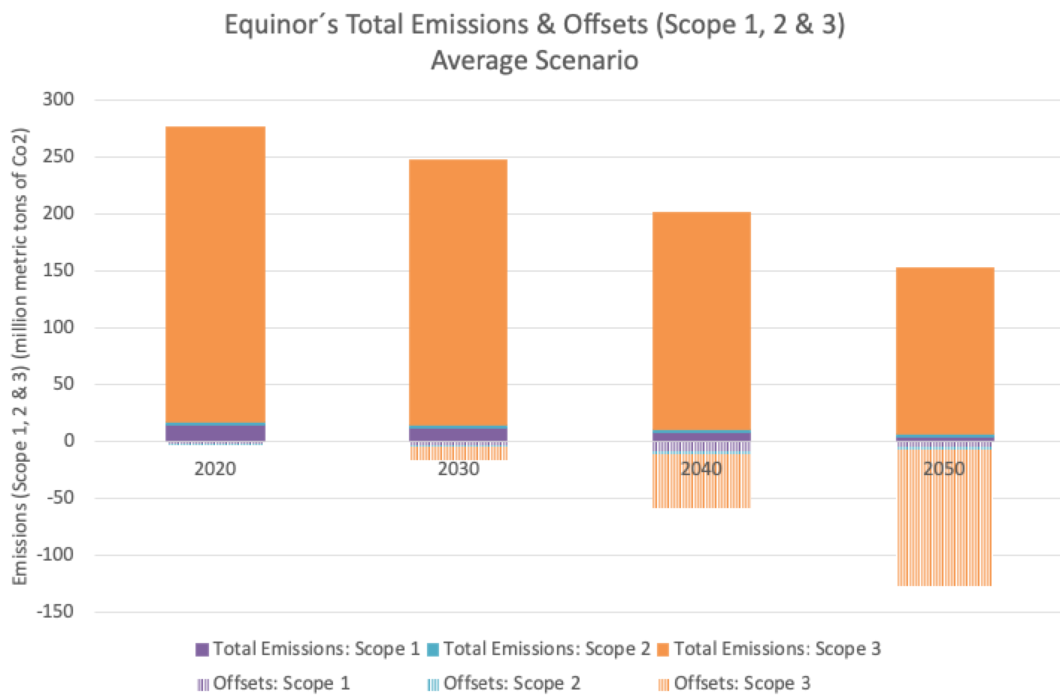
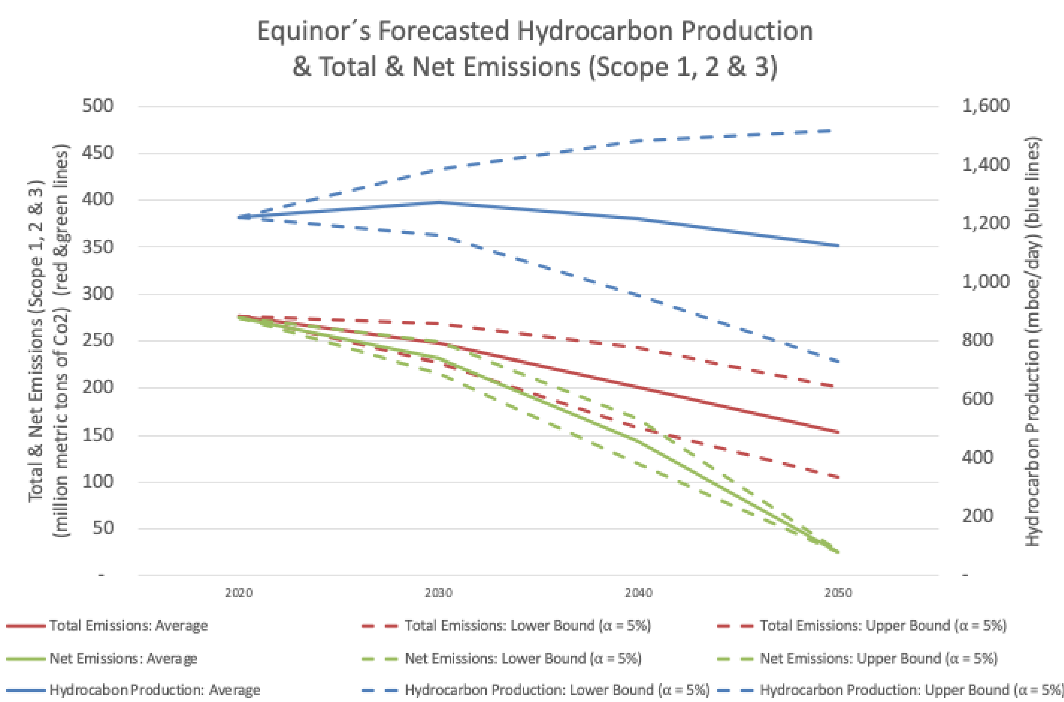


Figure 8.7: Equinor´s Production and Emissions



The average price of the portfolio will grow considerably from 2020 to 2040 to stabilize during the last decade of analysis ($90-95 per ton). This a result from a transition of NBS to TBS the portfolio combined with a certain balancing of costs between solutions.

Figure 8.8: Average Portfolio Carbon Price Modeled

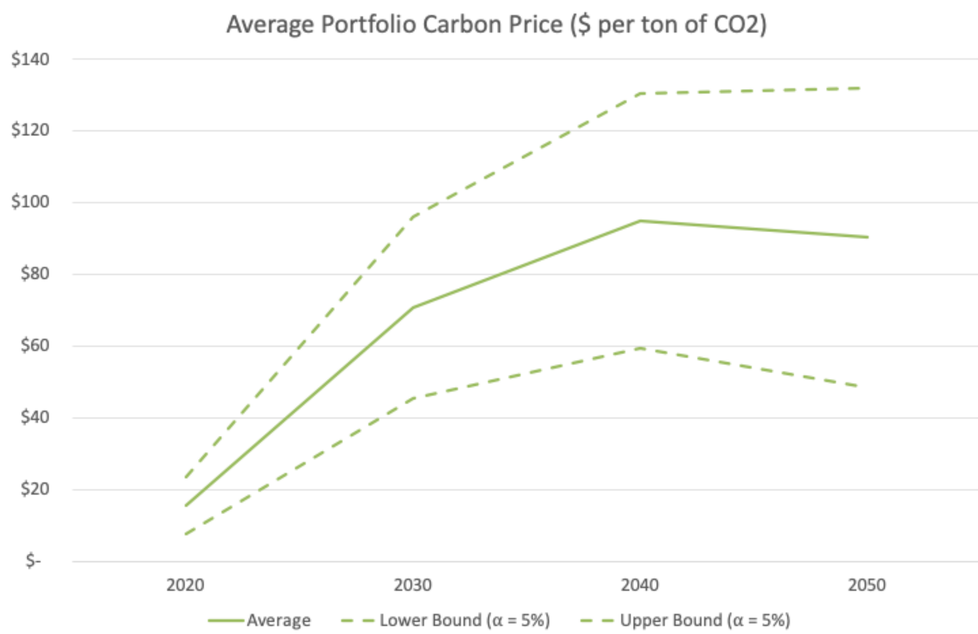
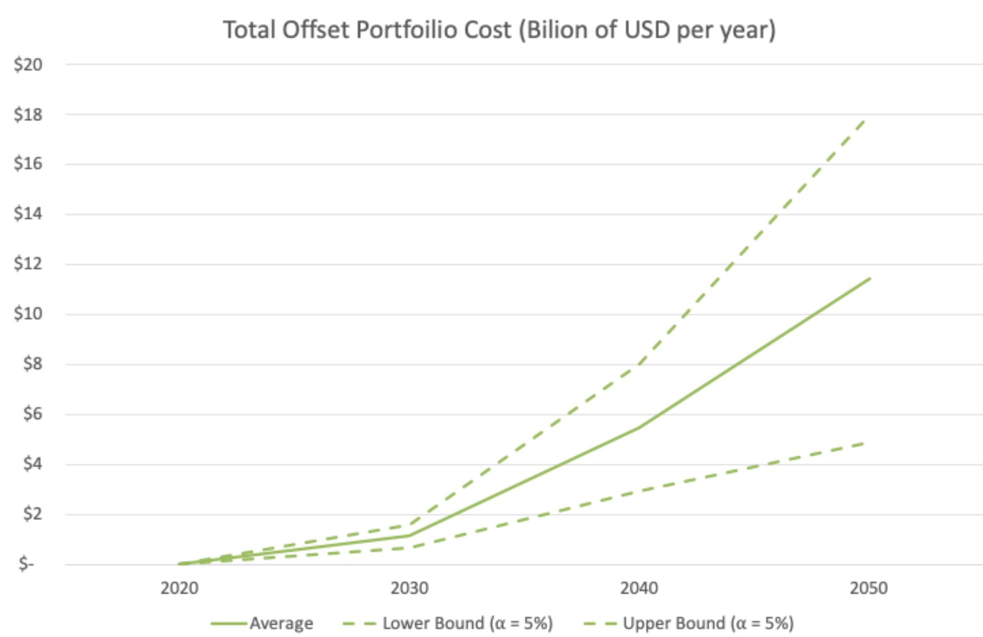


Figure 8.9: Equinor`s Total Offset Portfolio Cost Modeled



The offset portfolio cost will exponentially increase due to the effect of a rising price but, especially due to the amount of emissions to offset. In 2030 the portfolio could cost 1.1 ± 0.4 Billion USD per year and in 2050 11.3 ± 6.6 Billion USD per year.

9. Preliminary Recommendations for Equinor's Carbon Offset Strategy

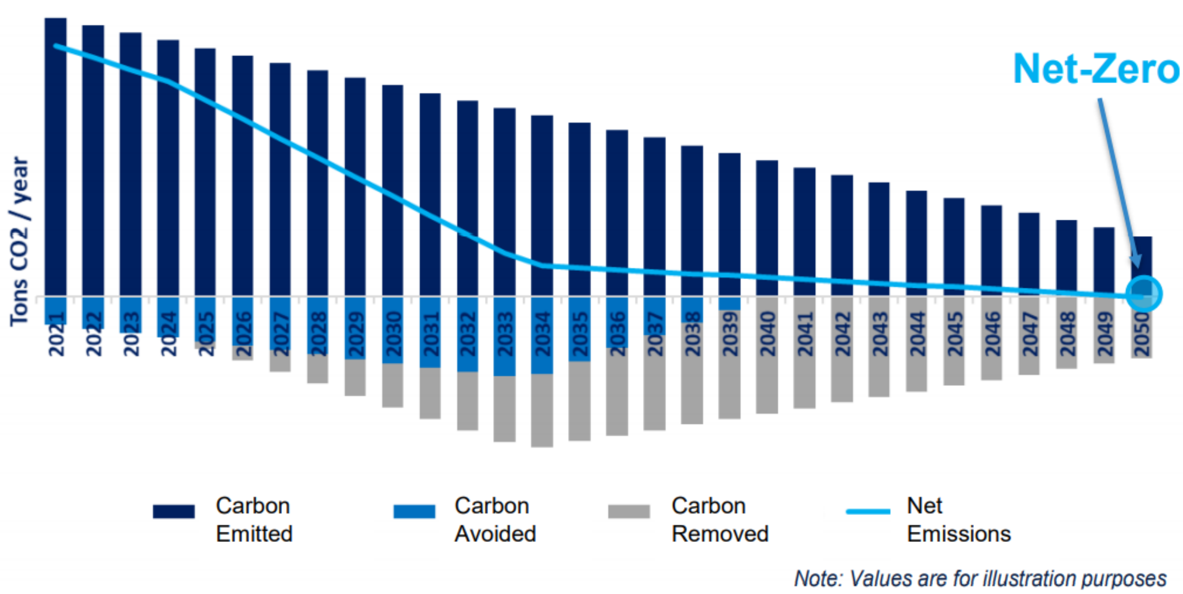
This section presents our preliminary recommendations for Equinor's carbon offset strategy.

9.1 General Recommendations

As the world continues to need at least some oil and gas to power economic activity, Equinor will likely need to purchase carbon offsets to achieve its 2030 and 2050 targets. We believe that Direct Air Capture is the most appropriate solution to offset carbon emissions. However, there is not enough DAC capacity available for Equinor to only purchase DAC offsets. Therefore, we recommend that Equinor builds a portfolio of offset solutions to meet its 2030 and 2050 targets. From now until 2030, Equinor should focus their efforts on investing and helping develop DACCS, which can be done by purchasing DAC capacity ahead of 2030 or partnering with companies to leverage Equinor's storage capabilities.

We believe that Equinor should apply a portfolio approach to managing its carbon offsets by 2030 because there is not enough of any single offset solution upon which Equinor can rely on. A portfolio approach would allow Equinor to offset its residual emissions, help develop a market for direct carbon removal, and mitigate risks associated with the various offset solutions. This approach consists of diversifying the carbon offset solutions, geographic location, and project developers from which Equinor purchases offsets. Diversification reduces the risk from each particular project and solution.

Figure 9.1: Indicative Role of Carbon Offsets in Equinor's Climate Strategy



A portfolio approach would allow Equinor to rely on the currently available solutions, mostly nature-based solutions that avoid emissions, and transition towards carbon removal and technology-based solutions. Most solutions available are nature-based solutions that avoid carbon emissions, mainly avoided deforestation projects and improved soil management projects. Equinor can start building its portfolio of carbon offsets by purchasing these offsets. However, Equinor needs to transition to removing carbon from the atmosphere with technology-based solutions as scrutiny from shareholders and the public towards companies relying on nature-based solutions increases.

Equinor must begin procuring carbon removal offsets from technology-based solutions and incorporate them into their portfolio by 2030. This entails procuring carbon removals from DACCS in 2021 or 2022.

BECCS is also a promising solution given that it has many of the same benefits as DACCS but at a lower cost. For BECCS to be considered a negative emissions technology, the biomass needs to be grown with the purpose of creating these carbon offsets. An existing biomass plant later equipped with CCS represents emissions avoidance instead of removal. If this issue, as well as food-water-land nexus issues, are solved BECCS can become an important component of Equinor's portfolio.

9.2 Specific Recommendations

This section provides specific recommendations on implementing the portfolio approach.

9.2.1 Implementing Portfolio Approach

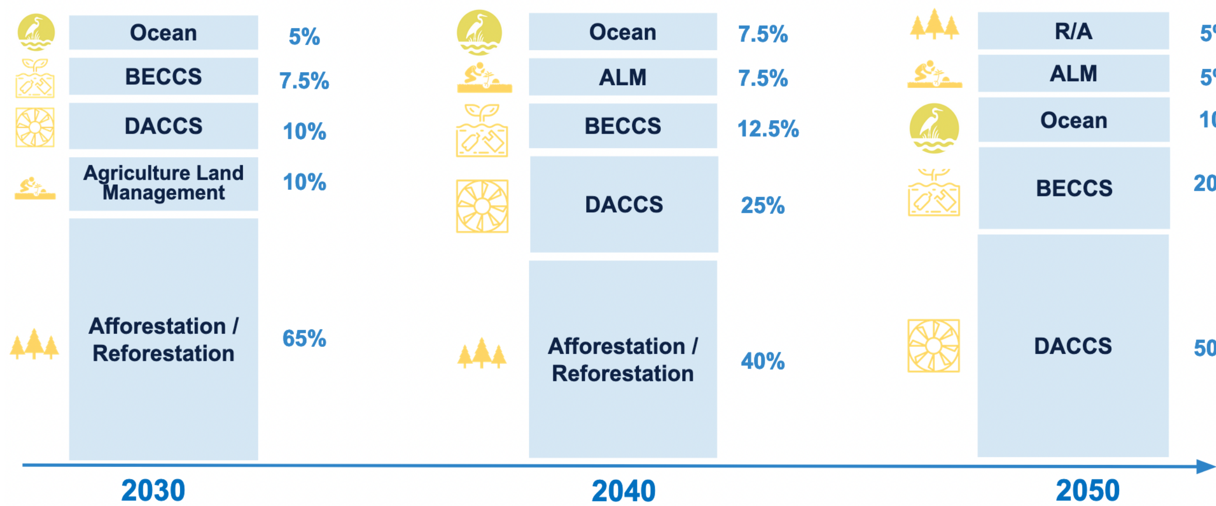
For implementing the portfolio approach, we recommend the following steps:

1. **Determine the quantity of CO2 emissions to offset:** First, Equinor should forecast the quantity of carbon offsets it will require annually to meet its climate goals. We have provided an estimate, but this will likely require further work.
2. **Develop a methodology to evaluate offsets:** We are providing a methodology for evaluating different offset solutions. Equinor must review and complete this methodology. We recommend engaging an external advisor to assist with developing the full methodology and evaluating the offsets Equinor plans to purchase
3. **Evaluate procurement method**: Equinor must determine what type of procurement they wish to pursue. Given the large quantity of offsets Equinor will likely purchase, we recommend Equinor considers issuing an RFP with clear evaluation guidelines that accepts proposals from every solution. This will allow projects to plan and provide the information Equinor needs to make a purchase decision while saving Equinor some time
4. **Evaluate projects**: Equinor should then apply the evaluation methodology to the project proposals, including life-cycle emissions analysis, company due diligence, risk assessment of each solution, and quality verification.
5. **Monitoring**: Finally, Equinor must develop and implement a monitoring and verification strategy for the purchased carbon offsets.

9.2.2 Recommended Portfolios for 2030 and 2050

Equinor should aim on increasing the portion of DACCS offsets in their portfolio. The table below shows an indicative recommended portfolio based on our supply and demand analysis.

Figure 9.2: Recommended Portfolio for 2030, 2040, and 2050



9.2.3 Helping Develop DACCS between 2021 and 2030

Ahead of building a portfolio of offsets to meet 2030 targets, Equinor should now focus on helping scale DACCS. The main ways of doing this are:

- **Placing purchase orders for 2030:** Equinor can place orders with one of the DAC companies to purchase offsets starting in 2030. This type of order would likely require an agreement and down payment from Equinor and would secure larger amounts of offsets than those available now for Equinor to use to meet their targets 2030 and onwards. Most of the purchases made so far are forward purchase orders of this type that would begin providing offsets in 2024 or 2025.
- **Purchasing offsets now:** Equinor can also purchase lower quantities of DAC offsets now from the DAC providers. This would provide much needed revenue to these companies to grow. However, the volumes available right now are low.
- **Investing in a DAC company:** Equinor could invest in a DAC company. This would directly help these companies scale. There are only two companies operating DAC projects commercially, Climeworks and Carbon Engineering, and both seem to have strong financial backing already. However, the need for DAC is large and there are very few DAC companies in the market. Below is a table with small DAC companies that might require Series A - C funding in the coming years and that already have backing from reputable investors.

Table 9.1: Promising DAC Companies in Early Funding Stages

Company Name	Soletair	Silicon Kingdom Holdings
Founded / HQ	2016 / Lappeenranta	2018 / Dublin
Description	Captures carbon from the air using green hydrogen to produce renewable fuels	SKH develops a passive DAC technology that needs no energy to power the DAC process.
Capital Raised	US$ 0.56 million	Unknown
Projects	Demo plant in Finland	Research with Arizona State University
Investors	Wartsila	ASU and others
Website	https://soletair.fi/	https://mechanicaltrees.com/

- **Co-developing DACCS projects:** Equinor could co-develop DACCS projects together with DAC providers, with Equinor leveraging its transportation and storage capabilities, either through the Northern Lights JV or Equinor's low-carbon solutions team. This option could help lower the cost of DACCS by scaling the storage part of the solution. The partnership between Northern Lights and Climeworks is a step in this direction.

We recommend Equinor proceeds by purchasing orders for 2030. This would allow them to start securing the DACCS offsets they need to achieve their 2030 targets. Equinor could also start purchasing earlier, for example, by 2025. If Equinor begins purchasing DACCS offsets before 2030, they could be used to offer carbon-neutral products. Equinor could invest in DAC companies or co-develop projects in addition to securing offsets for their 2030 portfolio.

9.3 Additional Recommendations for Equinor

This section presents additional recommendations for Equinor.

9.3.1 Carbon-Neutral Products

The expected initiative-led changes for carbon offsets creates an environment of uncertainty and cost pressure that makes it unfavorable to enter the carbon-neutral LNG market. For the scale needed to offset a cargo of LNG, which is roughly 250,000 tons of CO2, Equinor would likely have to enter into long-term offset contracts with developers to drive down the price. To remain cost competitive with others in the industry, Equinor would have to compromise and deviate from the recommended projects here. The risk of receiving public backlash and investing in an offset project that could be devalued under a new framework is not worth taking for a nascent product that still needs to figure out what is considered carbon-neutral.

9.3.2 Oil and Gas Climate Initiative (OGCI)

With the recent leadership transition in OGCI's Executive Committee, Equinor is in a stronger position to shape the oil and gas industry's approach to carbon offsets. OGCI's position paper on natural climate solutions[144] provides a starting point for best practices among member companies, but raising the ambition level would enhance the credibility of the organization and industry as a whole, and bring positive ripple effects for corporate risk management strategies for investing in carbon offsets. First, OGCI could increase transparency through publishing a joint registry for tracking carbon offsets to reveal the exact project details among all members. This would increase the stakes of investing in cheap and low-quality offsets, while developing a unified approach to report on carbon offsets. Second, creating a dedicated climate investment sub-group for investments related to carbon markets. In this group, companies ranging from scaling new solutions that are likely to provide further benefits in the carbon markets to monitoring technologies and software platforms can be grouped together. Given the magnitude of companies likely to enter the carbon markets to purchase offsets in the coming years and pressure to increase the environmental integrity of these markets, OGCI can claim that the investment fund contributes to shape tomorrow's carbon markets in a positive way. Lastly, OGCI can take a more active role to be associated with the carbon removal industry, as there will likely be a sharper divide between carbon removal and carbon avoidance in the coming years. Organizing workshops and creating an environment for potential pilot projects are first steps worth considering to grow closer to participants in this sector.

9.3.3 Acquire expertise and technology

The oil and gas markets are moving steadily towards a market where the carbon footprint of the products will distinguish the quality of the product and dictate market premiums. At the same time, the growth of carbon taxes and cap-and-trade mechanisms allowing offsets only heightens the desirability of expanding the internal resources to navigate the intersection of the oil & gas industry and carbon markets. In 2020, Shell acquired the Australian carbon farming company Select Carbon, while BP purchased a majority stake in the U.S. carbon offset developer Finite Carbon, and this demonstrates a willingness to build expertise within the industry. The cumulative amount of emissions reductions to expect from net zero targets in the coming decades will make carbon offsets relevant in the next years, regardless of the current environmental integrity issues.

[144] Oil and Gas Climate Initiative, "OGCI Position on Climate Natural Solutions", February 2021, http://www.ogci.com/wp-content/uploads/2021/02/OGCI_position_paper_NCS.pdf

Appendix

1. List of Abbreviations

BECCS: Bioenergy with Carbon Capture and Storage

CCS: Carbon Capture, and Storage

CCUS: Carbon Capture, Utilization, and Storage

CDM: Clean Development Mechanism

CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation

DAC: Direct Air Capture

DACCS: Direct Air Capture with Carbon Storage

EOR: Enhanced Oil Recovery

Gt: Gigatons

NBS: Nature-based solution

ICAO: International Civil Aviation Organization

ICROA: International Carbon Reduction & Offset Alliance

IMO: International Maritime Organization

JCM: Joint Crediting Mechanism

JI: Joint Implementation

SBTi: Science Based Targets Initiative

TBS: Technology-based solution

RFP: Request for proposal

Mtpa: Metric tonnes per year

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