OCEAN WALL

CARBON – CREDITS, CAPTURE AND STORAGE

November 2020

INTRODUCTION

The spectacular price rises, albeit following some significant falls, on the EU ETS (European Carbon Emissions Trading System) during the last 6 months have brought focus to a relatively overlooked sector.

Not only is Carbon Capture and Storage (CCS) gaining increasing interest from the ESG funds - research by Trustnet has found 41.25 per cent of ESG funds have made top-quartile returns in 2020 so far, while another 25.63 per cent of funds have made second-quartile returns, challenging the idea that sustainable investment means sacrificing returns - but Carbon Credits are also increasingly in the spotlight for hedge funds and banks.

The two areas are closely linked. Money put into developing the, often expensive and currently largely unprofitable without government support, CCS industry is often done so as part of a Carbon Offset Project – allowing companies that invest in CCS to claim offsets against their own carbon emissions, and possibly avoid fines for otherwise exceeding their capped emission levels.

The first half of the report focuses on the Carbon Credit market in Europe and considers medium- and long-term factors that will likely affect the price of Credits.

In the second part we look at the CCS Industry and its major players – from the smaller innovative companies to the giants of power who are trying to reduce their footprint.

And – because all roads lead to Brexit - one unexpected consequence of a possible no-deal Brexit will be the UK's participation in the EU ETS. To get around this, it is believed that UK companies have been setting up accounts located in other EU member states (primarily Holland) so they can continue trading – in fact, at one stage, the UK government was encouraging companies to do this. However, the UK's free allowance (which was temporarily suspended during 2019 before the implementation period started) will finish at the end of 2020 and only restart if a deal is reached. Otherwise the UK will either look at starting its own ETS or imposing a Carbon Tax instead.

The success of the scheme is widely debated and as Phase IV starts imminently, lasting through to 31st Dec 2030, a full review of the directive is being undertaken which will analyze its strengths and weaknesses and provide more direction for the long term. Don't expect any news on that ahead of 2026 though. A 2020 study estimated that the EU ETS had reduced CO_2 emissions by more than 1 billion tons between 2008 and 2016 or 3.8% of total EU-wide emissions so, thus far, it can be considered to be achieving its stated goals.

CONTENTS

CARBON CREDITS

COMMODITY TRADING

Carbon Credits are also called Carbon Offsets, Verified Carbon Reductions, Certified Carbon Reductions, Emissions Performance Credit, International Mitigations and EUAs.

One Credit = 1 tonne of CO2 removed or not emitted.

In a push towards a cleaner environment, certain governments are limiting the amount of CO2 emissions that a company can make by issuing them with a capped number of carbon credits (emissions they are 'allowed' to make) – mostly these are issued free of charge. Cleaner companies may have excess carbon credits they don't need and higher-emitting companies will need to buy extra credits to avoid fines. Each year governments reduce the carbon credits given to the companies to encourage them to implement carbon reductions.

Government regulators issue Carbon Credits mostly on a quarterly basis and the numbers are not released until shortly before the 'issue' date, leaving considerable room for speculation. The Carbon Credits given by the Governments are considered the primary market and there are a number of secondary markets.

PRICING IN THE EUROPEAN MARKET

EU Allowances (EUAs) are a form of carbon allowance used as the main currency in the EU Emissions Trading Scheme (EU ETS). The EU ETS is a form of Carbon Emissions Trading Scheme whereby total emissions are capped, Carbon Credits are allocated (free or by auction) and companies are allowed to trade those Carbon Credits between themselves. This, theoretically, results in companies competing to reduce emissions and ultimately to the cap being met by reducing emissions at the lowest cost. EUA trading is global, however the majority of trading comes from companies within Europe.

EUA trading takes place mainly on the Intercontinental Exchange (ICE).

Generally speaking the Carbon Credit prices will rise every year because there will be fewer of them issued and it is anticipated that companies will struggle to achieve the drops that Governments need them to make and so they'll be in the market for more Carbon Credits. Less supply and more demand! However, this is spread out over a period of 20-30 years.

Despite Covid bringing a reduction in emissions across Europe (you'd think this would reduce prices as this year as there will be a surplus of Carbon Credits) – unexpectedly there has been increased participation and an uptick on Carbon Credit pricing (now nearly Euro 30) and this is believed to be because hedge funds have entered the market and are looking longer term – they are anticipating that Covid will accelerate the move to be cleaner and so time frames to achieve greener emissions will tighten.

And it seems their predictions are bearing out to be correct. Already in September/October 2020 the EU announced a proposal to increase the union's emissions reductions target to at least 65% (currently 40%) by 2030, the UK confirmed plans to bring forward its ban on new fossil fuel vehicles from 2040 to 2030 and Poland announced that they will no longer mine for coal after 2049. Even China has said they will achieve a CO2 peak before 2030 and carbon neutrality by 2060. Acceleration is definitely happening.

In addition, some investors believe, in a buoyant bull market, that there will be plenty of money to give to companies to help them reduce their emissions. In a bear market there is likely to be less money to help companies and therefore this will add to their struggle to meet their quota of Carbon Credits and sent them into the markets to purchase more.

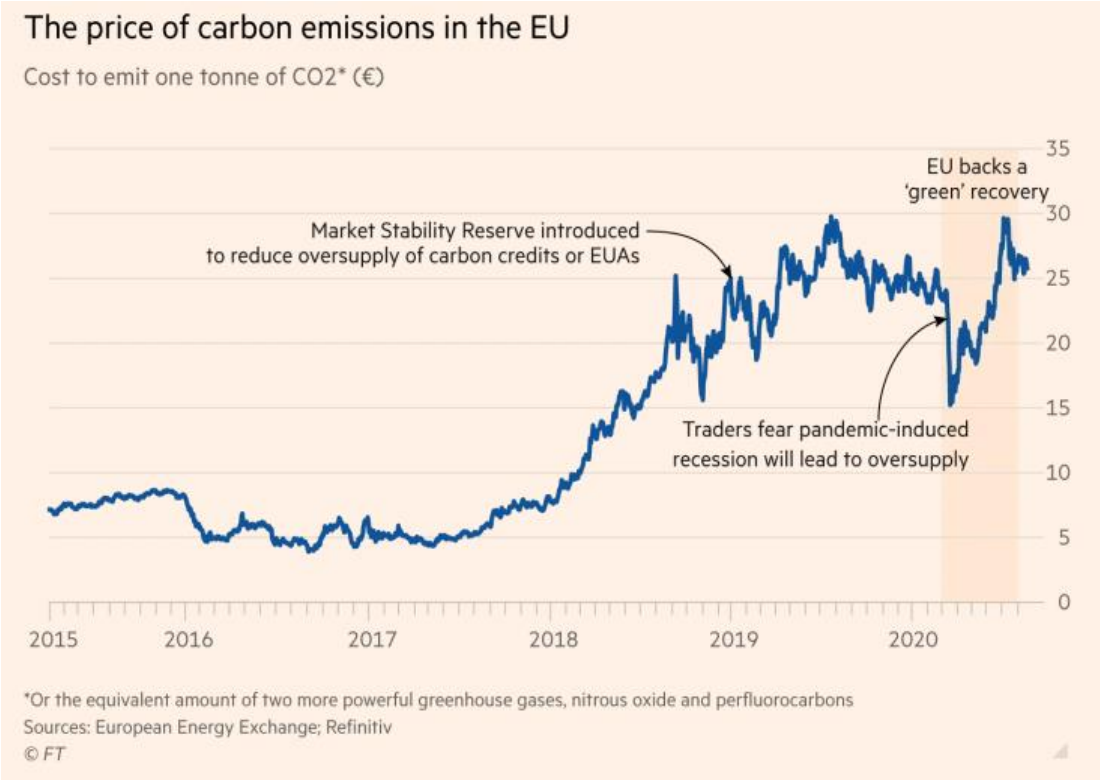
Hedge Funds and Banks seem generally convinced that there is still room for the price to increase again – talk is of Euro 40 by 2022, and there seems to still be considerable interest in the sector.

So, perhaps Yazz was right … The Only Way is Up…

SUMMARY OF A RECENT FT ARTICLE:

Carbon trading: the 'one-way' bet for hedge funds: The EU's 'green' recovery plan has driven up the price of carbon credits amid warnings that speculators stand to gain.

20th August 2020



"By 2022 the EU carbon price could easily reach €40," says commodities consultancy ICIS. "But if financial investors and speculators believe this, the price could easily reach much higher." Renewed interest in the EU carbon market could have significant ramifications for European industry. At about €25 a tonne, the carbon price is already high enough to have started to push coal off the electricity grid, with utilities switching to less-polluting natural gas or carbon-free renewables. The next stage, traders suspect, is for the carbon price to rise high enough — between €40 and €50 a tonne — to start forcing other sectors to invest in cleaner technology and fuels — good for the environment, but a seismic change for industry, the impact of which is not yet fully understood.

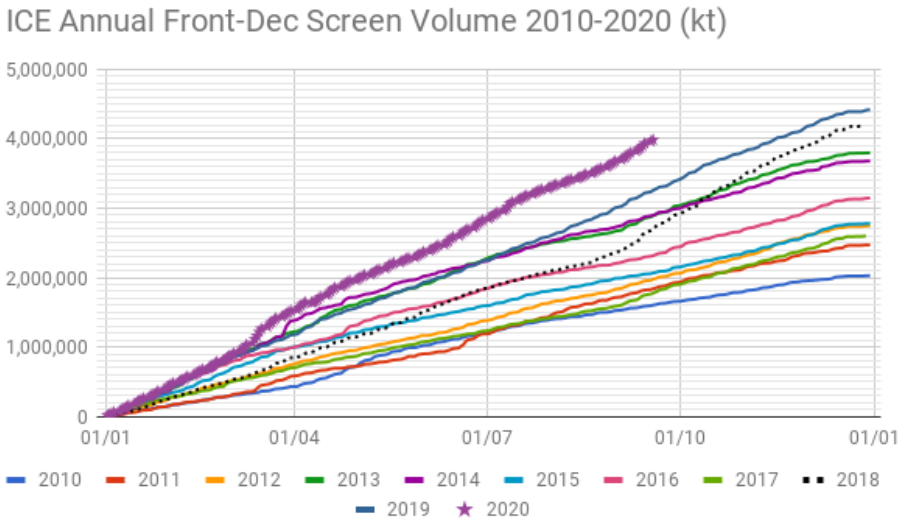
It's not just hedge funds that are showing an interest - Vitol, the world's largest independent energy trader, is expanding its five-strong carbon team. Some of the world's biggest hedge funds like Brevan Howard and Citadel are also said by rival traders to be playing more of a role, while banks such as Morgan Stanley, Macquarie and Citi have been steadily building their teams, looking to profit both from increased client activity and in-house trading. Insurers and pension funds are also reported to be taking a bigger interest as a potential hedge against climate-related parts of their portfolios.

In the face of a deep recession, the EU has not wavered in its commitment to tackle climate change, despite the associated costs. Its revised aim is to reduce greenhouse gas emissions by 50-55 per cent by 2030 from 1990 levels, up from the current target of 40 per cent.

Expectations of where the price may eventually settle vary widely. But in more than a dozen interviews with hedge funds, banks and investors active in the sector, not one said that they believed prices would fall significantly. The only differences were in how far they might rise, over what timeframe and how big the political risk might be should the mood in Brussels change. "The carbon

mechanism is already pushing out thermal generation and the next carbon abatement is likely to come from the industrial sector, for them to reduce their carbon emissions and encourage investment you need to see a much higher carbon price."

EU leverage Traders estimate that the price may need to double to about €50 a tonne in the coming years to have the full impact the EU intends. The key difference to the oil market is that in the carbon market the EU essentially holds all the levers of supply, writing the rules and deciding how many EU carbon allowances, or credits, to release — or absorb — to influence the price over time. The EU ultimately controls the whole supply. That is not to say it isn't a real market. In the short-term buyers and sellers often respond to the usual signals of supply and demand. If the economy slows and emissions go down, more participants are likely to sell, as seen this spring when coronavirus curbed demand and prices dropped almost 40 per cent from €26 to €16 a tonne. If the price falls too much — or potentially rises too high — the EU has the ability to tighten or loosen supplies through the "market stability reserve", or MSR, which was launched in 2019 to in effect reset the market after it had languished under the weight of excess supply built up during the financial crisis.



CARBON, CAPTURE AND STORAGE

In order to meet the goal of limiting the change in global temperatures to below 1.5 or 2°C by 2100 only a certain amount of carbon dioxide can be emitted before the turn of the century. That amount of carbon dioxide is effectively the world's 'carbon budget'. However, with worldwide emissions of greenhouse gasses continuing to rise, this 'carbon budget' is rapidly being used up. It has become clear that in order to meet its climate goals the world must take action both by significantly reducing its greenhouse gas emissions and by actively removing CO2 from the atmosphere. The IPCC Report on limiting global warming to 1.5°C states that between 100 and 1,000 billion tonnes of CO2 may need to be removed this century alone in order to limit global warming to 1.5°C[1]. Therefore, it is certain that there will be a significant level of demand for Carbon Dioxide Removal (CDR) and Carbon Capture and Storage (CCS) technologies as countries strive to meet their commitments to low emissions under the Paris Agreement.

The key difference between CDR and CCS is that whilst CDR actively removes CO2 that already exists in the atmosphere CCS prevents CO2 from, for example, power plants from entering the atmosphere in the first place by capturing the emissions at their source. Whilst CCS has the power to lower emissions, only CDR allows for negative emissions that can offset continuing emissions.

Importantly, these terms are often used interchangeably and thus, in many cases, references to the CCS market include the CDR market.

In November 2019 there were 19 large-scale CCS plants in operation[2]. However, according to the International Energy Agency's Sustainable Development Scenario, which is in line with the Paris Agreement, more than 2,000 plants will be needed by 2040[3]. So, whilst the CDR and CCS market has experienced significant recent growth it is still not near the size it needs to be to meet climate goals. As a result, there is a significant opportunity for the companies involved in developing and deploying CDR and CCS technologies to grow in the very near future.

In this paper I will outline CCS and CDR technologies and their potential for expansion, the existing market and policies related to it, how this market is likely to change in the near future, what demand for CDR and CCS is likely to look like, and specific opportunities for investment in the market.

TYPES OF CCS/CDR

CCS

CCS works by capturing CO2 at the source of emissions, usually at a power plant. This CO2 is then compressed and transported. It is then stored, generally by being injected into a deep rock formation

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[1] IPCC, 2018: Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E . Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp.*

[2] Global CCS Institute, 2019. The Global Status of CCS: 2019. Australia, (p. 12)

[3] The Hill, 2020. US leads new wave of carbon capture and storage deployment. U.S. Retrieved from (https://thehill.com/opinion/energy-environment/476783-us-leads-new-wave-of-carbon-capture-and-storage-deployment)

at a carefully selected site[4]. Importantly, after being captured, the CO2 can also be used rather than stored. This is referred to as Carbon Capture Use and Storage (CCUS). CCS works by preventing CO2 from entering the atmosphere in the first place, rather than by directly removing it. It can therefore be used to lower emissions in the energy industry.

There are two main forms of CDR: Direct Air Capture (DAC) and Bioenergy with Carbon Capture and Storage (BECCS):

DAC

DAC is the 'physical or chemical separation and concentration of CO2 from ambient air'[5]. It works by using an air contactor to bring CO2 into contact with a liquid or solid sorbent that the CO2 then binds to. This solvent/ sorbent is then heated or vacuumed which releases CO2 so that it can then be concentrated and transported[6]. This can be done using the same process as is used for CCS.

The main issue with DAC is that it will always be more expensive than CCS at power plants as the concentration of CO2 in ambient air is much lower. It therefore consumes more energy per ton of CO2 removed, as more air has to be processed in order to extract the same amount of CO2[7]. However, as it performs a different function in that it can create negative emissions, rather than simply lowering them, this difference does not mean that there is no place for DAC. In order for DAC to be both cost-efficient and effective at net-removal of CO2 from the atmosphere the energy used to capture CO2 needs to be both low-cost and zero-carbon.

DAC plants also do not have to be situated by a source of emissions it is far easier to place it next to cheap energy sources or the site of storage. Both of these factors can be key in reducing the costs of DAC. In addition, land requirements for DAC are minimal[8].

BECCS

BECCS works by using trees and other plants to draw down CO2 from the atmosphere. These products are then taken to a waste to energy plant where bioenergy combustion or biofuel conversion converts this biomass into energy that has many different uses. The CO2 emitted during this process is then captured and transported to a place where it can be stored. The technology required to capture the CO2 at these plants is very similar to that used to capture CO2 from fossil fuel plants[9].

The biggest issue with BECCS is how much land is required to grow the biomass necessary for conversion into energy. In order to meet the target of BECCS storing 3.3 gigatonnes of CO2 per year 300-700 million hectares of land would be required[10]. There are already worries about land scarcity as more arable land is needed to provide food for a growing population, and land also required for

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[4] Global CCS Institute, 2019. The Global Status of CCS: 2019. Australia, (p. 12)

[5] ICEF Forum, 2018. Direct Air Capture of Carbon Dioxide. Retrieved from (https://www.icef-forum.org/pdf/2018/roadmap/ICEF2018_DAC_Roadmap_20181210.pdf), (p.9)

[6] ICEF Forum, 2018. Direct Air Capture of Carbon Dioxide. Retrieved from (https://www.icef-forum.org/pdf/2018/roadmap/ICEF2018_DAC_Roadmap_20181210.pdf), (p.10)

[7] ICEF Forum, 2018. Direct Air Capture of Carbon Dioxide. Retrieved from (https://www.icef-forum.org/pdf/2018/roadmap/ICEF2018_DAC_Roadmap_20181210.pdf), (p.19)

[8] Ibid

[9] Global CCS Institute, 2019. Bioenergy and Carbon Capture and Storage. Australia. Retrieved from (https://www.globalccsinstitute.com/wp-content/uploads/2019/03/BECCS-Perspective_FINAL_18-March.pdf), (p.7)

[10] Ibid, (p.2)

reforestation. Availability of land will therefore be a key constraining factor on the deployment of BECCS.

BECCS could be particularly crucial in allowing aviation to reduce its carbon emissions as it can produce biofuels. The Carbon Offsetting and Reduction Scheme for International Aviation aims to stabilise net emissions of international aviation at 2020 levels[11]. Whilst the precise dates of this may change due to the impact of the coronavirus pandemic on the aviation industry, it is still clear that aviation is planning to decarbonize. Biofuels are likely to be a significant part of this process and this could create demand for BECCS plants if they are able to produce biofuels more efficiently than those creating synthetic fuels using captured carbon.

WHERE DOES THE DEMAND FOR CCS COME FROM?

Fundamentally, actually storing CO2 is a pure cost. Therefore, in order to make a profit from storing carbon, companies need financial incentives. Demand for CCS and CDR largely comes from the need to meet climate ambitions. Importantly, the IPCC predicts that it would be 138% more expensive to reach global climate goals without the deployment of CCS[12]. This is because it allows some industries that would find it very difficult to reach zero emissions, such as power plants, to continue operating for a period of time in a way that is compatible with net-zero emission targets. CCS can therefore be used to reduce the emissions that are the most difficult or expensive to eliminate, whilst CDR can offset the emissions that still remain afterwards. The largest demand for CCS and CDR will therefore come from governments attempting to meet their climate goals in a cost-effective way.

As CCS is an extra cost to a company, using it for industries with very high emissions, such as coal, is not necessarily the most viable way forward for governments or corporations. The costs of significantly reducing the size of the coal industry are lower and have a far more significant benefit to the climate. CCS technology should not, then, be used as an excuse to continue with high-emitting industries. Instead, it is best seen as a technology that can reduce the climate impact of industries that are difficult to either eliminate entirely or that are locked into the economy, perhaps due to existing infrastructure, for a period of time regardless of whether CCS is in use.

In addition, the public pressure for companies to reduce their emissions has resulted in many companies pledging to reach net-zero emissions in the near future. In order to meet these goals these companies will either need to buy carbon offset credits or offset carbon themselves. For example, Shell has committed to net-zero emissions by 2050[13] and is partly reaching that goal through its partnerships in the creation of CCS facilities such as the Gorgon facility in Australia and the Quest facility in Canada[14]. Energy companies can significantly reduce their emissions through the use of CCS.

Companies looking to offset their emissions have turned to CDR companies, particularly those pioneering DAC technologies. For example, Audi has partnered with DAC company Climeworks in order to ensure that some of the CO2 captured is attributed to Audi[15]. Occidental Petroleum has also

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[11] https://www.carbonbrief.org/corsia-un-plan-to-offset-growth-in-aviation-emissions-after-2020

[12] IPCC, 2014: *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. (p.25)

[13] https://www.shell.com/energy-and-innovation/the-energy-future/shells-ambition-to-be-a-net-zero-emissions-energy-business.html

[14] https://www.shell.com/sustainability/environment/climate-change/carbon-capture-and-storage-projects.html

[15] Volkswagen, 2020. In-Depth: Audi and Climeworks store CO2 from the atmosphere underground. Retrieved from (https://www.volkswagenag.com/en/news/2020/09/audi_climeworks.html)

partnered with DAC company Carbon Engineering in order to develop the world's first large-scale DAC plant[16].

Companies striving to reach net-zero emissions by purchasing carbon offset credits from those capturing carbon dioxide will be a core part of the demand for CDR. As more companies commit to Net-Zero goals, and as the dates by which these goals must be achieved comes closer, demand for credits will only increase.

Another important source of demand will be carbon usage. It is predicted that up to 700 million tonnes of CO2 could be utilized per year by 2020[17]. The ability to sell the CO2 captured will mean both that storage costs can be avoided and that companies can increase their income from selling the CO2 to a company. There is also an incentive for companies to use CO2 as an input into their products as its abundance means that it can be relatively inexpensive to purchase. As a result, McKinsey estimates that by 2030 the market for CO2 products could be worth between $800 billion and $1 trillion[18].

Currently the main use for CO2 is Enhanced Oil Recovery (EOR), which makes up for around 90% of CO2 usage currently[19]. EOR is a process of injecting CO2 into the subsurface in order to increase the amount of oil gathered from oil wells[20]. However, with the current low oil price it remains to be seen if EOR is still profitable in the long run and thus other innovations in the area of CO2 usage are likely to become more important.

The uses for CO2 range from carbonated drinks to being locked up in concrete, with McKinsey predicting that by 2030 new concrete formulations could use at least 150 Mt per annum of CO2[21]. Existing leaders in the CDR industry are already taking advantage of the potential for carbon usage. Global Thermostat, for example, sells some of the CO2 captured by its plants to a global food and beverage company. Meanwhile, Carbon Engineering is currently combining CO2 from DAC with fuel synthesis to produce synthetic gasoline. Unilever has also announced plans to use capture CO2 in its cleaning products as part of its 'Clean Future' plan[22]. It has partnered with Carbon Clean to use the soda ash that is produced from captured CO2 for its laundry products[23].

So, the carbon usage industry will create demand for both CCS and CDR technologies as it makes the process more profitable by reducing, or even eliminating, storage costs and by providing an additional revenue stream.

The demand for CDR and CCS from governments has led to many providing financial incentives for private companies to perform CDR and CCS. These incentives continue to grow in size and more are

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16 IEA (2020), *Direct Air Capture*, IEA, Paris https://www.iea.org/reports/direct-air-capture

17 Mac Dowell et al. (2017), 'The role of CO_2 capture and utilization in mitigating climate change', Nature Climate Change, vol. 7, pp. 243-249.

18 https://blogs.ei.columbia.edu/2019/05/29/co2-utilization-profits/

19 McKinsey, 2020. Driving CO2 emissions to zero (and beyond) with carbon capture, use, and storage. Retrieved from (https://www.mckinsey.com/business-functions/sustainability/our-insights/driving-co2-emissions-to-zero-and-beyond-with-carbon-capture-use-and-storage)

20 IEA (2018), *Whatever happened to enhanced oil recovery?*, IEA, Paris (https://www.iea.org/commentaries/whatever-happened-to-enhanced-oil-recovery)

21 McKinsey, 2020. Driving CO2 emissions to zero (and beyond) with carbon capture, use, and storage. Retrieved from (https://www.mckinsey.com/business-functions/sustainability/our-insights/driving-co2-emissions-to-zero-and-beyond-with-carbon-capture-use-and-storage)

22 The Guardian, 2020. Unilever plans to remove oil-based ingredients from all cleaning products. Retrieved from (https://www.theguardian.com/business/2020/sep/02/unilever-plans-to-remove-oil-based-ingredients-from-all-cleaning-products)

23 https://www.unilever.com/brands/home-care/clean-future.html

being put into place across the world. These policies and their impact on the CDR industry will be outlined in the next section.

POLICY

As explained above, national governments endeavouring to meet their commitments under the Paris agreement will be able to do so at a lower cost if CDR is involved in their plans. National governments have already recognised the importance of CDR in meeting their climate goals with 10 of the 13 countries that had submitted their strategies for lowering emissions under the Paris agreement by August 2019 including some form of CDR in their plans[24]. As governments recognise that they themselves will need to use CDR many are creating or scaling up financial incentives for private investment in CDR.

U.S

The United States currently dominates the CDR market with 10 of the 19 large-scale operating CCS facilities operating in the US[25]. This is partly a result of its strong financial incentives. Its 45Q tax credit currently awards $31 per ton of CO2 geologically stored and $19 per ton of CO2 injected for utilization purposes. In 2026 this will increase to $50 and $35 respectively[26]. Many of the plants in existence, including the Petra Nova plant came on-stream after the 45Q credit was introduced.

In 2018 California amended its Low Carbon Fuel Standard (LCFS), which is effectively a carbon credit market, to allow CCS projects to qualify for the generation of credits. In November 2019 these credits were trading at around $200 per tonne of CO2.[27]

In addition, Biden's taskforce, led by Alexandria Ocasio-Cortez and John Kerry, has committed to more investment in CDR technology[28]. It also states that 'Democrats commit to eliminating carbon emissions from power-plants by 2035 through technology-neutral standards for clean energy and energy efficiency'[29]. This is very likely to require CCS and, therefore, if Biden is elected and is able to get his climate policies enacted, it seems likely that US investment in CCS will increase and the demand for CCS from power plants will go up. Significantly, the World Resources Institute estimates that to reach a significant deployment of CCS in the US $360 million per year needed in tax credits, far lower than the $8 billion for solar power and $3 billion for fossil fuels that already exists[30]. Therefore, whilst significantly investment will certainly be needed this level investment is in line with other subsidies given by the US government.

To put the level of these financial incentives into perspective, it is estimated by the IEA that a commercial incentive of just US$40 per tonne of CO2 could allow 450 MtCO2 to be captured, used

[24] Global CCS Institute, 2019. The Global Status of CCS: 2019. Australia, (p. 37)

[25] Global CCS Institute, 2019. The Global Status of CCS: 2019. Australia, (p. 37)

[26] Global CCS Institute, 2020. Overview of Organisations and Policies supporting the Deployment of Large-Scale CCS Facilities. Australia, (p.8)

[27] Global CCS Institute, 2020. Overview of Organisations and Policies supporting the Deployment of Large-Scale CCS Facilities. Australia, (p.9)

[28] https://joebiden.com/wp-content/uploads/2020/08/UNITY-TASK-FORCE-RECOMMENDATIONS.pdf

[29] Ibid

[30] https://www.wri.org/our-work/project/carbon-removal

and stored globally with just commercial incentives by taking advantage of the low cost options for CDR and CCS[31].

PARIS AGREEMENT

Putting a price on carbon may also be achieved by the Paris Agreement. Its Article 6 contains two clauses regarding the creation of a carbon market. Article 6.2 allows for the international transfer of carbon credits and provides a framework for linking countries' emission trading schemes[32]. Article 6.4 would create an international carbon market for the trading of emission cuts from specific projects in the public and private sector[33]. The specific rules for these clauses have yet to be agreed and should have been decided at COP25 in 2019 but an agreement was not reached. The decisions regarding the specific form that these carbon markets will take have therefore been pushed back to COP26[34].

The key factor that will have an impact on the profitability of companies producing CCS and CDR technology will be whether Certified Emission Reductions made under the Clean Development Mechanism of the Kyoto Protocol will be eligible for trading in the emissions market[35]. If included this could significantly increase the supply of carbon credits, reducing their price, and therefore this would reduce the income that CCS and CDR plants could receive from carbon credits.

Significantly, Climate Analytics points out that this could lead to up to 0.1°C more warming[36]. This is shown by the difference between the blue and orange line in the figure below. So, the extent to which these credits are included will depend on the level of climate ambition held by those countries that stand to benefit the most from the inclusion of these credits. If countries increase their climate ambitions after Covid-19, then it seems that fewer and fewer of these credits will be included.

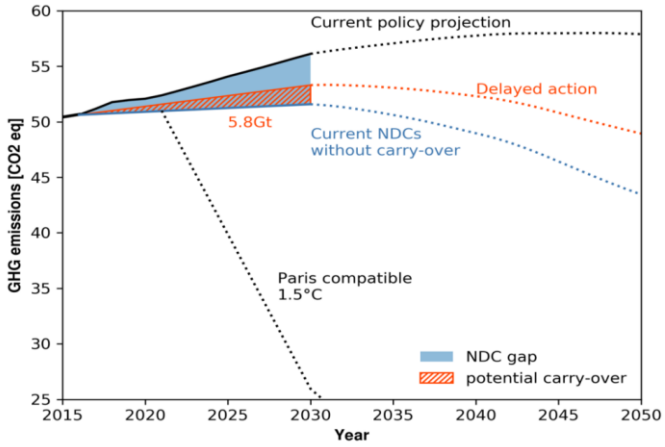

Figure 1: Impact of credit carryover

[31] Global CCS Institute, 2019. The Global Status of CCS: 2019. Australia, (p. 25)

[32] https://www.wri.org/blog/2019/12/article-6-paris-agreement-what-you-need-to-know

[33] https://www.carbonbrief.org/cop25-key-outcomes-agreed-at-the-un-climate-talks-in-madrid

[34] Ibid

[35] Ibid

[36] Climate Analytics, 2019. Article 6 Needs Ambition, Not Time Wasting. Retrieved from (https://climateanalytics.org/media/carry_over_ca_briefing_11dec2019.pdf), (p. 2)

EU

The European Commission has listed CCS as one of the seven building blocks of its plans to reach net-zero emissions by 2050[37]. In addition, the recent Climate Target Plan has increased the emission cuts that the EU aims to make by 2030 from a 40% cut from 1990 levels to a 50-55% cut[38]. This increase in climate ambition will mean that CCS and CDR must be deployed sooner, and thus more investment will be necessary.

The Circular Economy Action Plan lists as one of its key actions the proposal of a regulatory framework for the certification of carbon removals by 2023[39]. This is a necessary part of creating a carbon credit system, as without a sufficient regulatory framework it is easy to buy carbon credits that do not reliably remove the sufficient amount of CO2 from the atmosphere that they claim to. In addition, without regulations these credits can be 'double-counted', meaning that one act of emission reduction will be counted several times, and sold as several credits. In addition, many so-called carbon reductions from unreliable credits are not permanent, with poor quality projects often leaking CO2 back into the atmosphere. Emission cuts resulting from CCS, and particularly DAC, have the advantage of being both easy to measure accurately and easier to make permanent. Therefore, a sufficient carbon credit regulation system will point more companies to buying credits from operations that definitively remove emissions permanently.

These policies all provide new forms of revenue for CCS and CDR plants, and this will increase the demand for CCS and CDR technologies. In addition, as more plants come on-stream the 'learning by doing' within the industry will likely result in cost reductions. Indeed, this has already happened. For example, the Boundary Dam plant, established in 2014, faced costs of $100 per tonne of CO2 captured. Three years later the Petra Nova facility, which began operating in 2017, faces costs of $65 per tonne of CO2 captured[40]. Both of these plants were coal combustion facilities. There is still significantly more room for cost reductions.

As countries recognise the need for CCS and CDR technologies that are putting more money into funding R&D into these technologies. For example, in March 2020 the UK announced an £800 million Carbon Capture and Storage Infrastructure Fund[41]. The EU is setting up an innovation fund that will provide around €10 billion between 2020 and 2030 for innovative technologies, including in carbon capture, utilization and storage[42]. This investment into CCS and CDR technologies will allow for further cost reductions to make CCS more commercially viable. This will, once again, increase demand for CCS and CDR technologies as more plants are established and will allow the companies leading in innovating CCS technologies to grow significantly.

Some of the companies that will lead the growth of the CCS and CDR market are profiled below:

INVESTMENT OPPORTUNITIES IN THE CCS AND CDR INDUSTRY

[37] Global CCS Institute, 2019. The Global Status of CCS: 2019. Australia, (p. 43)

[38] https://ec.europa.eu/inea/en/news-events/newsroom/european-commission-launches-public-consultation-2030-climate-target-plan

[39] https://www.globalccsinstitute.com/news-media/insights/where-does-ccs-feature-in-the-european-green-deal/

[40] Global CCS Institute, 2020. Is CCS Expensive? Australia, (p. 4)

[41] https://commonslibrary.parliament.uk/research-briefings/cbp-8841/

[42] https://ec.europa.eu/clima/policies/innovation-fund_en

CARBON ENGINEERING

- (https://carbonengineering.com)
- Canada based
- Design suited for large scale DAC systems
    - Has been reported that the levelised cost of the design is likely to be around $94-232 per tonne of CO2 for a mature facility[43].
- Announced a partnership with Occidental Petroleum in 2019 to develop the first large-scale DAC plant, which would capture 1 million tonnes of CO2 per year[44]
    - The capture CO2 will be used for enhanced oil recovery
    - The plant is predicted to be operational by 2023
- Constructed a pilot plant in British Columbia in 2015[45]
    - Used the CO2 captured to create synthetic gasoline
- Overall, Carbon Engineering has raised around $105 million[46] in investments
- $68m funding round completed in March 2019[47]
    - Investment from venture capital firms, energy companies such as BP and high net-worth individuals such as Bill Gates
    - Advised by Fort Capital for this funding round
- Received CAN$25 million in funding from Canada's government in June 2019[48]
- Its carbon capture process has a high energy requirement but it is currently working on a purely electrical process[49]

GLOBAL THERMOSTAT

- (https://globalthermostat.com)
- U.S. based
- Has developed technology that removes CO2 from ambient air using low-cost heat[50]
- Its technology can be retro-fitted meaning that existing industrial facilities can be used for CDR[51]
    - This could reduce initial fixed costs for CDR plants
- Claims that when it is operating at scale (capturing over 1 million tonnes of CO2 per year) its costs will be $50 per tonne of CO2 captured[52]

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[43] Joule 2, 2018. A Process for Capturing CO2 from the Atmosphere, (p.1573), Retrieved from (https://www.cell.com/joule/pdf/S2542-4351(18)30225-3.pdf)

[44] IEA (2020), *Direct Air Capture*, IEA, Paris https://www.iea.org/reports/direct-air-capture

[45] ICEF Forum, 2018. Direct Air Capture of Carbon Dioxide. Retrieved from (https://www.icef-forum.org/pdf/2018/roadmap/ICEF2018_DAC_Roadmap_20181210.pdf), (p.10)

[46] https://qz.com/1638096/the-story-behind-the-worlds-first-large-direct-air-capture-plant/

[47] https://carbonengineering.com/news-updates/68-million-investment/

[48] https://carbonengineering.com/news-updates/canada-invests-25m/

[49] ICEF Forum, 2018. Direct Air Capture of Carbon Dioxide. Retrieved from (https://www.icef-forum.org/pdf/2018/roadmap/ICEF2018_DAC_Roadmap_20181210.pdf), (p.11)

[50] https://globalthermostat.com/the-gt-solution/

[51] Ibid

[52] ICEF Forum, 2018. Direct Air Capture of Carbon Dioxide. Retrieved from (https://www.icef-forum.org/pdf/2018/roadmap/ICEF2018_DAC_Roadmap_20181210.pdf), (p.12)

    - However, the details of this cost estimate are not currently public and have not been peer-reviewed in the same way as Carbon Engineering's cost predictions
- Has pilot plants operating in California and Alabama[53]
- Announced a joint development agreement with ExxonMobil in 2019[54]

CLIMEWORKS

- (https://climeworks.com)
- Switzerland based
- Develops and operates DAC technology
    - Its machines consist of modular CO2 collectors that are then stacked to build machines of any size
    - Effectively captures and permanently stores 90% of the CO2 filtered through the air collectors
- 3 pilot plants in operation in Switzerland, Italy and Iceland
- Has announced a partnership with Audi for a DAC plant in Iceland that will remove 4,000 tonnes of CO2 per year[55]
    - 1,000 tonnes of this will be credited to Audi to help it achieve its climate ambitions
    - The CO2 will be mineralized underground and stored there permanently
- First company to deliver CO2 from DAC as a commercial product
    - Provides CO2 from a pilot plant to food and beverage companies
- Has raised $160 million from grant funding and equity so far[56]
    - $76 million in a private funding round[57] ending in May/June 2020
    - $35 million of additional funding added in September

CARBON CLEAN

- (https://www.carbonclean.com)
- Developed the CDRMax Technology which can be used to perform CCS by capturing carbon from flue streams[58]
    - Capture rates of over 90%
- Established in UK with a subsidiary in the US[59]
- Its technology is used in over 30 plants around the world[60]
- Received around $60 million in investment, including from the UK government[61]

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[53] Ibid

[54] https://www.businesswire.com/news/home/20190627005137/en/ExxonMobil-Global-Thermostat-Advance-Breakthrough-Atmospheric-Carbon

[55] https://www.volkswagenag.com/en/news/2020/09/audi_climeworks.html

[56] https://globaluniversityventuring.com/climeworks-stretches-out-for-110m-close/

[57] https://www.bloombergquint.com/business/swiss-carbon-capture-startup-raises-76m-in-funding-round

[58] https://www.carbonclean.com

[59] Ibid

[60] Ibid

[61] https://www.owler.com/company/carboncleansolutions

- Closed a Series B investment round in July 2020 with an equity investment of $22 million including from Equinor and ICOS Capital[62]

DRAX

- (https://www.drax.com)
- British-based
- A leader in the BECCS industry
- Adjusted EBITDA of £410 million in 2019[63]
- Currently still produces coal, however this will end in March 2021
- Publicly listed, in the FTSE 250
- Aims to become carbon-negative by 2030[64]
- Has a pilot BECCS plant at Drax Power station that uses C-Capture technology to capture the CO2
- Has partnered with Mitsubishi Heavy Industries Engineering for a new BECCS pilot project at Drax Power Station[65]

CARBONCURE

- (https://www.carboncure.com)
- Based in Canada
- Manufactures a technology that utilizes CO2 as an input into fresh concrete[66]
  - The CO2 becomes embedded into the concrete permanently after undergoing a mineralization process that transforms it into calcium carbonate
    - The calcium carbonate then makes the concrete stronger
  - Reduces the carbon footprint of the concrete
    - Concrete is estimated to account for 8% of the world's CO2 emissions[67] so this could be a significant step for reducing possible offsetting costs for the concrete industry
- The equipment can be retrofitted into concrete plants[68]
- Closed a strategic investment round in 2018 led by Breakthrough Energy Ventures, a firm backed by Bill Gates
- Recently completed another funding round in September 2020 when Amazon co-led an investment syndicate that also included companies such as Microsoft and GreenSoil Investments[69]

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[62] https://www.businesswire.com/news/home/20200702005049/en/Carbon-Clean-Solutions-closes-22-million-Series

[63] https://polaris.brighterir.com/public/drax_group/news/rns/story/wvkdkpx/export

[64] https://www.drax.com

[65] Ibid

[66] https://www.carboncure.com/technology/

[67] https://www.bbc.co.uk/news/science-environment-46455844

[68] https://www.carboncure.com/technology/

[69] https://www.carboncure.com/news/amazon-and-breakthrough-energy-ventures-co-lead-investment-in-cleantech-company-carboncure/

LANZATECH

- (https://www.lanzatech.com)
- Leads the carbon usage industry with its CarbonSmart CO2 recycling technology
    - Has a commercial manufacturing facility in China attached to a steel plant that produced 16 million gallons of ethanol per year.[70]
    - Has deals with Virgin airlines to bake an ethanol-based jet fuel for commercial flight[71]
        - This fuel was used in a commercial flight for the first time in 2018[72]
- Has received around $290 million of investment[73]
    - Received $72 million investment from Novo Holding in Series E financing in 2019[74]
        - This partnership with Novo Holdings will also give it access to the company's technology which it plans to use to expand the range of products it can produce from captured CO2[75]

C-CAPTURE

- (https://www.c-capture.co.uk/investors/)
- UK based
- Patented a solvent-based technology that removes CO2 from emissions in the flue gas post-combustion[76]
    - This technology can be used at coal, gas, biomass, hydrogen, steel and cement plants, among others
- It has partnered with Drax in order to use its technology as part of the BECCS process at Drax power station[77]
- Raised £3.5m in 2019 in equity funding in a round led by BP Ventures, Drax and IP Group[78]
    - It has also raised £2.2 million from the UK government

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Contact Ian Ross with any questions.

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[70] https://techcrunch.com/2019/08/06/through-a-new-partnership-and-72-million-in-funding-lanzatech-expands-its-carbon-capture-tech/

[71] Ibid

[72] https://www.lanzatech.com/2018/10/04/virgin-atlantic-lanzatech-celebrate-revolutionary-sustainable-fuel-project-takes-flight/

[73] https://www.owler.com/company/lanzatech

[74] https://www.lanzatech.com/2019/08/06/novo-holdings-invests-72-million-in-sustainable-products-leader-lanzatech/

[75] https://techcrunch.com/2019/08/06/through-a-new-partnership-and-72-million-in-funding-lanzatech-expands-its-carbon-capture-tech/

[76] https://www.c-capture.co.uk

[77] Ibid

[78] https://www.c-capture.co.uk/c-capture-raises-3-5m-funding-round-led-bp-drax-ip-group/