The Green Bond

Your insight into sustainable finance

08 June 2023

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The Carbon removal issue

Letter to the reader

Dear reader,

Let me start by thanking Thomas Thygesen, Elizabeth Mathiesen and Tine Vist for their help in ensuring that The Green Bond publication has been mainstreamed and integrated into SEB's frames through their persistent and solid leadership over the past 4 years!

The financial market is an interesting place to be in. The parallel discussions on ESG, Sustainability and Sustainable Finance are creating massive headlines and confusion. We see headlines on litigation (two way), onboarding and offboarding of net zero commitments, as well as a significant decline in fossil-based capex.

However, unless we find ways of dealing with pollution (whether in the air, the soil, or the water) and biological imbalances (i.e., biodiversity loss) – our accelerating appreciation of stability risk, un-manageable climate consequences, as well as discounted cost of ignorance (both living and financial) – will continue to drive finance to identify and price risk of products and industries which will be phased out. Hence, with increasing data accessibility discounting factors will also change.

But there is a risk that when finance turns political (and vice versa), the headline risk increases alongside entering a non-familiar turf and create "translation" confusions.

Reflecting on our client discussions, we see an increasing conviction to be in the front of the transition, to reduce risk but also be prepared for the repricing of cash-flows which happens in a transition. A large part of the transition talk has been on de-carbonization and consequently we have decided to dedicate a large part of this edition of "The Green Bond" to carbon removals.

Alongside our regular market and transition updates, we will have contribution from Aker Carbon Capture, who represent a core part of the Nordic CCSU infrastructure, AIRBUS, who will share the aviation industry perspective of moving towards Paris through their strong transition initiatives and expected pathway – and lastly – a reflection by my colleagues Lina and Gregor on the New EU Carbon Border Tax.

Enjoy your reading,

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A word from the editor

Handing over the reins after 24 issues

In 2019, I took over as lead editor of the Green Bond. Today, 24 issues later, I pass that responsibility on. It has been an amazing period where sustainable finance went from the fringe to the mainstream and net zero in 2050 went from dream to possibility.

In June 2019, I assumed the role as lead editor of The Green Bond together with colleagues from SEB's investment banking and sustainable banking divisions. Our ambition was to prepare the publication for sustainable finance to move from pioneer market to mainstream segment, building on SEB's reputation for thought leadership in this area.

In the four years since then, we have updated and strengthened the GB publication. By June, we will have released 24 issues of The Green Bond together. During this time, we have created a new fundamental framework for analysing and understanding the clean energy transition, based on studies of long and deep historical technology cycles in the Transition Update section and strengthened the analysis of market trends in the Market Update section.

At the same time, the world has changed, and the transition has gone from vision to reality. Four years ago, it was still to a large degree about changing mindsets, with a large share of the investor community remaining doubtful about the very existence of a climate crisis. There is no real debate about this issue anymore, and the policy stasis that had held the transition back in the 2010s has been replaced by very activist policies designed to accelerate it instead.

The acceleration of the transition during those four years has been almost unbelievable. Global investment in renewable energy, electrification and other transition areas doubled from 2019 to 2022 and now stands at more than USD 1000bn per annum. During the same period, the sustainable finance market almost tripled, with more than USD 1500bn raised last year. For the first time since I started analysing the transition, it now looks like there is a realistic chance of completing the journey to net zero by 2050.

It will not be easy, but human ingenuity is a powerful force. If we can raise and allocate the capital that is required, then the technological revolutions driving the transition will allow us to both avert an irreversible climate disaster and lift the welfare of everyone on the planet at the same time.

It is now time to take the next step in that journey. I hope you will agree that The Green Bond has been rejuvenated and continues to be the standard-bearer for SEB's ambition to play a role in in shaping and driving the transition. From a research perspective, the exponential increase in transition-related investment means now is the time to focus on the role of capital markets in maintaining the accelerated pace – at the same time as getting a deeper understanding of where and how investors are likely to be rewarded with higher returns for participating, also in the stock market.

After 24 issues, I therefore hand over the baton to Lead Scientist Gregor Vulturius from SEB's Sustainable Finance Team, who will continue to combine expertise from the colleagues working with sustainability at SEB with insights from top external contributors.

My colleagues in the SEB Equity Strategy & Sustainable Investment team and I will continue to work with Gregor and the rest of the Green Bond editors and contribute to the transition and market update sections of the publication, so we are still going to be very much involved. However, I wanted to take this opportunity to thank you for taking an interest in our joint work so far and invite you to continue expecting something exciting when a new issue of The Green Bond lands in your inbox. It has been a privilege to share the journey with you all.

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Transition update

Waiting for the next surge

The transition is still gaining pace. China leads, but a surge in Western clean energy investment is underway and several energy-using sectors are close to tipping points. We still expect fossil fuel consumption to peak in 2023. The policy focus will turn to supply chains and access to key materials.

Western clean energy capex to play catch-up

Over the past few years, the conditions for an accelerated transition to a zero-emission energy system have finally fallen into place. Global renewable energy investment doubled from 2019 to 2022 driven by China, where major policy initiatives were launched already in 2021.

The Q1 BNEF data for global renewable investment show the China's investment levelled off after two years of strong growth, but also revealed early evidence of a surge in investments in the wake of major policy initiatives that are starting to take effect in other parts of the world.

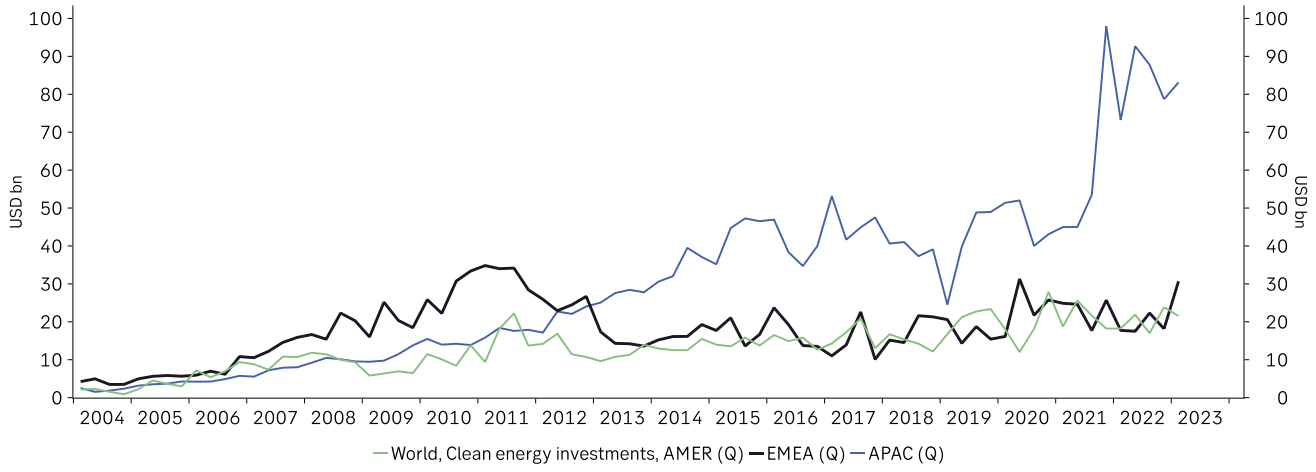
The positive momentum behind clean energy investment is not evenly distributed globally. China still has a firm grip on the lead, with quarterly investment in renewable energy maintaining the level of USD 80-90bn reached in 2021. This could still rise further as the government continues to intraduce reforms to accelerate the transition. As an example of China's level of ambition, BNEF reported that China's Guangdong province recently tendered bids to construct 23 gigawatts of offshore wind power. That is more wind power than the world has ever built in a year – and that's just coming from one region in China.

Outside China, the policy initiatives launched by the US and Europe over the past year have yet to affect investment in a major way. This is normal given the lead time for major energy investment projects. However, there are now early signs that investment is picking up outside China as well.

Q1 thus saw a 50% jump in renewable energy investment in the EMEA region compared with the level in Q4, taking it to the highest level in three years. According to the IEA, European countries have introduced more policy and regulatory changes to ease permitting for new projects in the last 18 months than over the entire previous decade, but this is only expected to have limited impact in 2023.

For now, the increase in investment in Europe thus appears to be driven by installations of small-scale residential and commercial solar PV. Within the next couple of years, we expect to see utility-scale investment follow.

Figure 1 Investment in clean energy investment



Source: Bloomberg New Energy Finance

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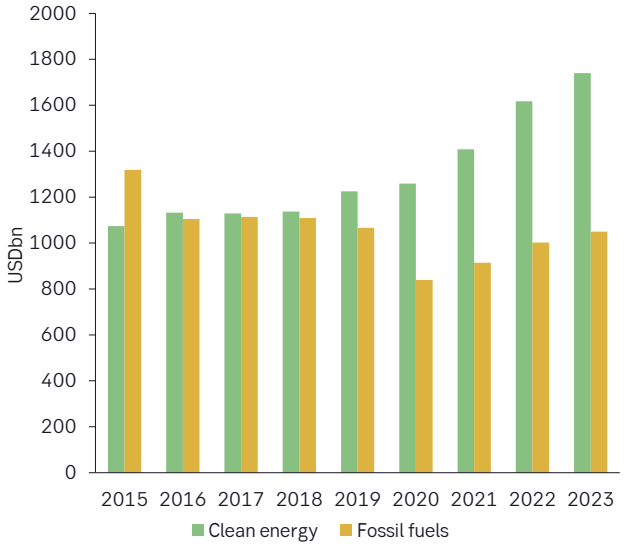
The US has yet to show any signs of a pick-up, but according to American Clean Power (ACP), during the first eight months after the IRA was passed, over USD 150bn in domestic utility-scale clean energy investments have been announced. This is equivalent to five years' worth of clean energy investments, surpassing total investment into US clean power projects commissioned between 2017-21.

Europe's surge in Q1 led to a new record for quarterly global investment at an annualized level of around USD 540bn. With policy support for the Western economies to play catch-up remaining strong, we still expect clean energy investment to double by 2025 and again by 2030.

Renewable energy supply ramping up

The recovery from the Covid-19 pandemic and the global energy crisis led to a significant increase in all kinds of energy investment. According to estimates from the IEA (which uses a broader definition of clean energy than the BNEF figures we normally use for reference), annual clean energy investment has grown much faster from 2021-2023 (24%) than investment in fossil fuels (15%), but both have increased.

Figure 2 Clean energy and fossil fuels capex



Source: International Energy Agency

This can mainly be attributed to the volatility in fossil fuel markets caused by Russia's invasion of Ukraine, which both accelerated the adoption of various clean energy technologies but also caused a short-term scramble for oil and gas supply. However, the underlying trends are still strongly in favour of renewable energy and show no evidence of a lasting interest in fossil fuels.

The global oil and gas industry had profits of more than USD 4tn in 2022, but the oil and gas resources approved for development in 2023 still falls well below the average level of the past decade. The cashflow was instead used for dividends, share buybacks and debt repayments.

According to the IEA, approximately USD 2.8tn will be invested in the global energy sector in 2023, with more than USD 1.7tn going to clean energy, which in the IEA definition includes renewable power, nuclear energy, grids, storage, low-emission fuels, efficiency improvements, and end-use renewables and electrification. Only USD 1tn will be invested in fossil fuel supply and power.

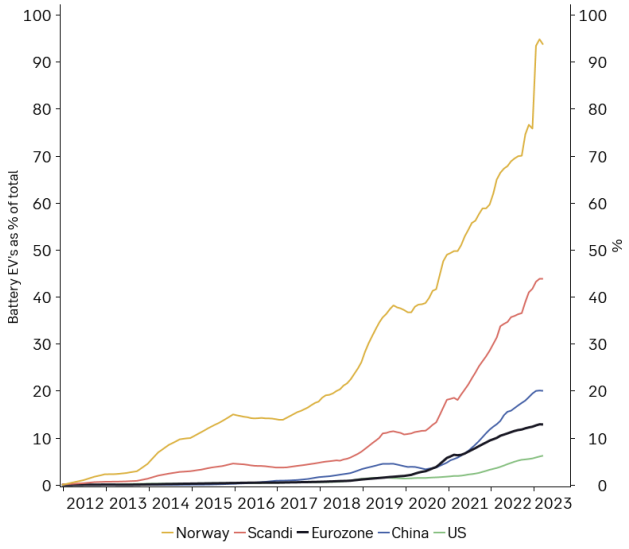
Solar energy investment alone is estimated to exceed fossil energy investment, a strong indication that 2023 still looks likely to mark the peak for fossil energy consumption. This would be an important achievement, even if it is only the first step towards decarbonization.

Developed economies and China have accounted for over 90% of the increase in clean energy investment since 2021. Barriers including higher interest rates, unclear policy frameworks, financial constraints, and high capital costs are holding back investment. The slow introduction of clean energy in the poorest countries of the world remains a challenge. SSAs are likely to play a key role in facilitating the raising of capital for these investments, given the limited local supply of saving.

Transition for energy users: EV boom continues

While the supply of renewable energy is picking up, there has also been an increase in consumer spending on electric cars, heat pumps and other appliances. China is the first major economy to reach a 20% market share for BEVs, but the Eurozone is not far behind. When it comes to adoption, the US remains a distant third despite Tesla's success on the production side, while a look at the Nordics show the likely development for all the major regions. Norway leads the way globally with a BEV market share of more than 80%, aided by strong policy incentives for early adopters.

Figure 3 Market share for battery EVs

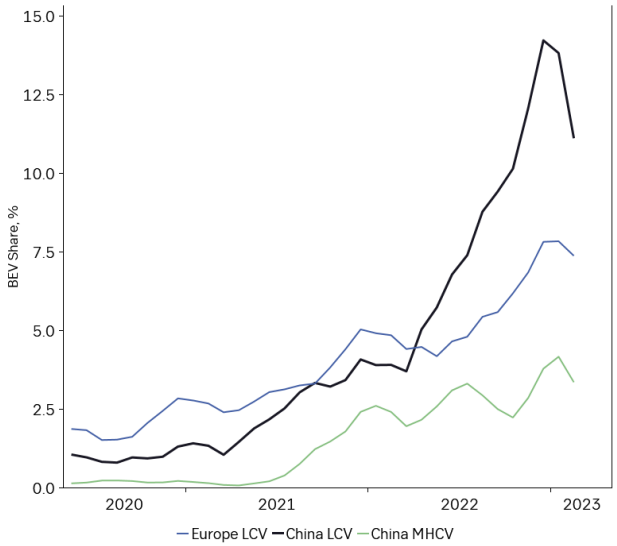


Source: Bloomberg New Energy Finance

Without such measures, it will take a bit longer in other countries, but the exponential trajectory is likely to persist, leading to a complete transition for cars in the early 2030s.

The auto sector remains the only major energy-using sector to have passed the tipping point and entered the exponential part of the S-curve. However, other sectors are not far behind, starting with light commercial vehicles. In Europe, the BEV share of commercial vehicle sales has tripled since 2020 to around 7%; in China, it is almost 10%. Heavy vehicles are not quite there yet, though, with a market share for BEVs going sideways around 3-4%.

Figure 4 EV share of commercial vehicle sales



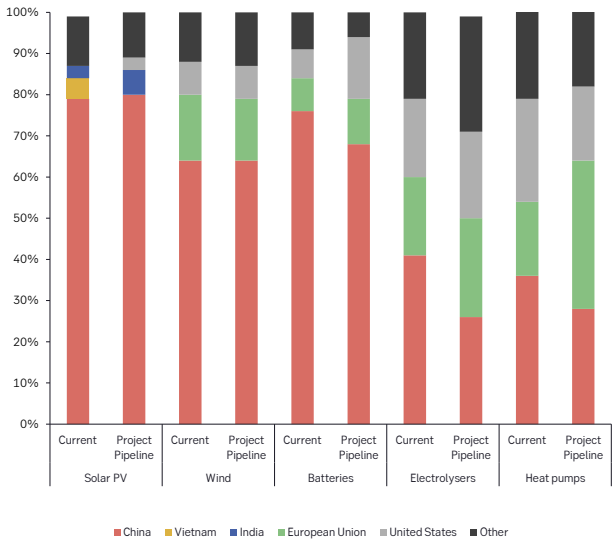
Source: Bloomberg New Energy Finance

Shipping is also slowly moving towards the tipping points where things suddenly move fast. Danish shipping company Mærsk has just announced that the world's first container ship to sail on green methanol will be delivered in September, with EU Commission President Ursula von der Leyen as godmother (perhaps acknowledging financial support from the EU). Zero-emission shipping remains in the experimental incubation phase, but there is little doubt that the experiences from first attempts like this will shape the shipping industry's future over the next 10-20 years.

Transition supply chain: new contested area

With both the supply of clean energy and the electrification of energy users taking off, the manufacturing supply chains gain in significance. The concentration of manufacturing capacity for solar PV, wind, batteries, electrolysis, and heat pumps is primarily found in China. This concentration extends beyond manufacturing and permeates various steps along the supply chain. China's prominent role in technology manufacturing is a result of its long-term industrial strategy, which involved significant investment in clean energy supply chains.

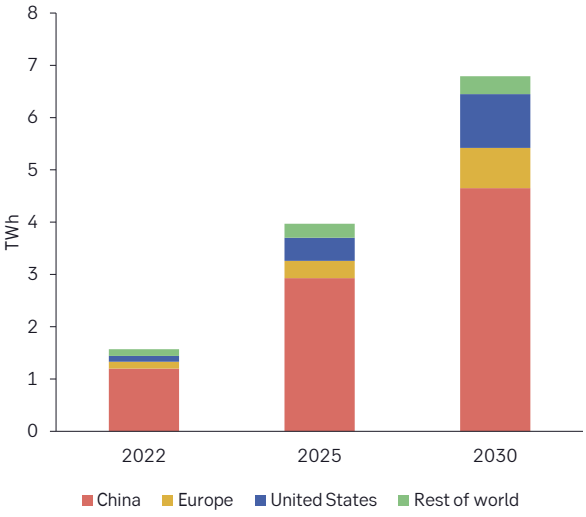
Figure 5 Clean tech manufacturing concentration



Source: International Energy Agency

As a result, China has not only reduced the costs of clean energy technologies within its own borders but has also become the leading exporter of several clean energy technologies worldwide. The competition is not standing still, though. Tesla is breaking new grounds in the manufacturing of EVs. Our colleagues from SEB's Equity Research's capital goods team recently visited Tesla's Model Y factory in Berlin, which is the stepping-stone for Tesla's next gen vehicles (yet to be presented). And for the next gen cars the theme is "a step-change in cost".

Figure 6 Battery manufacturing capacity



Source: International Energy Agency

Tesla is pitching a massive cost reduction in the making targeting an overall cost reduction of 50% which would put it in the USD 25K range. The plan is a 40% reduction in manufacturing footprint and in specific areas, e.g., the drivetrain, the ambition is a 75% reduction in factory size and 65% reduction in factory cost.

To achieve that its breaking engineering ground moving to a combo of parallel and serial assembly as opposed to the +100-year-old recipe of serial assembly line production.

However, even if Tesla does excel at manufacturing EVs, China will still control the EV supply chain. IEA data shows that China is the main player at every stage of global battery manufacturing, except for the mining of critical minerals. In 2022, over 75% of the battery manufacturing capacity in the world was in China. Even with increased capex in the west, it's still likely to be 65% in 2030.

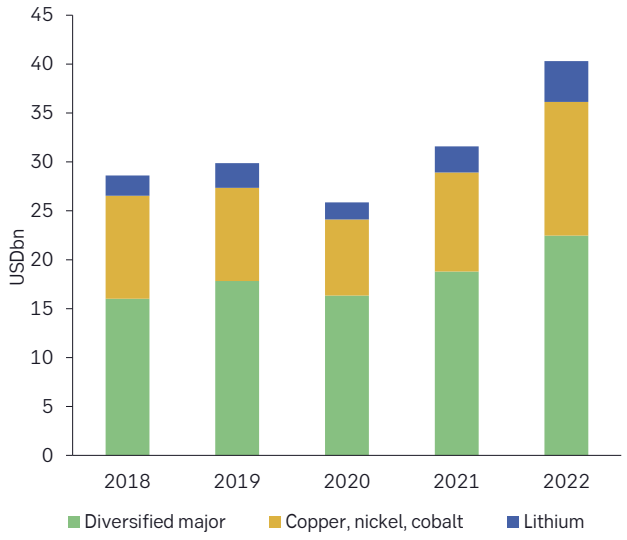
Both the US and the EU have launched major policy initiatives to reduce their dependency on Chinese suppliers. The IRA has catapulted the US to the fore of the race to localize clean tech, notably by extending generous subsidies to energy technology producers. The ACP also noted that 46 new utility-scale clean energy manufacturing facilities were announced since the act was passed.

This puts the EU under pressure. Europe would need to invest an estimated USD 149bn in manufacturing plants to meet 100% of its clean energy demand locally by 2030, according to BNEF. The Green New Deal for industrials does open for subsidies, but they are delegated to the individual member states and lack scale today.

Commodities remain a key bottleneck

Expanding the supply of materials for the transition remains a major challenge. The capital cost and the cost of clean energy technologies have increased in recent years due to higher prices for critical materials, semiconductors and bulk materials like steel and cement. This could become a big problem for an accelerated transition, particularly as the investment in new mining capacity has only recently started to pick up.

Figure 7 Investment in mining

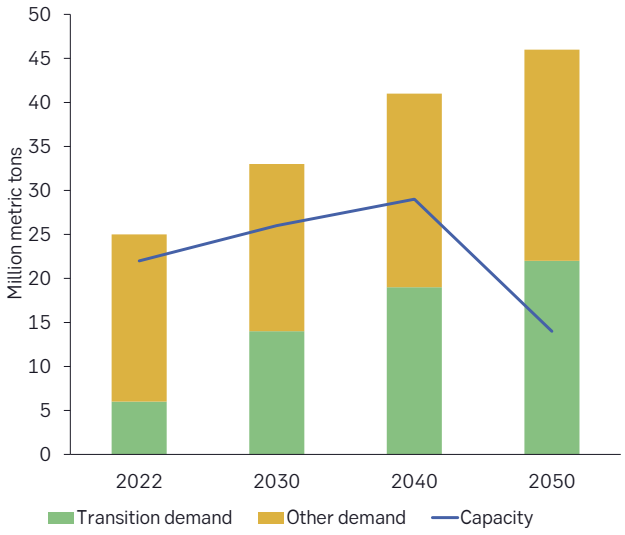


Source: International Energy Agency

According to the IEA, investment in critical mineral mining rose by 30% in 2022. Exploration spending also grew, notably for lithium, copper, and nickel. However, with a time-lag of 10 years from exploration to production and at least five years from the start of investment in a new mine until it is operational, current investment levels are unlikely to deliver the needed supply expansion in time.

According to BNEF estimates there was already a 4-million-ton deficit in primary copper supply, which excludes recycling, in 2022. This gap is set to grow eightfold to 32 million tons by 2050 unless current reserves can be supplemented with new geological discoveries and projects. This will not be easy. As an illustration, the Democratic Republic of Congo produces 70% of the world's cobalt, and just three countries account for over 90% of global lithium production.

Figure 8 Copper demand and supply capacity



Source: Bloomberg New Energy Finance

Recycling can ease some of the burden but has limits (defined by historical metal production), so an expansion of primary supply will most likely be needed. Companies engaged in the transition may provide an unexpected source of capital here. BNEF recently reported that General Motors will invest USD 650mn in Lithium Americas and help develop the Thacker Pass mine in Nevada. In Germany, Volkswagen also plans to invest in mines 'to bring down the cost of battery cells, meet half of its own demand and sell to third-party customers'.

This kind of vertical integration was also part of the first great automobile revolution. Ford's first auto factory complexes had their own steel works, harbor, electricity production and rubber plantations as this was the only way to ensure that the necessary production inputs were available when needed. If companies secure their own supply, it can help avoid serious shortages.

Sustainable Debt Market Update

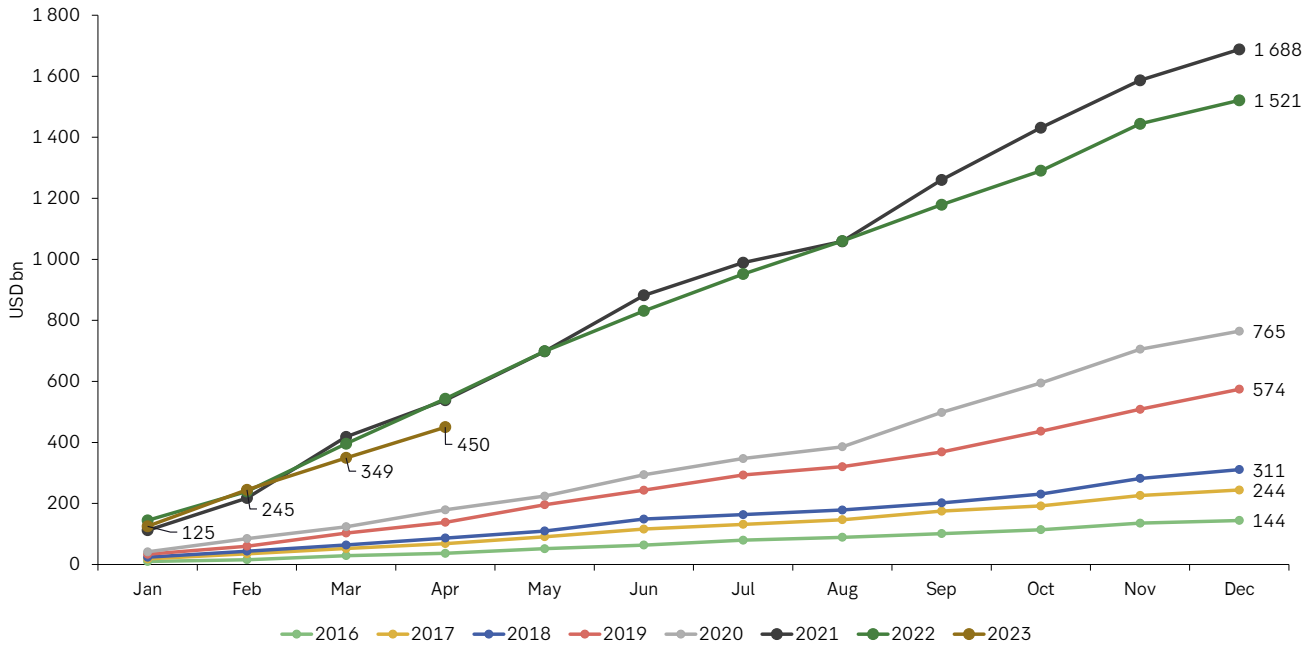
Weakness extends into 2023

Sustainability-labelled debt issuance continues to drift lower. The main reason is that issuance of bank loans is down, especially in Asia and North America. Labelled bond issuance, on the other hand, is still rising. In Europe, where ESG is less politically embattled than in the US, fund flows continue to support the demand side.

Sustainable finance: still sinking

The first months of 2023 have seen a further decline in global sustainable debt transactions, extending the decline in the last months of 2022. The first four months of 2023 saw sustainable debt issuance decline to USD 450bn, down from 543bn the same period last year. The general impression is thus still the same as through the last months of 2022: Sustainable debt is still rising almost twice as fast as in any year before 2021, but issuance is at the same time drifting further away from that 2021 peak at the same time as transition capex finally is picking up.

Figure 9 Cumulative sustainable debt transactions



Source: Bloomberg New Energy Finance 30 April 2023

Green bonds still holding the line

Taking a closer look at the distribution of issuance across the main product types within sustainable finance, the distribution is also the same as we saw in 2022.

Green bonds are the only segment with substantial issuance growth, while sustainability bonds, typically focused on EM investment, just managed to eke out a marginal gain. These are both segments with a high degree of transparency and a direct link from lending money to seeing action/physical capital on the ground.

Social and sustainability-linked bonds have both seen issuance decline modestly, but in general sustainability-labelled bonds have held up relatively well and even posted a small gain in the first four months of 2023.

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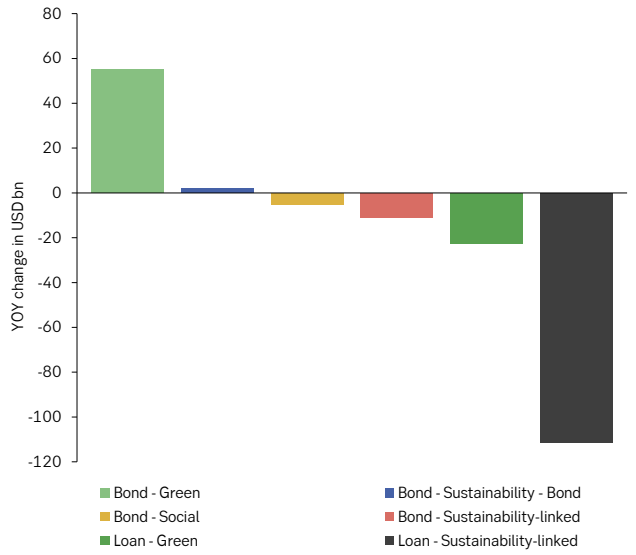
Instead, it's the sustainability-labelled bank loans that have seen the biggest decline. Green loan issuance has dropped by around USD 20bn, but it's sustainability-linked loans that are the main culprit with issuance down more than USD 100bn compared with the first four months of 2022.

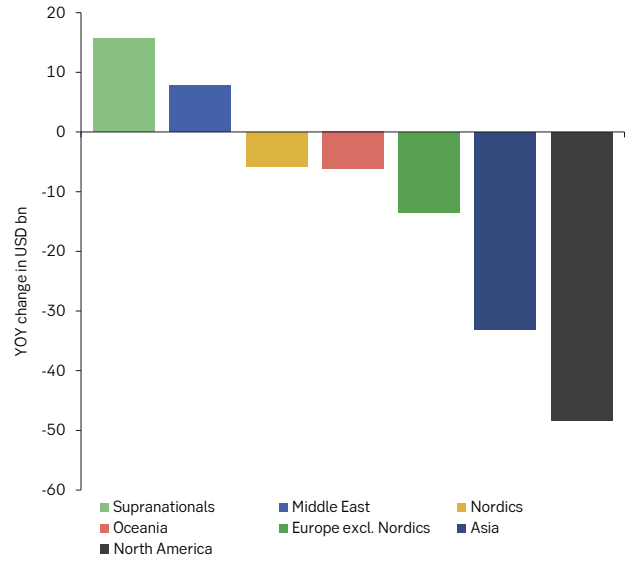
Figure 10 Y/Y sustainable debt by product type, Jan-Apr



Source: Bloomberg New Energy Finance 30 April 2023

The regional distribution also shows a clear segmentation. SSAs are still issuing more sustainable debt than a year ago, and the Middle East has also been raising a higher amount. The Nordics and Oceania have seen modest declines, Europe a bit more than that, but the big moves have come from Asia and North America. These two regions alone explain most of the aggregate decline.

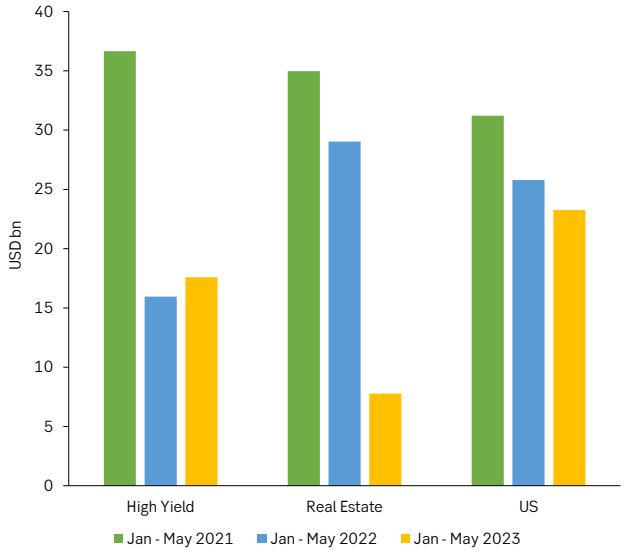
Figure 11 Y/Y sustainable debt market by region, Jan-Apr



Source: Bloomberg New Energy Finance 30 April 2023

There are thus two key explanations for the decline in sustainable debt issuance. First, it is exclusively due to a decline in the creation of sustainable bank loans, while sustainability-labelled bond issuance has increased from 397.7bn to 411.3 bn. Second, it is exclusively due to falling activity in Asia and especially North America, while the rest of the world has seen close to unchanged issuance.

Figure 12 Sustainable bond issuances Jan-May



Source: Bloomberg 5 June 2023

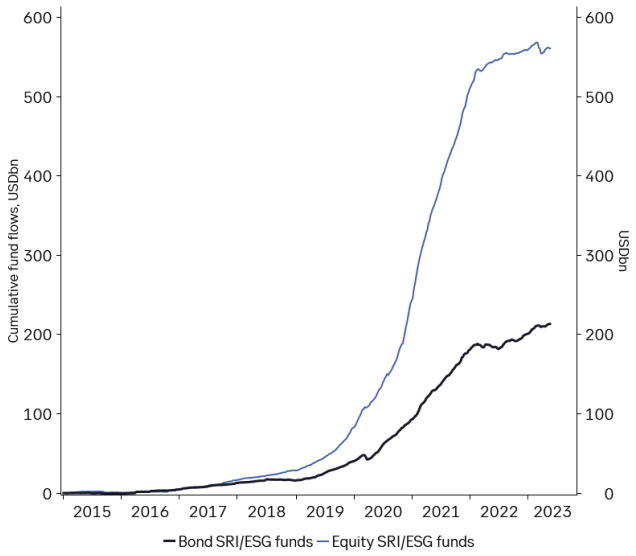
Within the overall growing segment of sustainability-labelled bonds, the weakness is especially marked in the real estate sector and for high-yield bonds, both segments where activity generally has come down sharply over the past quarters. From a regional perspective it is again the US that stands out with a modest decline.

Demand has also levelled off

Is this weakness mostly about supply or demand for sustainability-labelled debt? We can get a clue from looking at fund flows, and there does seem to be an element of softer demand at play. Developed market flows into SRI/ESG-labelled funds for both bonds and equities have thus levelled off over the past 18 months after posting exponential growth in the preceding years.

This has coincided with a slowdown in general fund inflows, so it is not necessarily a sign that investors are moving away from the segment. However, over the past couple of quarters, it also looks like the share of total fund flows going into SRI/ESG- labelled funds has started to decline.

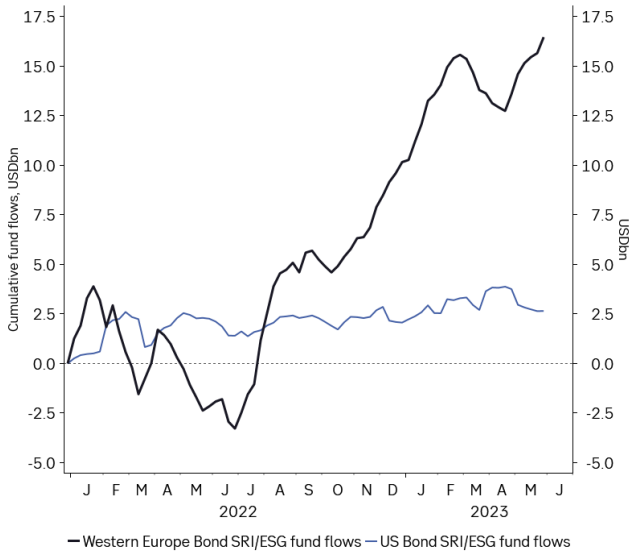
Figure 13 ESG fund flows bond and Equity



Source: EPFR

The most likely explanation for this weakness is the political conflict surrounding ESG as an investment concept over there. 15 US states have now introduced laws trying to make ESG as an investment strategy illegal. This is forcing asset managers and institutional investors to weigh up the benefits of ESG risk assessment against the threat of lawsuits and loss of investment mandates.

Figure 14 ESG bond fund flows EU vs US

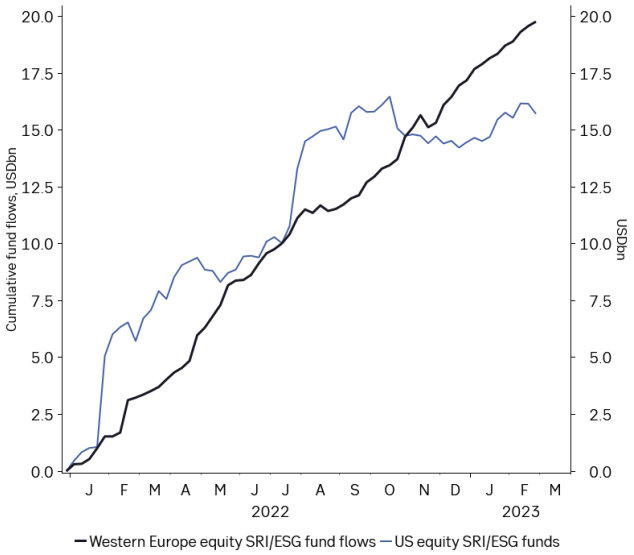


Source: EPFR

This is not the situation in Europe, and the divergence does appear to be reflect in fund flows. Both for SRI/ESG-labelled equity and bond funds, a gap has opened with European fund inflows continuing while they have levelled off in the US.

For bond funds, Europe has seen inflows of around USD 20bn over the past year, while they have been close to zero in the US. For equities, US has been flat for six months, while Europe has seen inflows of 6-7bn. In both cases, though, the numbers are much smaller than the inflows we became accustomed to in the preceding years.

Figure 15 ESG Equity fund flows EU vs US



Source: EPFR

The US debate about ESG appears to be unnecessarily tied into a broader conflict about cultural values. Some political segments have filed ESG under the broader heading of 'woke' and thus see this as part of a broader political conflict. There is nothing woke about ESG, though, it is a well-established market practice designed to identify risks for companies and check if they have been reflected in asset prices.

At the same time, ESG was never intended to be an investment strategy controlling the composition of a portfolio. To the extent that pension funds without further justification (like a claim that high ESG rating leads to higher return) make portfolio composition subordinated to ESG concerns, they could face a problem with their fiduciary duties towards pension-savers.

We suspect that we are missing some more 'neutral' instruments focused on e.g., transition investment to take sustainable finance to the next level and disarm the combatants in the US ESG debate at the same time.

Development of the Nordic BECCS Market

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The Nordic region is uniquely placed to be a major source of high-quality carbon removals for the burgeoning voluntary carbon market, which by some estimates will be worth USD 50bn globally by 2030 and approaching USD 1tn, by 2050. Aker Carbon Capture's post combustion CO_2 capture technology can be applied to capture CO_2 emissions from the combustion of sustainably-sourced biomass feedstocks in a process known as BECCS (bio-energy with carbon capture and storage). Nordic BECCS projects offers favourable attributes for producing high quality carbon removals.

Today Aker Carbon Capture is working with biogenic CO_2 emitters across the region to mature large scale carbon removals projects. Ørsted ordered in May of this year five modular and standardized Just Catch units from Aker Carbon Capture for their large-scale BECCS project in Denmark. In this landmark project, Microsoft will purchase 2.76mn tonnes of high-quality, durable carbon removal over a period of 11 years. This represents one of the world's largest carbon removal offtake agreements by volume to date.

Many of the key elements for generating high quality carbon removals are already in place, but there remain challenges that need to be overcome before the Nordic carbon removals industry can be scaled in line with projected demand.

The IPCC stated that, to have any chance of staying within 1.5 -2.0 degrees of global warming, there is a need for greenhouse gas removals (GGR) of between 5-16 Gigatons of CO_2 pa by 2050. The urgency is clear, but progress in deploying GGR technologies at the required industrial scale – specifically carbon dioxide removals – is still at an early stage.

In the Nordic region, around 75mn tonnes of biogenic CO_2 emissions are generated each year from the Pulp and Paper, Power and Heat, and Waste to Energy (WtE) industries, Figure 16. The supply of biomass feedstocks used by these industries is mostly residues from the Scandinavian forestry industry and in the case of WtE, from municipal waste.

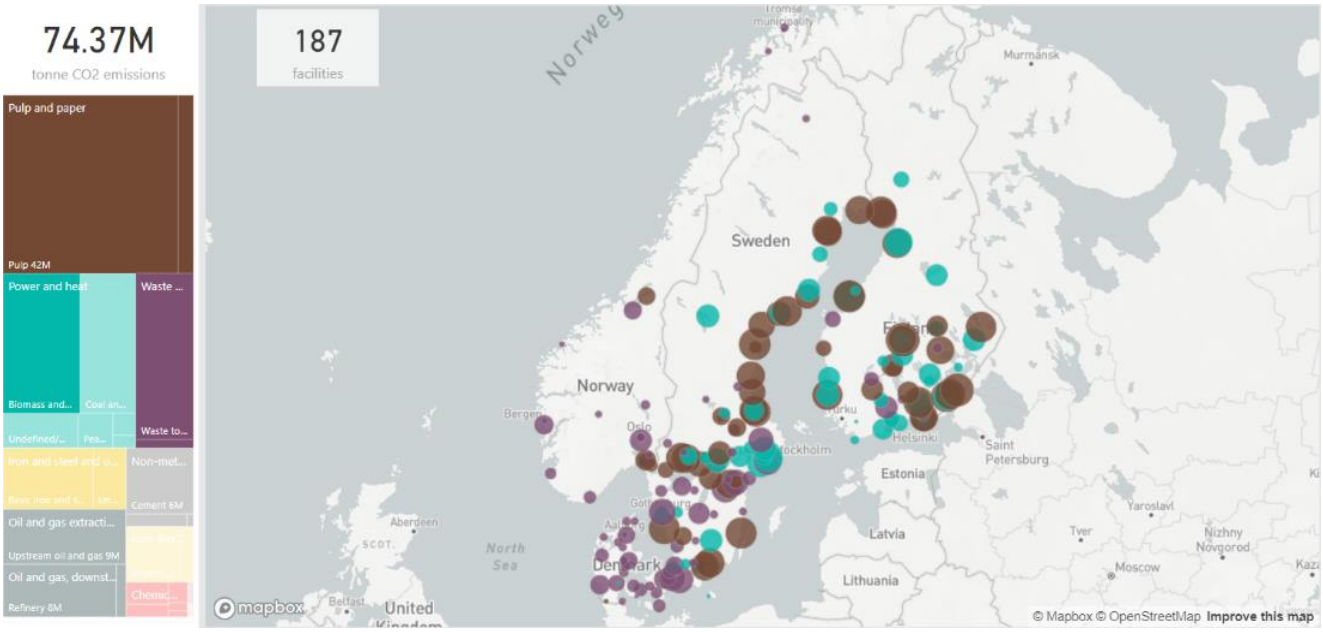
Moreover, the development of large-scale sites for geological CO_2 storage development is moving forward in Northwestern Europe, with a focus on regions with existing infrastructure, coupled with subsurface expertise from the oil and gas industry. There is the potential to generate significant volumes of carbon removals by applying post combustion carbon capture to existing industrial point sources of biogenic CO_2 emissions, then transporting and permanently sequestering the captured CO_2 in geological storage.

For organizations operating in industries with large point source biogenic CO_2 emissions, the nascent Voluntary Carbon Market (VCM) now presents an opportunity to realize significant value from a by-product of core business operations.

Critical elements required to establish a scalable BECCS industry in the Nordics, may be divided into three categories: Policy/Regulation, Technology and Full CCS Value Chain development. All three elements have numerous linkages and dependencies that need to be matured in alignment with one another.

Shaping Policy and Regulation to support market growth
Supportive policy is critical to provide clarity and credibility in carbon markets. This involves the need for a well-designed, enabling, and transparent regulatory system which incorporates the triad of monitoring, reporting and verification (MRV).

Figure 16 Biogenic emissions in the Nordic region



Source: Endrava, CaptureMap

Policy and funding remain crucial to further accelerate the development of the carbon removals market. From a BECCS perspective, state financial support for early projects is essential for the development of the infrastructure required to accelerate implementation and allow the industry to scale.

Nordic countries are taking steps to incentivize the implementation of BECCS projects to produce negative emissions. As an example, Denmark targets 500,000 tonnes of CO_2 removals per year from 2025 through its CCUS strategy. This target is linked to a funding tender of DKK 2.5bn for negative emissions from technological processes, with an operational support period of eight years.

In addition, the Swedish government has recognized the large potential for BECCS as a key mitigation measure and has committed SEK 36bn to support BECCS projects through a reverse auction system.

However, lack of clarity around interpretations of Paris Agreement Article 6 is leading to uncertainty on both the supply and demand side of the VCM. A unified understanding on the principles of carbon removal accounting towards national NDCs and corporate Net-Zero strategies is paramount, especially when transferring across international borders.

Maturing technology to capture CO_2 at scale

For BECCS in the Nordics, post combustion carbon capture is the most viable option for capturing CO_2 from industrial point source emissions. Classed as a tailpipe technology, this can be retrofitted to existing processes with minimal impact on upstream operations.

Amine-based post combustion CO_2 capture has the highest technology readiness level (TRL) of any comparable technology and is today already being deployed at an industrial scale. Aker Carbon Capture is currently delivering a modularized Just Catch plant to Twence's waste-to-energy facility in The Netherlands with a capture capacity of 100,000 tonnes CO_2 per year. At Brevik in Norway, Aker Carbon Capture is delivering a Big Catch capture plant to Heidelberg cement Norge with a capture capacity of 400,000 tonnes per year. These are both based on Aker Carbon Capture's proprietary amine-based capture technology.

Integrated solutions to strengthen the business case

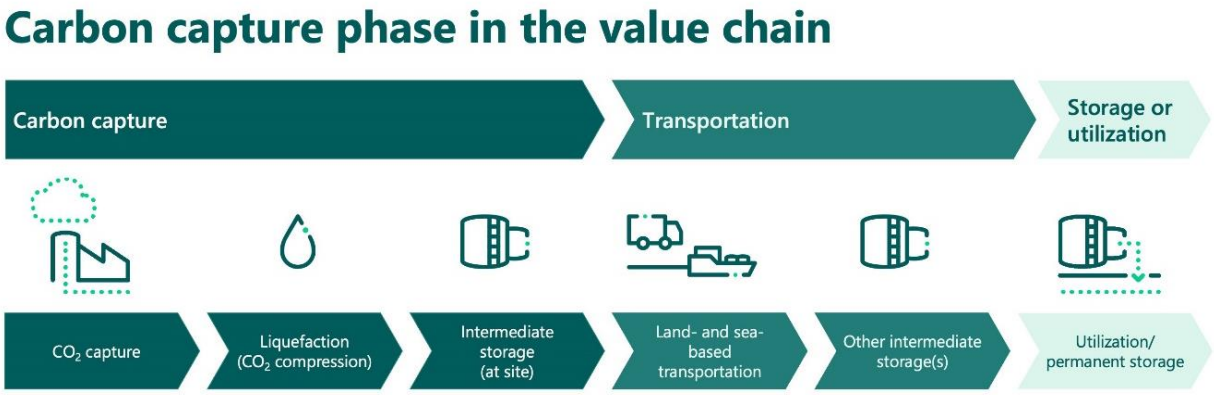
The energy penalty associated with CO_2 capture and liquefaction has a significant impact on the levelized cost per tonne for carbon removal and hence for the overall business case for implementing a BECCS project.

Industries with potential for BECCS in the Nordics, such as Biomass combined heat and power (CHP) generation, Pulp and Paper and Waste to Energy, are all typically connected to regional district heating networks, have highly efficient existing processes, but have minimal waste heat or steam that can be used within a carbon capture process. Through advanced heat integration, Aker Carbon Capture's technology has demonstrated a reduction in the energy penalty for carbon capture by a factor of five versus typically quoted figures for standard monoethanolamine (MEA) based capture processes.

Connecting the CCS Value Chain

The first large-scale CO_2 storage infrastructure is now under development in the North Sea. The governments in Norway, UK, Denmark and the Netherlands have all incentivized the development of CO_2 storage, with annual injection capacity typically ranging from 3-5mn tonnes per year for the initial projects. This first wave of projects, consisting of the Norwegian Northern Lights, the British Northern Endurance Partnership and Hynet, the Danish Greensands and the Dutch Porthos are all planned to start operation in the period 2024-2027.

Figure 17 Carbon capture phase in the value chain



Source: Aker Carbon Capture

Connecting emitters' facilities to CO_2 storage sites requires the development of a CO_2 transport network. Export and storage projects typically require anchor volumes of 1-2mn tonnes of CO_2 per annum to be commercially viable. Except for the pulp and paper industry, typical bio-emissions from industrial point sources in the Nordics are in the range of 0.1 - 0.4mn tonnes per annum. Individual BECCS projects standalone volumes could therefore struggle to support the case for transport and storage infrastructure development alone.

CO_2 export hubs will be required so that CO_2 volumes can be aggregated prior to transport to final storage locations. Across Sweden there are a number of ongoing collaborative initiatives between emitters and port operators to develop regional CO_2 export hubs, including the CINFRACAP project in Gothenburg, CCNET project in Malmö and the NICE project in Stockholm.

Aligning timelines across the CCS Value chain

The business case for developing export hubs and CO_2 storage sites is dependent on committed volumes of CO_2 being available for injection once the storage projects come online. Emitters are reluctant to take large investment decisions to implement carbon capture without clear line of sight to available export and storage options. This "chicken and egg" paradox in the CCS value chain underlines the need to align project development timelines across the full value chain.

Utilization demand for Bio- CO_2 in synthetic fuel production will provide near term offtake options for bio-emitters. Large scale BECCS at Pulp and Paper mills with harbour access, could support standalone point-to-point transport solutions and present attractive opportunities for first mover BECCS project developers.

Concluding remarks

Establishing a viable BECCS project today is complex and to facilitate further projects, clarity around aspects of relevant policy is needed. Continued investment in CO_2 transport and storage infrastructure will be essential to unlocking the huge potential for BECCS in the Nordics. Nevertheless, through close cooperation between actors across the value chain, carbon removals from BECCS is becoming a reality for those who see the opportunity.

Carbon removal in aviation

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Commercial Aviation Decarbonization Roadmap
Commercial aviation, responsible for 2.5% of human generated GHG (GreenHouse Gases) emissions, has embarked on an ambitious journey towards decarbonisation. In October 2022, the ICAO (International Civil Aviation Organization) adopted a long-term aspirational goal of achieving net-zero carbon emissions by 2050.

To reach this goal, the industry is exploring multiple solutions, including technological innovation in aircraft design and the use of new energies such as hydrogen and Sustainable Aviation Fuel (SAF). Efficiency improvements in airport operations and air traffic management are also being pursued.

Airbus is fully committed to contributing to reaching the net-zero CO_2 emissions by 2050 target set by the aviation industry under ATAG (Air Transport Action Group), IATA (International Air Transport Association) and ICAO commitments. The company' roadmap includes the ability to use 100% SAF on all aircraft from 2030 onwards. SAF is seen as a key first step in the decarbonisation of commercial aviation, with biomass-based SAF and synthetic SAF both playing complementary roles.

In addition to its focus on SAF, Airbus has launched a project to develop a fully native hydrogen-powered aircraft for operations from 2035 onwards. Hydrogen has the potential of emitting no CO_2 during flight with a low carbon footprint if produced from renewable or low-carbon electricity.

Airbus' most recent aircraft incorporate technologies that reduce emissions by up to 25% compared to our previous generations across the entire Airbus Family. The company also offers a series of recommendations for operation optimization and also delivers services through its Navblue subsidiary, which can save a few percent of emissions in operation.

Figure 18 Airbus ZEROe hydrogen-powered aircraft

Source: Airbus

Despite these efforts, some hard-to-abate volumes of GHG emissions will remain. For example, even the most advanced SAF pathways will achieve 80% CO_2 abatement. This means that even if 100% SAF is used, 20% of the CO_2 emissions will still need to be abated with Carbon Capture. Indeed, in the aviation industry, it is not feasible to capture residual emissions at the source with a carbon capture system at the exit of an aircraft's engines during flight.

The Role of Carbon Capture
In such a context, Carbon Capture plays two important roles for commercial aviation.

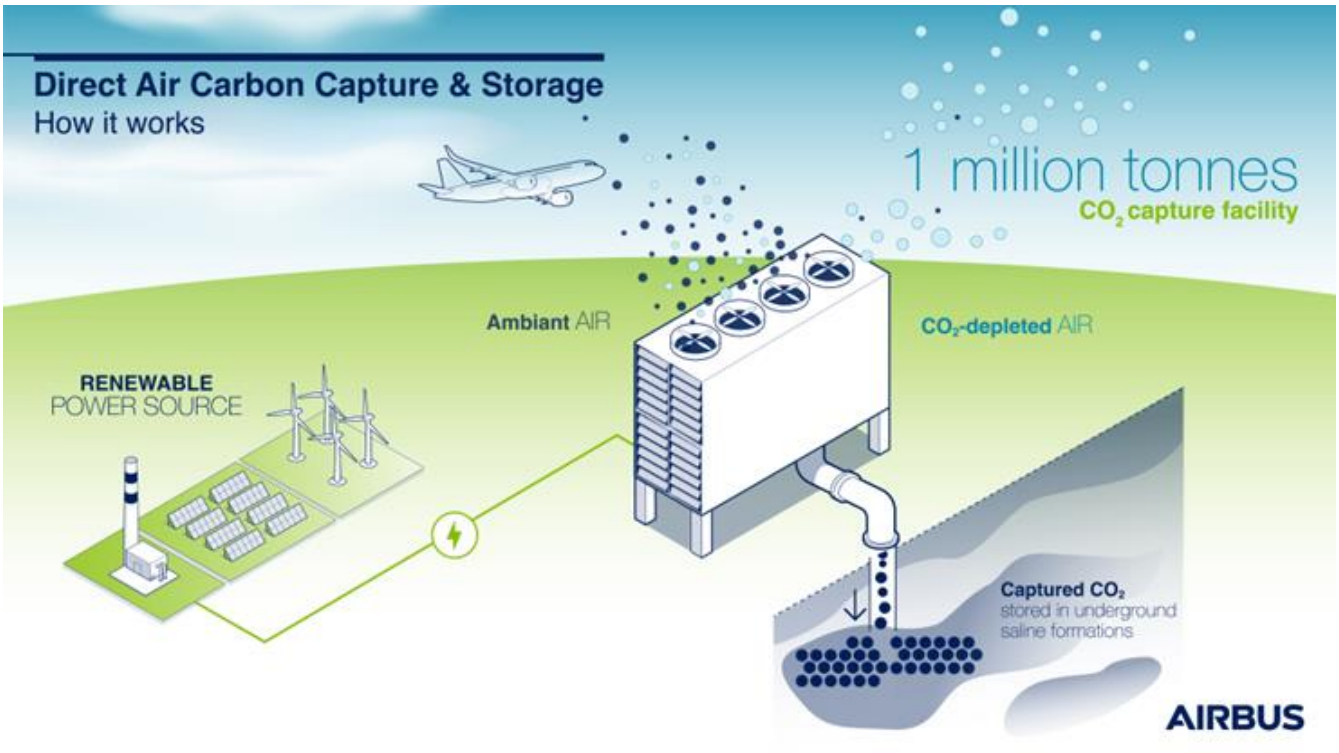
The first one is for offsetting the hard-to-abate residual CO_2 emissions. This is why Direct Air Carbon Capture (DACC) is critical to the decarbonization of commercial aviation. It is one of the main solutions to remove the remaining hard-to-abate volumes of CO_2 directly from the air.

The second role of Carbon Capture is related to the production of synthetic SAF. Indeed, Sustainable Aviation Fuel is key for the decarbonization of commercial aviation but is primarily relying on biomass-based SAF to date. To accelerate the increase of the use of SAF the development of synthetic SAF is also required. This is why research and development into the production of synthetic SAF is very active worldwide. Although the technology and efficiency of this pathway still need to be improved, synthetic SAF offers the significant benefit of relying on widely available components: hydrogen molecule (that can be obtained from water electrolysis) and carbon molecule, which could come ideally from carbon capture technologies.

Carbon removal technologies, together with hydrogen, are therefore emerging as promising complementary solutions to biomass-based SAF for aviation. One such technology, with the highest potential for aviation, is Direct Air Carbon Capture and Storage (DACCS), which removes human-induced CO_2 directly from the air.

Airbus has partnered with1PointFive, Carbon Engineering's licensed US partner, to bring Carbon Dioxide Removals (CDR) to the aviation industry. A direct air capture facility acts like a large-scale, highly efficient tree: it sucks air out of the atmosphere and extracts the CO_2 present there.

Figure 19 Direct Air Capture & Storage



Source: Airbus

Beating the challenges

To make a significant impact on global CO_2 levels, carbon capture technologies must be scaled up to an industrial level as quickly as possible. Currently, they are still in their infancy. While there have been some promising developments and pilot projects, much more needs to be done to bring these technologies to scale. This will require significant investments in R&D and the establishment of supportive policies and regulations to incentivize their developments.

A range of natural and technological approaches to remove carbon emissions from the atmosphere is available today, including:

- Reforestation and improved forest management
- Improved crop management
- Crops or forests to produce energy, with the carbon emissions from the energy production being captured and sequestered in geological formations (bioenergy carbon capture and storage - BECCS), and
- Direct air capture of carbon dioxide from the atmosphere with the captured carbon being utilized or sequestered.

Each of these approaches has limitations, from land constraints with related displacement of natural habitats. They might also face difficulties in relation to permanency for nature-based solutions or to permitting and access to low-cost renewable energy for techno-based solutions.

Techno-based solutions such as Direct Air Capture are still far from being cost-competitive compared to the other

solutions due to high energy intensity requirements. As past low-carbon technology transitions suggest, this calls for policy and political strategies beyond carbon pricing. Standardization will also be required to facilitate Carbon Dioxide Removals (CDR) recognition and to ensure common criteria (e.g., permanency, additionality, monitoring, reporting and verification accuracy) will be met for CDR to be considered of high environmental integrity and supporting sustainable development.

Way forward

In conclusion, it is clear that carbon capture and removal is a crucial component in the efforts to combat climate change. The strategy must always prioritize avoiding and reducing emissions before turning to carbon offsetting or carbon removals. As carbon dioxide removal becomes increasingly commoditized, it is essential that a robust, liquid, and transparent market is established to ensure its effectiveness. This will require collaboration between governments, businesses, and individuals to create a system that incentivizes sustainable practices. The way forward is clear: we must develop and prioritize carbon capture and removal in our efforts to create a safe and sustainable future for all.

EU Carbon Border Adjustment Mechanism: An overview of the EU's "carbon border tax"

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Over three years ago, the EU announced its ambitious plan to become the first carbon neutral continent by 2050. The European Commission presented a plan titled "The European Green Deal", which outlined a roadmap for reaching this goal.

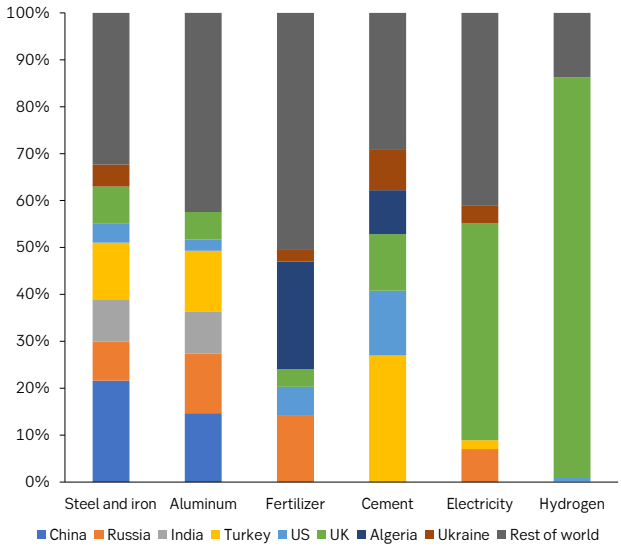
As the EU set out to significantly reduce its carbon emissions and "greenify" the economy, concerns were raised about the potential relocation of carbon-intensive industries to regions with less stringent climate policies. Such relocation, known as carbon leakage, could significantly undermine the EU's environmental efforts and lead to the shifting of emissions rather than their actual reduction.

What is the CBAM

The primary objective of the Carbon Border Adjustment Mechanism (CBAM) is to prevent carbon leakage by ensuring that the price of imports reflects their carbon content, thereby reducing the competitive disadvantage faced by EU industries subject to stringent emissions regulations. The policy aims to incentivize both domestic and international industries to decarbonize, encouraging the adoption of cleaner production methods and technologies.

Initially, CBAM will apply to the import of only certain carbon-intensive goods, or processed products from those goods, that are at most significant risk of carbon leakage. The sectors covered by the mechanism include cement, iron and steel, aluminium, fertilizers, electricity, and hydrogen. In 2022, the value of EU imports of products covered by the CBAM exceeded US 130bn. Exports to the EU in CBAM sectors are concentrated among just a few big trading partners with the UK, China, Türkiye, Russia and India making up more than half of total EU imports.

Figure 20 EU imports from non-EU countries of origin, sectors covered by CBAM in 2022



Source: Bloomberg New Energy Finance, ICT

How will it work

The CBAM will enter into force in its transitional phase on 1 October 2023. During this phase, importers to the EU will have to start counting and disclosing CO_2 emissions. Once the permanent CBAM system will then enter into force in the beginning of 2026, importers will be required to purchase CBAM certificates corresponding to the embedded carbon in their products. The price of these certificates will be based on the average price of emission allowances in the EU Emissions Trading System (EU ETS).

Once fully phased in, CBAM will capture more than 50% of the emissions in ETS covered sectors. By 2030, the product scope of the mechanism will be reviewed to assess the

feasibility of including other goods covered by the EU ETS[1]. To comply with WTO rules and level the carbon costs for importers and domestic corporates, the phasing-out of free allocation under the EU ETS will take place in parallel with the phasing-in of CBAM in the period 2026-2034.

It is important to note that the CBAM for the most part limited to goods. This means that manufactured products that contain some of the goods covered by the mechanism, such as, for example, electric appliances and cars, will not be covered by the EU's "carbon border tax"[2].

Potential benefits

The introduction of the CBAM has significant implications for various stakeholders. EU industries will be relieved of the competitive disadvantage caused by different carbon pricing regimes, creating a more level playing field. It is expected to stimulate the adoption of cleaner technologies and practices within the EU.

Moreover, the CBAM could potentially encourage non-EU countries to enhance their own climate policies to avoid paying additional costs associated with carbon-intensive exports. For instance, Türkiye's Medium Term Program (2023–2025) explicitly connects its plans for introducing a national ETS in Türkiye to the CBAM[3]. It may also provide an incentive of companies without carbon pricing like India in establish emission trading or carbon tax schemes.

Figure 21 Global emissions trading schemes, average price Jun 2022 – Mar 2023

Jurisdiction	Carbon price (USD)	Scope
EU ETS	87.22	Covers 40% of EU emissions
UK ETS	92.69	Covers around a third of UK emissions
California Cap and Trade Program	27.22	Covers around 85% of the state's emissions
China ETS	8.80	Power sector, covering around 4bn tons of CO_2
South Korea ETS	15.03	Covers around 66% of South Korea's emissions

Source: International Carbon Action Partnership

Potential challenges and concerns

Implementing the CBAM faces several challenges and concerns. Firstly, ensuring the accuracy and reliability of carbon footprint measurements for imported goods poses a significant technical challenge. Establishing a robust and transparent monitoring system will be crucial to the success of the CBAM. Additionally, the potential for trade disputes and tensions with non-EU countries, particularly those heavily reliant on carbon-intensive industries, remains a concern. The EU must navigate these challenges while ensuring compliance with WTO rules.

Additionally, some analyses have pointed out that CBAM covering only raw materials and not produced goods might put European manufacturers at a disadvantage as opposed to their counterparts in developing countries[4].

Implications for corporates and financial institutions

The private sector will be affected by the CBAM in various ways. Firstly, it is likely to influence the costs for imports into the EU, as companies in carbon-intensive sectors outside of the block will face increased costs due to the purchase of CBAM certificates. Increased import costs may also affect EU companies that use imported goods for domestic manufacturing.

At the same time, the CBAM may help to improve the price competitiveness of carbon-intensive industries in the EU – as intended by the new regulation. However, EU industries will likely require additional support to adopt low or zero-emission solutions to meet EU climate targets and manage the phase-out of free ETS allowances.

Moreover, the mechanism may have implications for international trade and relations, potentially leading to trade disputes. Non-EU countries heavily reliant on carbon-intensive industries might view the CBAM as a trade barrier or protectionist measure, potentially triggering retaliatory actions. These trade-related uncertainties and disputes could have broader impacts on financial markets, affecting investor confidence and market stability.

On the other hand, the CBAM incentives importers to reduce their carbon footprint to avoid additional costs associated with the EU carbon border tax. This will likely result in an increased demand for clean technologies, renewable energy, and energy efficiency solutions from suppliers both outside and inside the EU.

Financial institutions will need to consider the risks associated with the CBAM and carbon-intensive assets in their risk assessment and investment decision making. The potential impacts of the mechanism on the profitability and valuation of carbon-intensive industries, as well as the risk of carbon leakage, may require a reassessment of investment strategies and risk management frameworks.

[1] Carbon Border Adjustment Mechanism (europa.eu)

[2] See Annex I of the regulation for a complete list of goods and processed goods included in the CBAM

[3] World Bank State and Trends of carbon pricing 2023

[4] The unintended consequences of CBAM on the EU Industrial Strategy – EURACTIV.com

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This report was published on 08 June 2023.

Cut-off date for calculations was 30 April 2023, unless otherwise stated.

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