The Green Bond

Your insight into sustainable finance

23 November 2022

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Rethinking sustainable investment

Letter to the reader

About time!

The other day I was in a talk with a US counterpart where we discussed the heated debate currently ongoing in the US on the role of finance from the ESG perspective. Some stakeholders require engagement to work with you, while others will cut your line if you dive into ESG divestment strategies which might hurt their stakeholders. They might even question if ESG is aligned with prudent financial management.

Being a strong believer in the transition, and considering the value created and the risk of not acting – it feels wrong to support the concerns raised on ESG in the US (on whether it breaches the financial duty to engage). However – if ESG strategies in finance are created on a conviction of doing right, rather than a fundamental analysis of fiduciary (financial) elements, there is a significant risk of raising critiques and thereby delaying the transition – which is exactly what we currently experience in the US. Hence, this debate is necessary in order to move forward!

Additionally, there is a risk that the reporting requirements currently being established to monitor engagement and labels, can become a compliance issue. This might result in the professions currently working in the field and driving the transition being pushed away from the front row and into reporting. So, the establishment of standards and reporting needs to take this into consideration when balancing reporting requirements. In this context, the current US discussion is a core requirement to ensure prudence and thereby insure durability and speed in the transition. This obviously doesn’t mean that I don’t support ESG strategies and activities. But it does mean that there is a need to build the root system alongside the growth – and in the financial world that consist of the fiduciary mandate provided to the industry.

The recent COP27 has been on the minds of many, and the expectations around the ability for others to deliver results never come to an end. From a business perspective, it is difficult to plan your work around expectations from policy debates. Consequently, it is the core understanding of stakeholder preferences, be it clients, employees, investors, lenders, or the general public, is what drives business priorities, innovation and development. On that note: When speaking to our institutional investors they are, on a broad range, decarbonizing their portfolios, meaning that the access and cost of capital will reflect that. When we speak to our industrial clients, there is a rooted focus on resource accessibility, efficiency and regulations, as well as client preferences, driving supply- and sub-supply chains.

When we talk to potential new employees, especially in the wake of the COVID pandemic, qualified professions search for purpose. And when we speak to regulators – especially in the area of finance – they try to identify the financial stability risk associated with climate risk. So, the core stakeholders of finance, and therefore the business of finance, are all moving in one direction – towards the transition – and that is where money will go! I was recently in a panel discussion, where I was asked to express my opinion of a famous investor and their recent investment into oil. I answered that I expected the ongoing capex to be low and the price to remain fairly high, which will keep a nice cash-flow – and this needed to be seen in the timing aspect of increased taxes, less demand, and halting investments in the supporting infrastructure. BUT there is something I regret not saying then. And that is that alongside these strictly financial reflections, one also needs to consider the management time allocated to defending these investments from the climate perspective, both in front of corporate and private stakeholders, and the resulting challenges in acquiring the desired staff. This is obviously not a recommendation to buy or sell, but just a reflection on some of the elements that need to be considered when looking into such a potential investment.

Finally, I am grateful to our external article providers, Enerdata and Copernicus/ECMWF, who are illustrating ways of assessing the future of the European energy system in the context of climate. I am also grateful to my colleagues, for their contribution on the ECB climate score and its benchmark for gradually decarbonizing its corporate bond holdings.

Enjoy your reading,

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Transition update

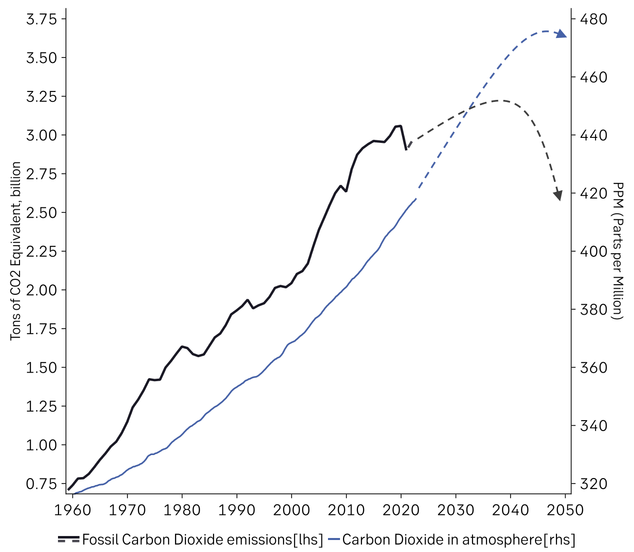
The case for transition investment

The outlook is caught between hope and despair. We think hope will prevail because a surge in clean energy investment is underway. Renewable energy is a technology revolution and accelerated transition can halt emissions, but also comes with significant challenges that capital markets must help to address. It will require long-term capital for EM transition and for sectors that must be first movers in new technologies that are not fully developed. We introduce a new framework for sustainable investors.

Best of times, worst of times

After a year of upheavals both in energy markets and financial markets, a new, faster long-term transition trajectory is starting to take shape at the same time as the negative effects of our earlier procrastination is beginning to emerge. From a climate crisis perspective, this leaves an outlook caught between hope and despair, but we continue to believe that hope will eventually dominate.

Figure 1 CO_2 emissions and in atmosphere

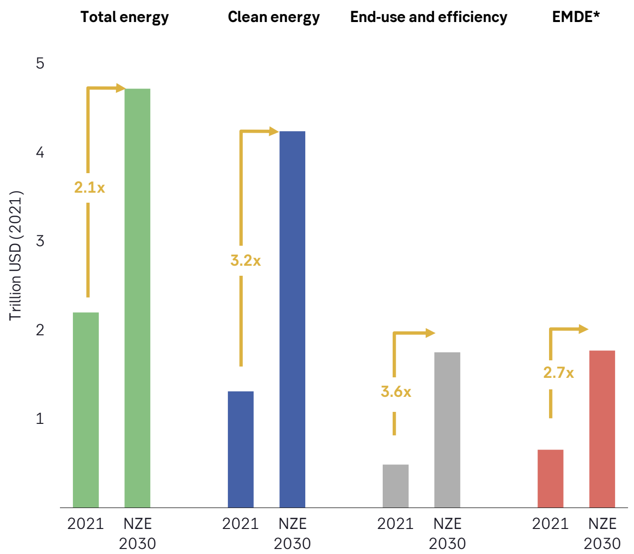


Source: Macrobond

This gap is also evident when we look at the underlying driver of global warming in the shape of greenhouse gas emissions (Figure 1). The positive signal is that emissions have not returned to pre-pandemic levels after the reopening even though the global economy has recovered to a higher GDP level. This is an encouraging sign that suggests we could be close to peak emissions, especially if we continue investing aggressively into new energy infrastructure in the remaining part of this decade.

The less positive side is that this comes a bit late because of the significant time-lag between a peak in emissions and a peak in the CO_2 level in the atmosphere. As a result, the combined verdict from three UN agencies is that the 1.5°C scenario no longer is realistic to achieve, even though the worst tail risk scenarios also look less likely. No matter what we do, we now have to be prepared for adverse effects of global warming to hit us.

Figure 2 Energy investment in the NZE Scenario



Source: International Energy Agency (2022), World Energy Outlook 2022, IEA, Paris. Note: EMDE = Emerging Market and Developing countries ex. China

The starting point is also challenging when it comes to achieving net zero emissions by 2050. This was once again highlighted in the IEA's annual update of their Net Zero Emission scenario in the World Energy Outlook that was released in October. According to the IEA, the current level of total energy investment in the world is less than half of what is needed by 2030 (Figure 2).

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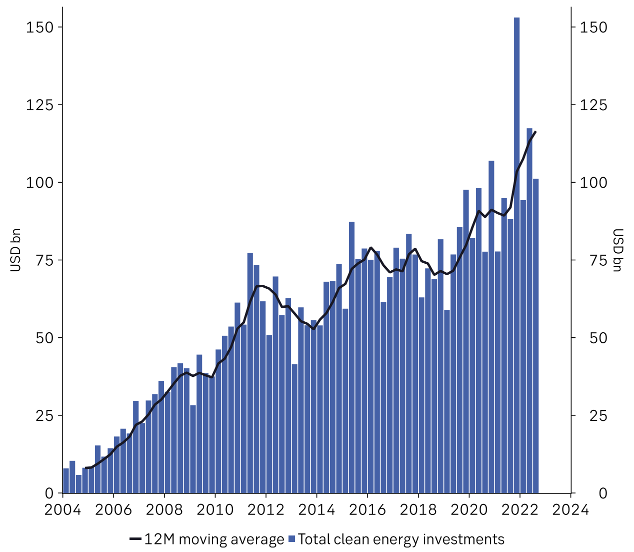
Renewable energy investment would have to triple, increasing the annual investment level by USD 3tn in the same period. The bad news is thus that we still are nowhere near where we need to be. However, there are also positive signals from actual transition investment because the gap has finally started to close after a lost decade in the 2010s (Figure 3).

Figure 3 Investments in clean energy



Source: Bloomberg New Energy Finance

New data from BNEF show an increase in renewable energy investment of almost 50% over the past four years, which means that the required doubling by 2025 remains very much within reach. We think this is the beginning of a lasting trend because the latest push reflects a deeper and more profound change in the economic climate.

Regime change: 'economic arms race' begins

The catalyst for this regime change may not be the one we had hope for. The shock of the war in Ukraine has amplified secular shifts that were set in motion by the pandemic. We are now back in a multipolar geopolitical regime.

In the way as when the first cold war started around 1950, the emergence of evenly matched 'superpowers' now rules out direct military confrontation, forcing major economies to engage in an economic race instead. Trade wars, pandemic disruptions and more recently war in Europe and energy shortages have made it clear that securing supply chains for energy and other essential goods is a national security policy issue and not an economic policy issue.

Like in the first decades after WWII, the result is likely to be increased resource utilization. Once it becomes a question of not falling behind in the 'economic arms race' rather than trying to do the right thing for future generations, the budget limitations are likely to fall away. In such a scenario, governments will have to use all resources at their disposal, subordinating all other concerns to the aim of keeping up with the other side. This means ramping up investment in the three areas outlined in the second row in Figure 4 and subordinating all other parts of economic policy to this overriding national security objective.

From a financial perspective, such a regime change would lead to a trend change for inflation and interest rates after a long period of zero rates and falling real yields.

From a climate crisis perspective, a new cold war would have a silver lining. It would shift clean energy investment decisions from being driven by long-term climate concerns to being driven by economic performance concerns.

Figure 4 Security trumps all other factors in a cold war

Source: SEB

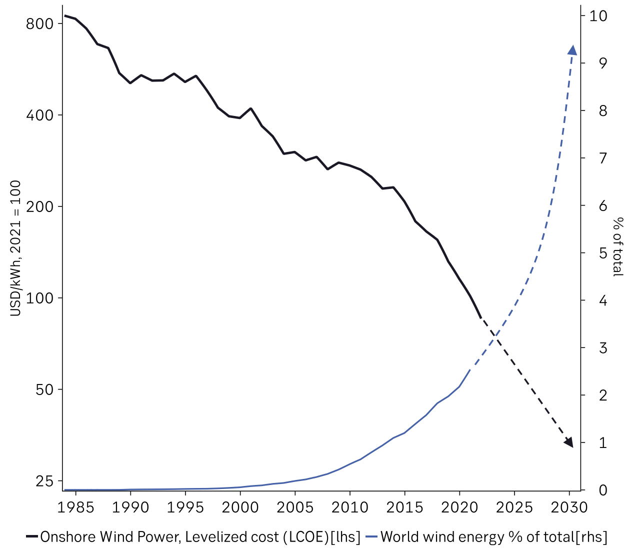
Clean energy is a technology revolution

Renewable energy is already cheaper than fossil alternatives at the same time as it reduces the dependence on foreign suppliers, so it will be the first choice when the major economic systems compete to build a superior and more secure economic infrastructure. It shows the hallmarks of a true technology revolution with positive feedback loops. This means the economies that are first to scale these technologies will see faster gains in economic performance going forward.

The key characteristic of technological revolutions in the past has been that rapid price declines occur due to the learning curve effect. Technologies develop as they are used through trial and error and learning by doing. This creates a positive feedback loop where the more you invest, the faster the price declines. In general, these feedback loops were in effect through 30 years of incubation where the technology developed enough to be competitive and through the next 30 years of diffusion until the new technology has reached a penetration rate of around 50%.

This effect has also been evident across different renewable energy technologies during their incubation period and the start of the deployment phase. As Figure 5 shows, the cost of wind power has declined at the same time as the installed base has increased, much as we saw with IT equipment with Moore's law. As wind power continues growing as a fraction of total global energy consumption, the marginal cost will fall towards zero.

Figure 5 Wind power LCOE and global energy consumption

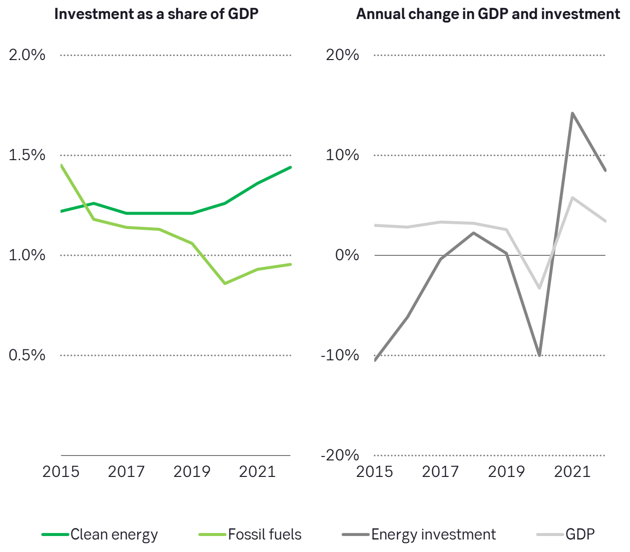


Source: Macrobond

As described above, it now looks likely that we are embarking on an accelerated transition, driven more by geopolitical competition than climate concerns.

These trends are already well underway. Investment in renewable energy started outpacing investment in fossil fuels around the middle of the last decade, but the increase has until recently been disappointingly slow. However, total energy investment has surged in the 2020s also as a share of world GDP (Figure 6).

Figure 6 Historical energy investment and GDP trends



Source: International Energy Agency (2022), World Energy Outlook 2022, IEA, Paris

Due to the positive feedback loops described above, this shift has a realistic chance of getting the world economy to net-zero by 2050. Accelerating the transition is in our view likely to lead to an even faster decline in the cost of renewable energy, which in turn allows for a faster diffusion of clean energy.

The three challenges facing the transition

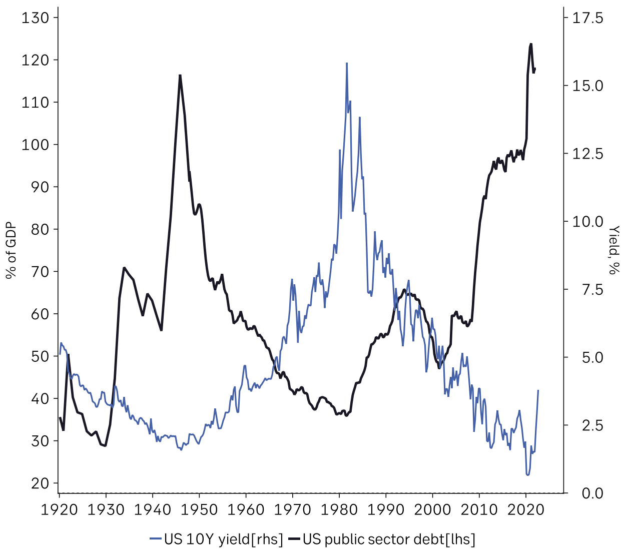
A faster transition also poses some serious challenges. Completing the same installation in half the time requires more capital and physical resources during the installation period and faster technological improvement increases the risk of obsolete green assets.

The capital requirement for energy investment is substantial, but not insurmountable. Investment in renewable energy infrastructure would have to triple to around 4-5% of GDP within the next decade, and lower fossil energy investment will only offset a small part. The world's total energy investment would have to increase by what corresponds to 2-3% of world GDP.

Compared with the measures introduced during the pandemic, this is not an extreme amount. However, it is likely to be upheld over decades, and it comes at the same time as investment in other security-policy driven areas like military capacity and near-shoring of key parts of supply chains also impose a burden on public budgets.

And all this is happening while most governments are struggling with high debt burdens. Both in the Eurozone and the US, the past years have pushed debt levels to record highs rarely seen in peacetime. In the US, the public sector debt is now higher that immediately after WWII (Figure 7). For developing economies, the challenge of raising more debt looks even more challenging.

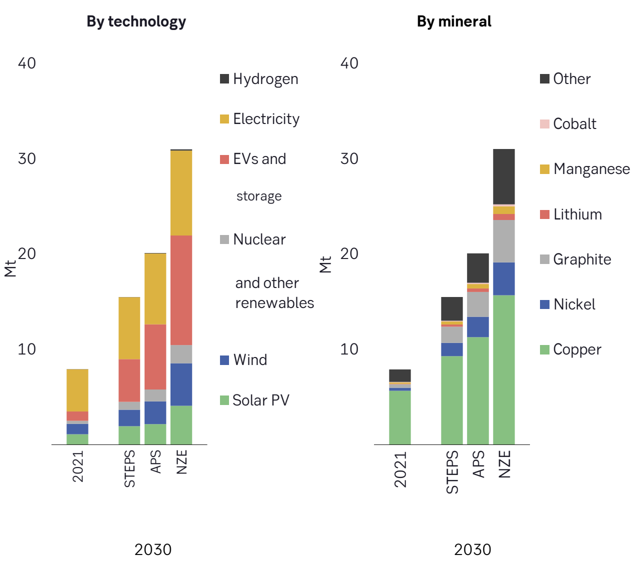
Figure 7 US 10Y yield and public sector debt



Source: Macrobond

The second challenge is the amount of physical resources required for an accelerated transition concentrated over a shorter period. The IEA estimates that their Net Zero scenario will require more than a tripling of the demand for minerals from the energy sector (Figure 8).

Figure 8 Mineral requirements for clean energy technologies by scenario, 2021 and 2030



Source: International Energy Agency (2022), World Energy Outlook 2022, IEA, Paris

This will in turn require very substantial investment in new mining and materials supply, even if this sector is one of the 'hard-to-abate' high emission sectors that sustainable investors are reluctant to engage with. Expanding the supply of commodities will take time and require more capital on top of the energy investment itself. It also highlights the need to engage with all sectors during the transition.

The final challenge is the higher risk of creating green obsolete assets if we accelerate the speed of technological progress. The problem is that whatever we can invest in today could be outdated a few years later when superior applications have emerged. This is always the case, but in an accelerated transition, there is less time to profit from today's technology before a better version comes to the market.

This problem is addressed to some extent in energy markets with PPA agreements, which reduce the downside risk by guaranteeing a minimum price for energy during the repayment period for the project. This strategy provides strong incentives for new investment projects to be launched despite the prospect of significantly lower marginal costs for future generations of clean energy technology that may be available long before the current investment has paid off.

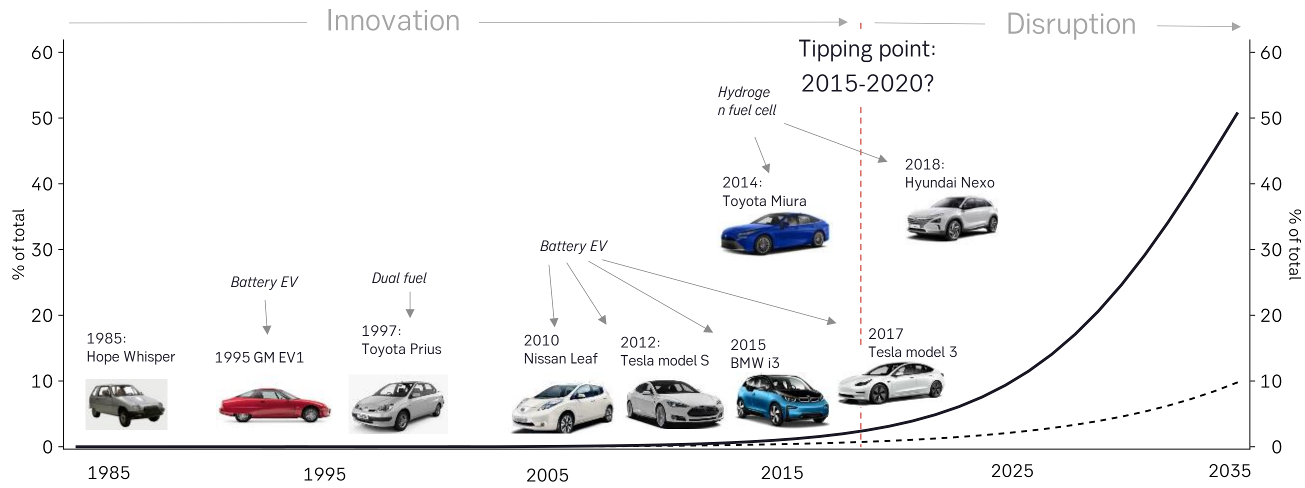
However, the situation is more complicated when it comes to energy users in the energy-intensive sectors where current technologies do not allow electrification and new technologies, like Power-to-X transformation of electricity into engine fuel, production of green steel or zero-emission container ships, have yet to reach their cost tipping points.

We illustrate this problem in Figure 9, which shows the diffusion curve for EVs. This is the most advanced transition among energy users, with battery-powered EVs reaching cost/performance parity with fossil-powered cars in the second half of the 2010s after the usual 30-year incubation period that started with experimental vehicles back in the mid-1980s.

Hybrid or dual-fuel vehicles dominated the initial phase of this development due to the poor performance of pure EVs using the battery technology available back then. Toyota has almost 15 years of market leadership with the Prius before pure EV models started to become competitive. In an accelerated transition, that period would be cut to something like five years – and once the superior technology arrives, the value of the last generation of the old version declines fast.

Even today, as scaling of EV production starts to gather pace, there is legitimate doubt about whether we have identified the ultimate technology winner.

Figure 9 Obsolete green assets – the automobile sector example



Source: SEB

The past few years have seen the emergence of ambitious new models powered by hydrogen fuel cells from Toyota and Hyundai. These are today not as competitive and to some extent lack the critical infrastructure needed to scale fast (fuel stations, green hydrogen supplies). On the other hand, EV batteries require lots of commodities that might become very expensive if we ramp up production, and they also need to get the whole supply chain moving to ensure enough charging stations and grid electricity is available.

EVs also suffer from a size problem, current technology appears to favour extremely heavy vehicles to get long enough range, and this is not the most energy-efficient way of transporting people around. A breakthrough in battery technologies could still seal the win for EVs, but that would make today's models look dated. Alternatively, a big breakthrough for hydrogen fuel cells could tilt the scales the other way. Considering how much capital has already been spent on EV facilities, the risk of obsolete assets for first movers is a real problem. Doing the same thing with ships, metals or planes looks even more risky – and yet ass a society, we need companies to be first movers.

Where can investors make a difference?

Adding it all up, we are finally on the cusp of a major investment surge that just might allow the world economy to decarbonize in time to prevent an irreversible climate disaster. However, there are also major challenges embedded in this scenario: raising enough capital for the energy investment and adaptation costs especially in developing economies, expanding the supply of basic inputs to the capex boom and finding investors with a long enough time horizon and risk appetite to provide funds for companies that run the risk of being first movers in hard-to-abate sectors.

Investors can make a difference if they are willing to enter the spaces where market forces have trouble pushing enough capital through on their own.

We can break the financing requirement associated with an accelerated transition into three broad groups: clean energy investment, adaptation to/damages from climate risks and transition investment from energy-users on the corporate side (Figure 10).

Figure 10 Total capital requirement

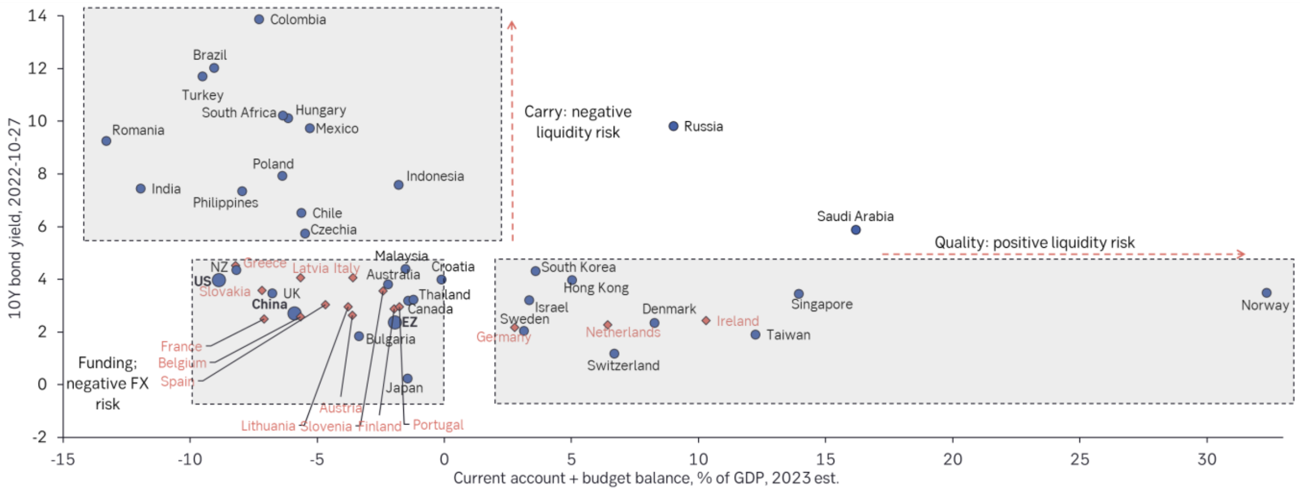
Clean energy USD 2-2.5tn/year	Damages + adaptation USD 0.5-1tn/year	Transition USD 1-1.5tn/year
Upgrading energy infrastructure	Reducing economic, physical and social costs	Electrifying production systems
Gvt/SAA/PPP	Gvt/SAA/agency/muni	Corporate
Renewable energy, grids, storage, transportation	Displacement, floods, water, food, buildings, damages	R&D/capex in decarbonized production value chains
Green bonds	Sustainability bonds	Transition finance?

Source: SEB

Each block requires substantial increases in funding over the coming decade, in our view totalling an increase of around USD 4-5tn annually compared with today's level. However, some of this will be relatively easy to support, while other parts require support from dedicated investors aiming to play a supportive role.

Government involvement is likely to be significant in the first two boxes. Securing energy supplies has historically been one of the most important roles for governments, not least because failure to do so can be socially and politically destabilizing as we now see. Renewable energy is already the cheapest option, so it is natural that the public investment will focus on expanding this supply.

Figure 11 Some have abundant capital, others have high interest rates



Source: Macrobond, IMF and SEB

At the same time, global warming is starting to cause economic damage. This places an added burden on public sector spending as the cost of these non-insurable risks is likely to end up being picked up by governments.

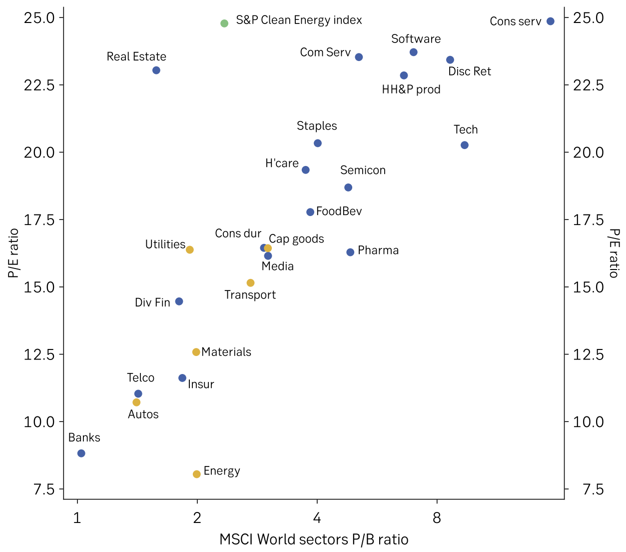
Western governments are unable to lift the full burden of financing a new infrastructure alone. However, they benefit from deep capital markets and low risk premiums and can easily mobilize private capital by structuring investment projects, so the government takes most of the risk to incentivise private investors to take the rest with the prospect of a safe long-term cashflow.

The situation is different in developing economies, where the damage from global warming is likely to be more concentrated. The economic damage caused by global warming will further limit the appetite of global investors to lend to third world governments that already face much higher risk premiums due to political and economic stability concerns. The countries that need capital the most are the 'carry' group in Figure 11 that face 5-10 %-points higher yields when they raise capital, while those who have abundant capital are in the 'quality' group where you find the three Scandinavian markets with no net public debt and international creditor status. Nordic investors should thus be particularly well positioned to facilitate this kind of transformation.

This is one area where sustainable investors can make a difference. There are already structures in place to facilitate such investment, most notably the sustainability bonds from the World Bank and other SSAs. These instruments essentially provide access to capital at the low interest rate of rich countries but deploying it in poor countries where the cost of capital can be orders of magnitude higher, with SSAs taking the responsibility for governance and sustainability when the capital is used.

The other area where capital is required, and the market is reluctant to go is the large group of energy-intensive sectors that will have to replace their capital stock at an accelerated pace with new equipment based on technology that currently is not ready. As described above, this is a highly risky endeavour which requires both a long time-horizon and a high tolerance for risk (as well as preferably some kind of government risk-sharing to subsidise the development of technologies that are not ready).

Figure 12 Stock market valuation by sector



Source: Macrobond, Bloomberg

These are sectors where there currently is a high and hard-to-abate emission level, which can't be changed quickly due to a lack of technological alternatives. This leaves them off the map for most of the sustainable investor community, based on the way these have structured their investments until now. As you can see in Figure 12, their valuation is far lower than for the clean energy index.

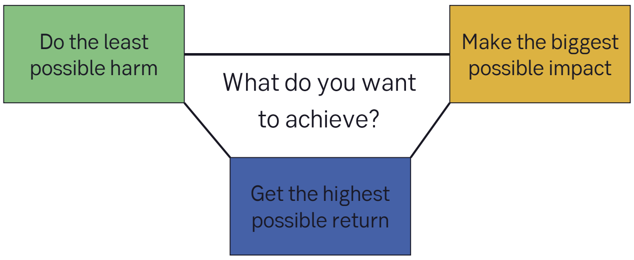
At the very least, making it feel comfortable to invest in these parts of the market will require some strong reassurances about both the allocation of capital provided today and the company's long-term commitment to being a first mover in the decarbonization process.

New framework for sustainable investors

From an investor's perspective, this analysis points to a change in the way we approach sustainable investment.

In the dominant approach so far, which you could call ESG 1.0 or 'do no harm' portfolios, the general idea appears to have been (when marketing them) that one strategy could cover all major objectives: you could simultaneously reduce your reputational risk, increase your expected return AND help to reduce climate risks (Figure 13). However, the past few years have shown the limitations of such an approach, and we now need to be more specific and realistic about the choices you have to make as a sustainable investor.

Figure 13 What is the objective?



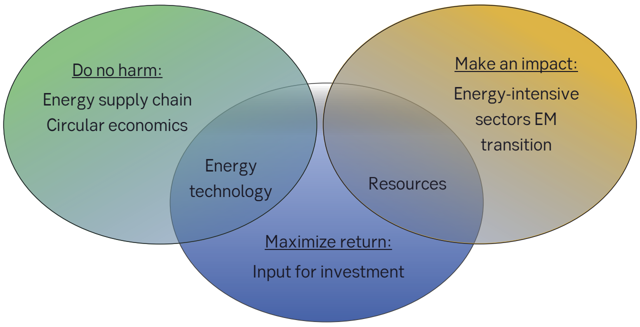
Source: SEB

If you select a passive 'do no harm' approach, then it should be clear that one cannot exclude a broad group of potential portfolio combinations by imposing ESG score or emission level constraints and get the same expected return as the market portfolio. This insight was initially masked by the surge in inflows during the liquidity explosion after the pandemic which in hindsight led to an ESG bubble in 2020-21, but the past year has changed that view. Going forward, we do not expect the marketing of ESG funds to reflect this change.

Clean energy equities are a big part of most ESG portfolios and could potentially be long-term outperformers. They come with a compelling long-term volume story and are definitely green. However, this is a crowded space with much higher valuation than the broader market, so investors here are not going where the market in unwilling to go. It is also doubtful if high margins will be tolerated in this space where governments are so heavily involved. We do not think the long-term return will necessarily exceed the market return.

The best way to participate directly in the energy transition in Western economies is probably through relatively safe income streams in bonds. Apart from clean energy stocks, the composition of most ESG portfolios is tilted towards US technology companies and other low-emission sectors, which means you don't get your hands dirty, but also makes it hard to claim that your capital is making an impact.

Figure 14 Transition and equities: no 'silver bullet'



Source: SEB

Investors that want to make an impact must go where markets currently are not going. Two areas stand out. The first is allocating capital to the transition in developing economies where governance risks are high and need to be controlled. The second is to allocate to transitioning companies in the stock market, which involves a clear risk of a lower return and a higher reputational risk. This is where other investors are reluctant to go, reflected in a chronically low valuation, and your capital could make a real difference here. But you will need a higher tolerance for risk and a longer time horizon, and you will need assurances about how the capital will be invested and what the long-term ambitions are.

Finally, for investors that just want to profit from the transition, there is a third group of companies that supply inputs for the investment in both energy production and transition for energy users. Clean energy companies may have limited margins because they are in government-sponsored projects, and transition companies may fail to reach their target, but they will pay their suppliers of steel, copper, cement, ball bearings, gear boxes and all the other stuff that goes inside.

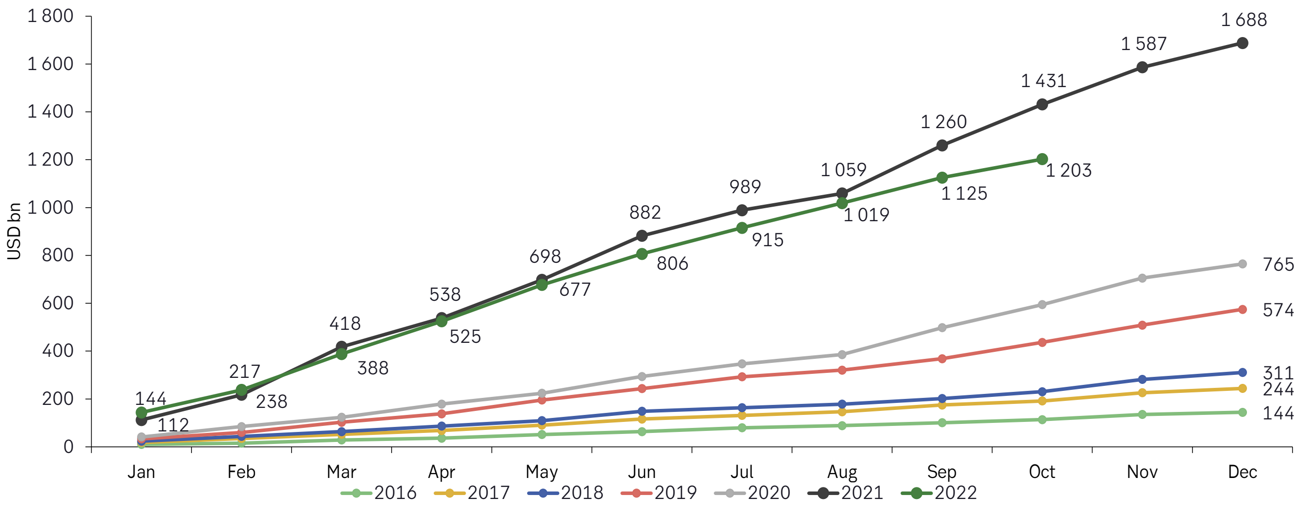
These are areas where current capacity is not geared for the secular demand shift that is coming, suggesting they will benefit from both faster volume growth and better support for margins. There is a small overlap here, as energy technology companies from the 'green' segment and commodity producers from the 'yellow' transition segment also are likely to be part of the blue 'alpha' segment (Figure 14).

Sustainable Market Update

The gap widens

Total issuance of sustainability-labelled debt in 2022 continues to lag 2021 and the gap is widening. The absence of corporate sustainable bonds also in the high yield segment suggests the current range of sustainable instruments may have to be expanded. ESG benchmarks continue to underperform in equity space, and clean energy equities remain expensive.

Figure 15 Cumulative sustainable debt transactions



Source: Bloomberg New Energy Finance 31 October 2022

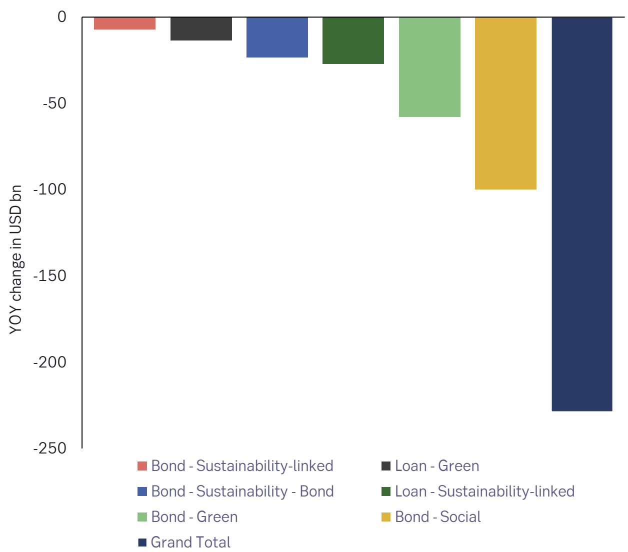
Decline widens as market looks for alternatives

We started into Q3 hoping that the sustainable finance market would make up some of its losses this year. However, October saw another decline of sustainable-themed bonds and loans in Y/Y terms. This brings the total market to USD 1203bn in new sustainable debt, 16% behind Y/Y (Figure 15).

Given that the last two months of the year usually see a lower level of activity, we now assume that the sustainable finance market in 2022 will close around 15% below last year's record. Figure 16 reveals that the general decline in new sustainable debt is now affecting every single part of the market. The slowdown in social bonds and sustainability bonds has been a trend since the beginning of 2022 as fewer sovereigns see the need to raise new capital to deal with the Covid-19 pandemic.

However, declines in the volume of new green bonds and sustainability-linked bonds has only started to manifest in the past two months.

Figure 16 Y/Y change in sustainable debt market by product type, Jan-Oct 2022



Source: Bloomberg New Energy Finance 31 October 2022

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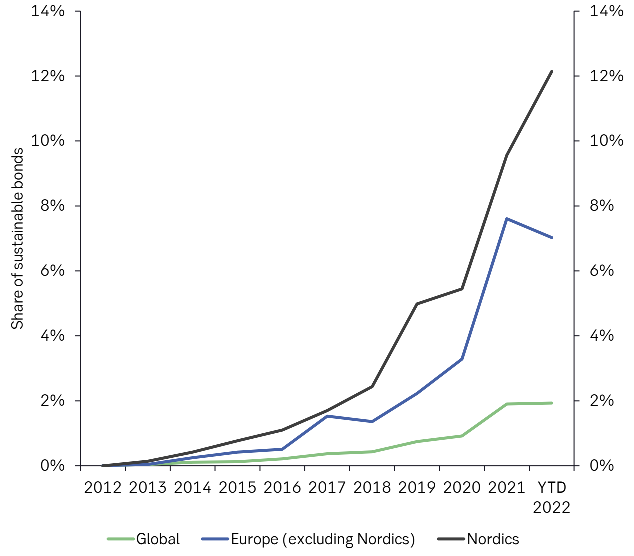
The decline in the issuance of sustainable bonds – i.e., green, social, sustainability and sustainability-linked bonds –largely follows the downward trend of the global fixed income market. Both the volume of newly issued labelled and the non-labelled bonds have decline in lockstep by around 30% each in 2022. The share of sustainable bonds in the global bond market has thus not changed this year (Figure 17). In the Nordics it increased by more than 2%.

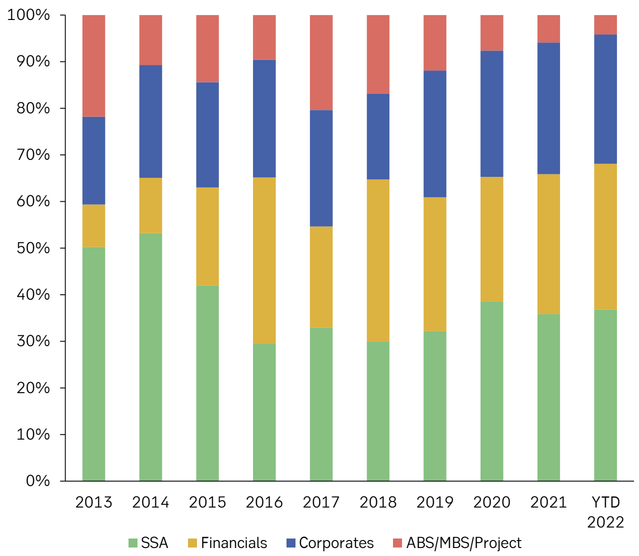
Figure 17 Share of sustainable bonds of the global, European and Nordic bond market



Source: Bloomberg 17 November 2022

While this makes the decline in sustainable debt creation easier to understand, the broader pattern is nonetheless a clear disappointment. We had not expected the labelled bond share of the total market to level off at this low level. This raises the question if the range of sustainable instruments is broad enough.

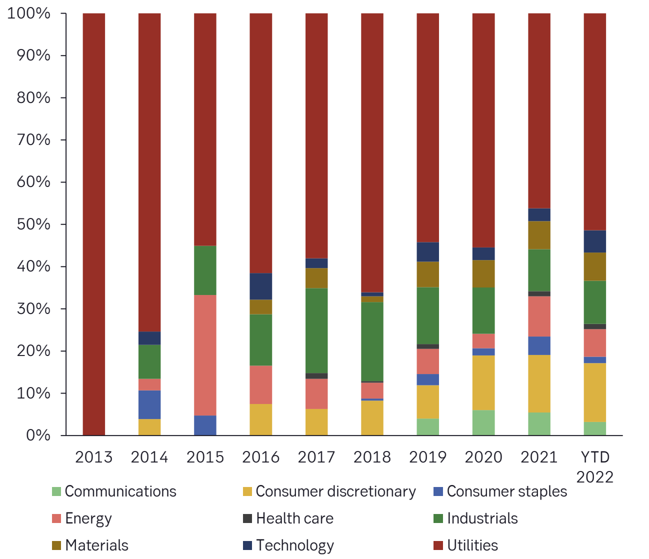
Figure 18 Green bond issuance (use of proceeds)



Source: Bloomberg New Energy Finance 31 October 2022

Looking at the issuance of green bonds, there is one segment that currently does not raise a lot of sustainable finance debt. Most green bonds are issued by governments, financial companies and SSAs (Figure 18). Even the small share of green bonds that are issued by non-financial corporates, more than half comes from utilities alone (Figure 19). Perhaps this reflects the lack of credible long-term commitments which may make it harder to take a 'green funding' instrument to the market. This suggests that additional sustainable finance instruments for raising capital are needed to solve a broader range of transition challenges and support a larger number of businesses.

Figure 19 Corporate Green Bond issuance by industry, distribution



Source: Bloomberg New Energy Finance 31 October 2022

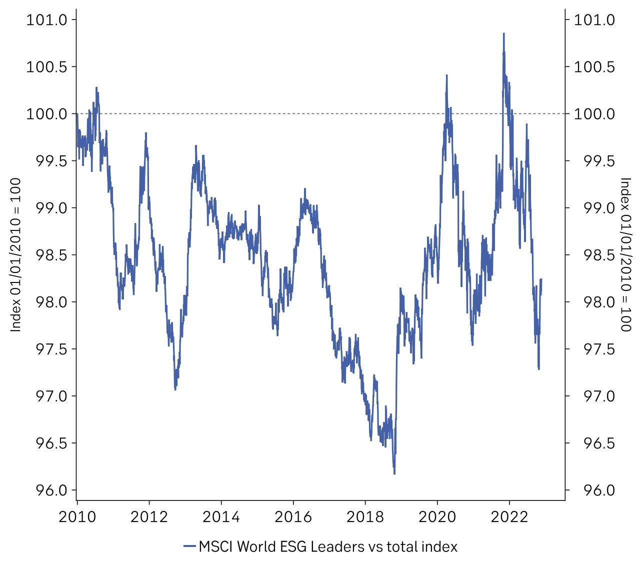
However, it is doubtful if the bond market is the most suitable market for this kind of capital rising. The words long-term and risky normally suggest the kind of investment where investors should share in both the upside and the downside, a symmetry that is stronger on the stock market than on the bond market.

'Green' equity portfolios still struggle

In the stock market, the ESG indices that are behind most current sustainable equity portfolios continue to lag the return of the broader market amid what appears to be sustained outflows from ESG-designated funds.

Refinitiv Lipper, a research house, show that SRI funds saw an outflow of USD 108bn in the first 9 months of 2022 after seeing inflows of more than USD 600bn in the same period in 2021, most likely driven by disappointing returns that in part reflect the technology stock tilt of the underlying ESG benchmarks. This is the first period of sustained outflows from this market segment since the company started tracking the flows in 2017.

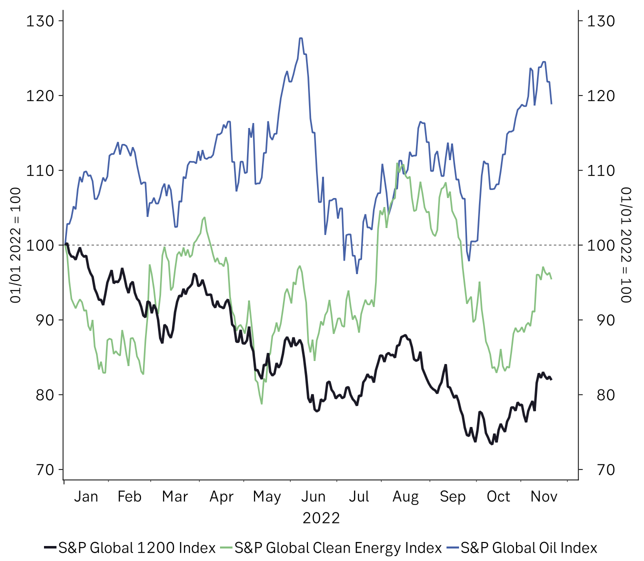
Figure 20 MSCI World ESG Leaders excess return



Source: Bloomberg

As we have noted before, it should not be too surprising to see negative excess returns over time as the ESG portfolio universe is a subset of the broader market universe (Figure 20). This may have been forgotten during the period of massive inflows, but in 2022 it was expensive to curtail exposure to energy and commodities and tilting towards tech stocks. Relative performance will vary from year to year, but over time passive ESG benchmarks are unlikely to match market returns, and this may limit future inflows.

Figure 21 S&P Global, Clean Energy and Oil indices

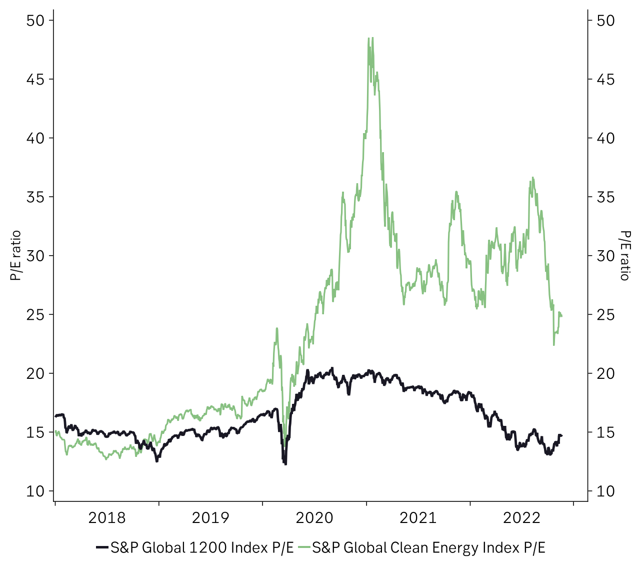


Source: Bloomberg

The other core component of sustainable investment portfolios is the clean energy segment, which has benefited from the increased focus on energy shortages and the need for major investment to restore balanced.

The S&P Clean Energy index has outperformed the broader S&P Global index by more than 10%, taking back a little bit of the 50% shortfall in 2021 (Figure 21). However, at the same time it has nonetheless underperformed the Oil & Gas index by more than 20% so far in 2022 so it was not the most rewarding way to gain exposure to the energy theme.

Figure 22 S&P Global index and Clean Energy index P/E



Source: Bloomberg

From a forward-looking perspective, it is encouraging that the Clean Energy index valuation premium has narrowed with the P/E coming down to around 25 after peaking at almost twice that level in early 2021 (Figure 22). However, this is still a premium of 75% for s market segment that had no premium before 2020. This still suggests that crowded positioning will reduce the long-term return.

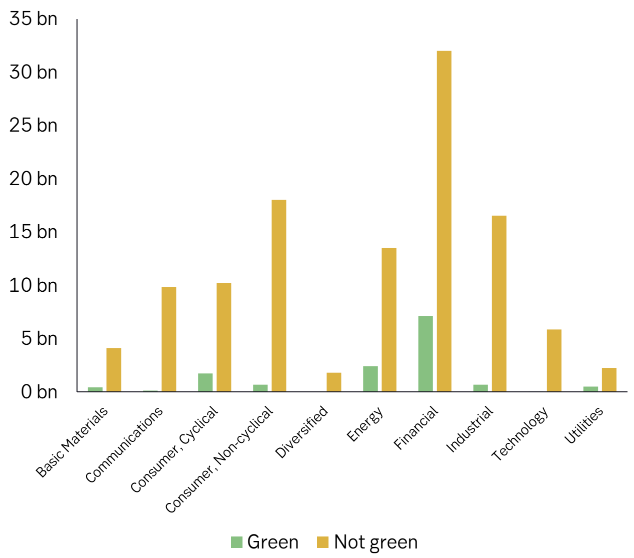
Nordic green high yield bonds: gaining speed

Looking at the Nordic high yield bond market, we note a similar pattern as in the investment grade market.

The largest amount issued in green high yield bonds comes from the financial sector, followed by the energy sector. The financial sector is heavily overrepresented when it comes to bond issuance, also in green labelled high yield market.

As seen in Figure 23, the green Nordic high yield market is still small compared with the total market, but at 16% the total share is even higher than in the IG market. However, it is not evenly distributed. Green bonds have mainly been issued by the financial and energy sectors. Utilities and cyclical consumer goods are also showing some activity, but again we are really seeing no major green bond issuance from high yielding companies in industrials and materials.

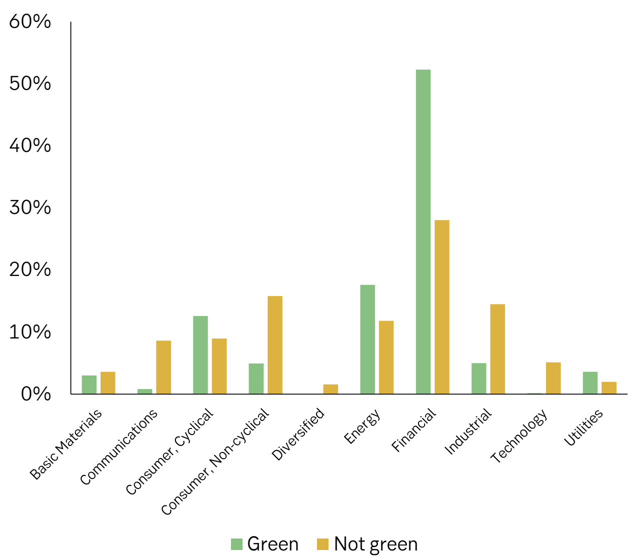
Figure 23 Amount outstanding by sector green vs not green labeled Nordic high yield bonds, USD bn



Source: SEB, Bloomberg

As Figure 24 shows as much as 52% of outstanding in green labelled high yield bonds in the Nordic high yield bond market comes from the financial sector, compared with 28% for the non-green labelled counterparts.

Figure 24 Share per sector green vs not green labeled Nordic high yield bonds

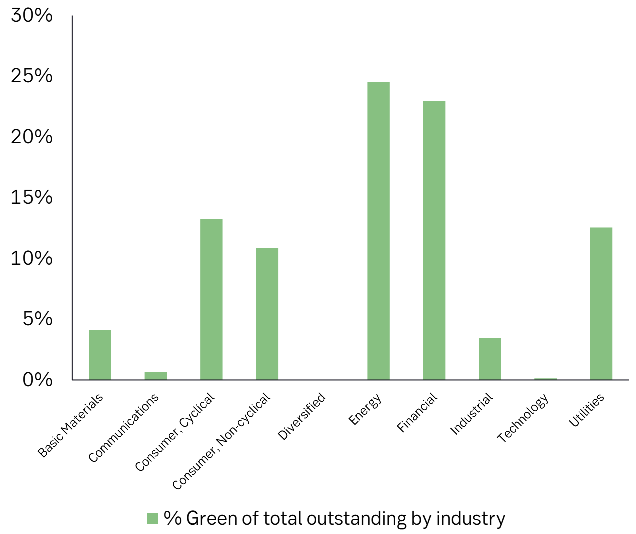


Source: SEB, Bloomberg

The energy sector is the second largest for green high yield bonds with 18%, compared to 12% of the non-green market, followed by cyclical consumer goods with 13%. All three sectors have a higher weight in the green bond than the non-green market.

Sector-wise the share of green labelled HY bonds in the energy, financial, utilities and consumer durables sectors stand out. As much as 25% and 23% of the issued in HY bonds are green labelled for energy and financial respective, followed by 13% in the utility sector and the cyclical consumer sector. However, the utility sector only accounts for about 2% of the HY bonds in our universe. (Figure 25).

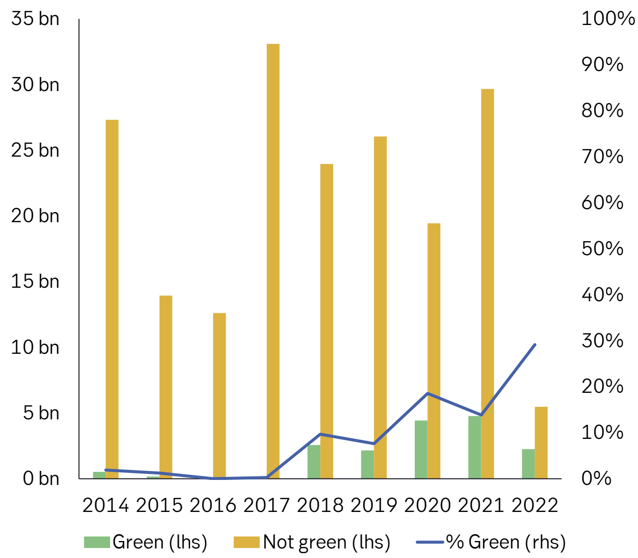
Figure 25 Share of green labelled Nordic high yield bond market per sector



Source: SEB, Bloomberg

The issuance of new green high yield bonds has declined in 2022, but so has all high yield bond issuance. There is still an encouraging trend, with green bonds now making up 30% of all new Nordic high yield bonds issued but like for the IG market it has levelled off. However, if this ratio is maintained as issuance picks up, the green HY segment is likely to continue increasing its share of the total market.

Figure 26 Share of amount issued per year in USD bn, green vs non-green labeled Nordic HY bonds



Source: SEB, Bloomberg

COP27 – Multilateral talks stagnate but bilateral partnerships show way forward

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The 27th Conference of the Parties concluded in the early hours of Sunday, 20 November, in Sharm el-Sheikh, Egypt. At the end of COP27, which lasted two weeks, the negotiators reached an agreement on the final deal of the conference – the Sharm el-Sheikh Implementation Plan. Some observers have called the deal a breakthrough, while others expressed that it was made at the cost of lacking ambition in reducing emissions, especially from the burning of fossil fuels.

"Loss and damage" payments for vulnerable countries

One of the most important points of progress at the conference was an agreement between parties to establish new funding arrangements and a dedicated fund to pay for "loss and damage" from climate change. The argument behind the agreement is that over the course of history, wealthy countries produced the most greenhouse gas emissions, which are causing the extreme events, such as heat waves and floods, that we see today. However, it is often the poor and developing countries who are most vulnerable in the face of these destructive effects of climate change, while they contributed very little of the emissions that caused them. Over 190 countries have signed up on the agreement to create a fund for addressing the loss and damage associated with the adverse effects of climate change.

The development on "loss and damage" funding can certainly be viewed as a breakthrough, especially considering that it is the first time when language around this issue was included in a COP deal. However, there has been some criticism around the language that was used, with critics claiming that it was not strong enough, and didn't provide clear guidelines around how the funding should be structured.

No increased ambition on the "phasedown" of fossil fuels

Last year, at COP26 in Glasgow, negotiations revolved largely around the inclusion of language around the use of fossil fuels. Several parties then argued for the Glasgow Pact to include a call for a "phase-out" of coal power. In the end, the opponents of such a clause, mainly India and China, negotiated softer language – a "phasedown", instead of a "phase-out", of unabated coal power. This change of wording resulted in strong criticism, including from the British presidency of COP26.

This year, observers were eager to see if the parties would reconsider the language of the clause and raise its level of ambition. In fact, a number of parties, led by India, and including the EU and the US, argued in favour of widening the scope of the text, to also include oil and gas, in addition to coal. However, the final text of the Sharm el-Sheikh Implementation Plan reflected the text of the Glasgow pact without any changes.

This, unsurprisingly, sparked criticism, with some observers claiming that the progress made on loss and damage funding is "cancelled out" by the lacking ambition in the plans to reduce the emissions that cause the loss and damage in the first place.

Moreover, critics spoke out against the vague language used in the Plan to call for an increase in "low-emission" energy sources. They argued that without specifications, the words of the text can be interpreted in a way that would even allow for continued use of fossil fuels, as long as they can be classified as "low-emission", for example through use of carbon capture and storage technology, or in comparison to the more polluting energy sources, such as coal.

Global carbon offset market

One of the expectations before the conference was that countries would make progress started at COP26 in the shaping of the global carbon offset trading schemes that fall under Article 6 of the Paris Agreement. Article 6 regulates mechanisms for cooperation between countries and global trading of emissions, either bilaterally between countries, or on a carbon offsets market. While the parties at COP27 did adopt some texts around this topic, they didn't make any significant progress, leaving most question around carbon offsets up for debate at future conferences[1].

Finance

The Sharm el-Sheikh Implementation Plan highlights that USD 4tn needs to be invested in renewable energy every year until 2030 for countries to be able to reach net-zero emissions by 2050. Moreover, a global transformation to a low-carbon economy will require investment of at least USD 4-6tn per year, according to the UN Environment Programme's 2022 Emissions Gap report. The Plan also highlights that "delivering such funding will require a transformation of the financial system and its structures and processes, engaging governments, central banks, commercial banks, institutional investors and other financial actors."

Moreover, the document called on the shareholders of multilateral development banks and international financial institutions to "reform multilateral development bank practices and priorities" and to significantly increase climate ambition "using the breadth of their policy and financial instruments for greater results, including on private capital mobilization…". It further encouraged them to "define a new vision and commensurate operational model, channels and instruments that are fit for the purpose of adequately addressing the global climate emergency."

The wording around reform of multilateral development banks followed calls from several representatives from both developed and developing countries to reform the World Bank, which, they claimed, failed to provide sufficient support to developing countries in their climate mitigation and adaptation efforts.

Just Energy Transition Partnerships

While the provisions included in the Sharm el-Sheikh Implementation Plan required negotiation and agreement from the nearly 200 parties of the COP, there are other developments that happen at the conference, which do not need approval from all parties, but can still bring forth progress in climate mitigation and adaptation efforts. Among such developments are bilateral partnership agreements, or so called "Just Energy Transition Partnerships" (JETP), between developed and developing countries, where the latter outline transition plans, and the former pledge money to finance them.

One example of such a partnership is a USD 20bn deal that was struck between Indonesia and a number of wealthy countries, including, among others, the UK, Germany, Denmark, Norway, as well as the EU, and a number of private sector actors.

The partnership, announced on the side-lines of the G20 summit in Bali, that took place at the same time with COP27, will help the country transition away from coal and towards clean energy. In more specific terms, the money provided by the partnership will be used to retire Indonesia's relatively new fleet of coal power stations and replacing them with renewable energy to meet the country's electricity demand[2].

Other countries that announced engagement in Just Energy Transition Partnerships at COP27 were South Africa and Egypt.

Sector-specific initiatives

Another example of smaller-scale positive developments we saw at COP27 are sector-specific initiatives. COP27 spotlighted challenges in the agriculture sector and related question of food security.

The Egyptian presidency of the conference together with the Food and Agriculture Organization of the UN launched a "Food and Agriculture for Sustainable Transformation" initiative. According to FAO, the goal of the initiative is "to implement concrete actions that would result in improving the quantity and quality of climate finance contributions to transform agriculture and food systems by 2030, to support adaptation and maintain a 1.5-degree pathway whilst supporting food and economic security[3]."

The conference also saw progress on some initiative started in Glasgow last year. For example, more countries showed support to the Methane Pledge, which aims to reduce global methane emissions by 30% from 2020

[1] Explainer: How far has COP27 inched beyond past climate deals? | Reuters
[2] Rich nations pledge $20bn for Indonesia's coal-to-clean switch (climatechangenews.com)
[3] Food and Agriculture for Sustainable Transformation Initiative - FAST (fao.org)

levels by 2030. The pledge now has over 150 country signatories, which is significant, because methane is an extremely potent greenhouse gas, which can be significantly more damaging to the climate than carbon dioxide.

At COP27, one of the world's biggest methane emitters – China – announced a plan for cutting its methane emissions with support from the US, which was a welcome surprise for the observers.

COP27 also saw some development in the forestry sector, with EU launching a Forest Partnership with five partner countries, including Guyana, Mongolia, the Republic of Congo, Uganda and Zambia. The goal of the partnership is to reverse deforestation in supported countries and consequently enhance climate and biodiversity protection[4]. Moreover, over 25 countries, including the UK, Pakistan, the Republic of Congo, and others, committed to holding each other accountable on the pledge to end deforestation by 2030 and promised to invest billions of dollars into this cause[5].

Bottom-up efforts will push multilateral talks forward

One can easily feel despair about the slow progress at COP27 – especially given the contrast to last year's fireworks of bold announcements. Some observers – including the Chair of the European Parliament's Delegation Bas Eickhout – have called COP27 and 2022 a "lost climate year". The fact that delegates relented to the pressure of oil producing countries and refrained from calling for a phase out of fossil fuels is indeed concerning. Even more worrying is the fact that the 1.5° target seems increasingly out of reach.

At the same time, COP27 showed that bottom-up efforts to spur mitigation are key to driving global ambition. Bilateral partnerships like the one between US, Japan, and the EU with Indonesia or actions on methane reduction can set in motion a race between countries or sectors jostling for climate, political, and economic leadership. Building just energy transition partnerships and finding impactful business opportunities is where the financial sector can bring to bear its core competences.

Similar initiatives that bring together countries, corporations and the financial sectors are urgently needed to rapidly mobilize investments into adaptation to climate change. Private capital is crucial to help those most vulnerable to the impacts of extreme weather events caused by climate change. Overcoming barriers to investment through public-private partnerships and financial risk mitigation is key to success in this regard.

[4] COP27: EU launches Forest Partnerships (europa.eu)
[5] COP27 Countries band together to keep forest promise | Reuters

Estimation of the ECB climate score for issuers in four high emitting sectors

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On July 4 this year, the European Central Bank (ECB) announced its aim to gradually decarbonize its corporate bond holdings[6]. Climate change considerations will be incorporated into both the Corporate Sector Purchase Programme (CSPP) and the Pandemic Emergency Purchase Programme (PEPP) by tilting purchases towards eligible issuers with better climate performance.

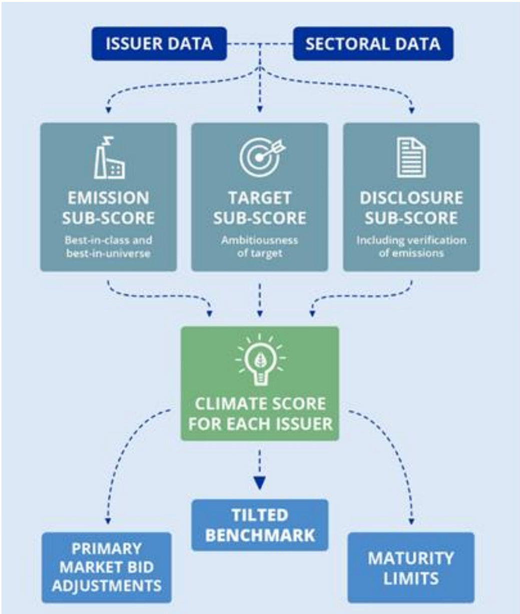
For that purpose, the ECB has developed a climate scoring methodology. The ECB climate score builds on three sub-scores: (1) the backward-looking emission sub-score, (2) the forward-looking target sub-score, and (3) the climate disclosure sub-score. Based on information made available by the ECB (see FAQ), we have tried to recreate the central banks scoring system to understand possible effects of future tilting of the CSPP portfolio.

Recreating the ECB climate score

At the time of the analysis, the CSPP portfolio consisted of 1868 bonds from 409 issuers. SEB used data from ISS ESG, the Science Based Targets initiative (SBTi) and Bloomberg to analyze the four highest emitting sectors in the portfolio: Energy, Industrials, Materials and Utilities. We also included the Health Care sector as comparison.

According to the ECB, the **emission sub-score** reflects the past greenhouse gas (GHG) emissions of an issuer. It encompasses Scope 1 and 2 data for the issuer concerned and Scope 3 data at sector level[7]. The sub-score compares issuers with their peers inside a sector as well as with all eligible issuers.

Figure 27 ECB climate score methodology



Source: ECB

To calculate the emission sub-score for issuers in the four high emitting sectors, we use reported and estimated emission intensity data (Scope 1 and 2, in t CO_2e/m EUR revenues) for the intra-sector comparison (best-in-class).

For the comparison across the four sectors, Scope 1, 2 and 3 intensity data is used, with Scope 3 data being estimated on sector level. All reported emission data is from FY2020.

The ECB calculates the **target sub-score** based on the decarbonization targets set by issuers. Companies with credible and more ambitious targets receive a better score.

[6] https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220704~4f48a72462.en.html
[7] According to the Greenhouse Gas Protocol

To proxy this, we assess if the issuer has a net zero ambition or is committed to the Science Based Target initiative. For targets that are SBTi validated, and 1.5 degree aligned, the highest sub-score is assigned.

For the **disclosure sub-score**, the ECB focuses on the quality of the issuers' climate reporting, such as the completeness and verification by third parties. As a proxy, we assess if the issuer has a TCFD report, if they include climate risks in their audit report and how material their GHG disclosure is.

Based on the ECB's FAQ document, we also determined that both the target and the disclosure sub-score will automatically revert to zero if the company does not report GHG emissions (Scope 1 and 2). To recreate the climate score proved to be challenging as information about the methodology was quite scarce. Further challenges concerned the data quality, sustainability data was partly from 2020 and data was missing for 83 out of the 409 issuers[8].

Results

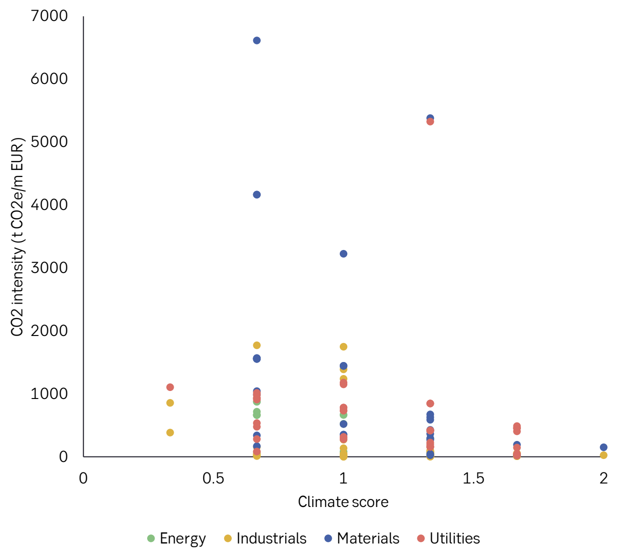
We calculate each sub-score on a scale from 0 (worst) to 2 (best). The ECB does not specify how the sub-scores are weighted together which is why we chose to weight them equally. Note that results would look very different if a larger weight is assigned to e.g. the target setting sub-score. Note that our analysis is limited to the four high emitting sectors. We would expect that emission sub scores for issuers in the four sectors too look different if the universe is expanded to include all sectors in the CSPP.

The scoring exercise can be summarized in three different results:

(1) Unsurprisingly, only looking at the total emissions or emissions intensity will not be enough to draw conclusions about how well an issuer will perform under the ECB climate scoring methodology and how the CSPP portfolio will be tilted. In our model, several of the portfolio's highest emitters (in terms of total Scope 1 and 2 emissions) have a climate score above the average of 1.07 of all four sectors as shown in Figure 28.

This shows that at least in our interpretation of the ECB's methodology, poor carbon performance today can be compensated for by ambitious (validated) climate targets and strenuous risk disclosure. Given the expansion of climate-related reporting requirements in the EU through the Taxonomy and Corporate Sustainability Reporting directives, the ECB may adopt a more demanding definition of its disclosure sub-score in the future.

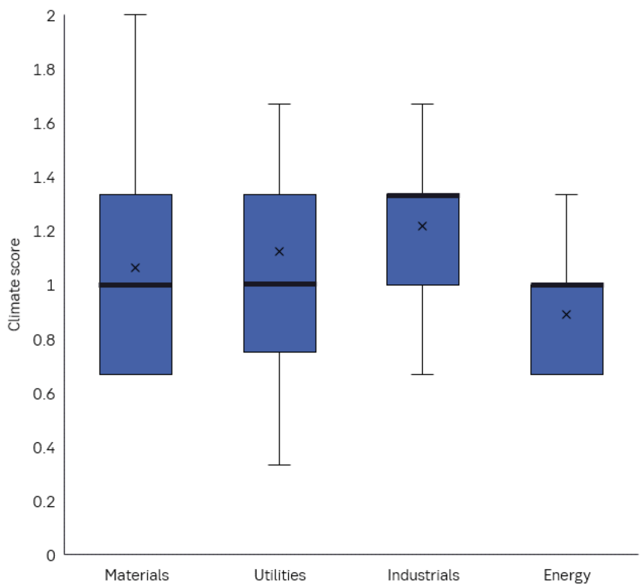
Figure 28 CO_2 intensity compared to recreated climate score



Source: SEB/ISS

(2) Our results also show that decarbonizing the ECB's corporate portfolio can have different implications depending on how the bank approaches the tilting. Future risk exposure of the CSPP portfolio will depend on how the ECB is going to increase its weighted allocations to issuers with higher carbon scores within and across industrial sectors. Figure 29 shows the climate scores of the four highest emitting sectors. Note that "x" represents the average.

Figure 29 Climate score distribution by sector



Source: SEB/ISS

Energy is the sector with lowest average score (0.89). If the ECB plans to tilt its sector exposure to improve the

[8] Data quality was more limited for unlisted issuers

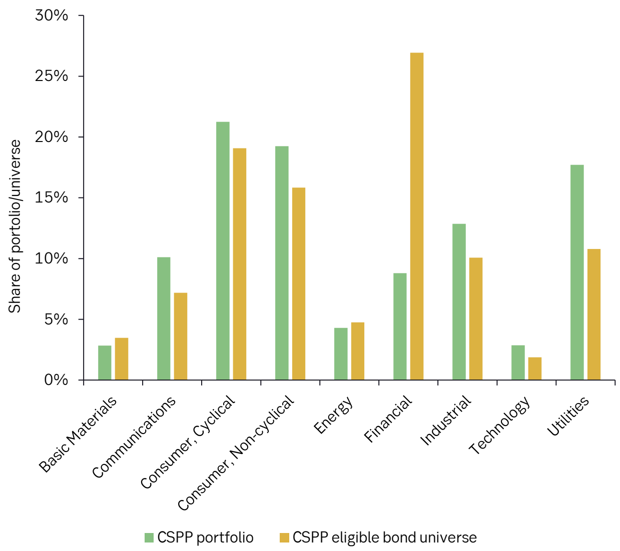
overall portfolio score, we would expect a tilt away from that sector. However, if the ECB plans to tilt intra-sector, they will have much less possibility to do so in the Energy sector than in the Industrials or Materials sector where we can observe a large spread of scores between issuers.

(3) The impact of the climate scoring methodology on the CSPP portfolio including the pricing of the underlying securities will depend on the size of investments that will be reallocated. The ECB has stated that the tilt will only affect redemptions meaning principal amount plus any interest owned from maturing bonds in its corporate purchasing program.

Given that ECB has made the decision to make no new net purchases as of July 2022, this further limit the amount of redemption funds that can be invested taking into consideration the carbon score of issuers. Over the course of the next 12 months (Nov 2022 – Oct 2023), the ECB expect to reinvest a total of EUR 26.36bn in redemptions[9].

Figure 30 shows the sector-level distribution of the bonds included in the CSPP portfolio and compares it to the universe of outstanding bonds which would meet the CSPP's eligible criteria[10]. Not knowing the ECB's current weighting of investments, the data implies that the CSPP is more exposed to high emitting sectors like utilities and industrials than the benchmark index.

Figure 30 Share of outstanding amounts in the CSPP portfolio and CSPP eligible bond universe by sector



Source: SEB/ECB

Implications for the ECB portfolio and bond market

First, we expect that climate considerations will not affect the amount that the ECB will invest in bonds – only how it allocates the bank's future investments of CSPP redemptions. This means that the announced tilting of reinvested redemptions is separate from the ECB's monetary policy goal of no net-purchasing of bonds.

Second, the impact of the climate score methodology on the primary bond market depends on how much of the ECB's reinvestments are spent on purchasing newly issued bonds. The share of primary bonds in the CSPP has increased from 3.8% in 2016 to 23.6% by end of October 2022[11]. If the ECB maintains its current distribution between primary and secondary bond markets, it will spend EUR 6.2bn of CSPP redemptions it expects to reinvest in the coming 12 months.

Third, implications of the ECB's plan on the bond market will also depend on how the bank will use its methodology to reallocate within and across sectors. The bank's possibilities to reallocate with the energy sector are particularly restricted. Our results also suggest that the CSPP is overexposed to utilities and industrials when compared to the benchmark index, making reallocations in these sectors likely.

Fourth, with its decision to tilt is bond purchasing program towards issuers with better carbon performance and climate targets, the ECB takes a more proactive approach to addressing climate change than the Fed. Given the EU's leadership role in sustainable finance, it is possible that other central banks in Europe and elsewhere will eventually follow the ECB's example.

Fifth, even though the ECB is taking more targeted steps in managing its exposure to climate-related financial risks, the bank has so far only disclosed a limited amount of information about its climate score methodology. This lack of detailed information suggests that the ECB does not want to distort capital markets. Keeping a tight lid on its methodology gives the ECB more degrees of freedom to act and readjust it in the future. The ECB is expected to reveal further details about its scoring methodology in Q1 2023.

[9] https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html#cspp
[10] https://www.ecb.europa.eu/mopo/implement/app/html/cspp-qa.en.html
[11] https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html

Managing renewable energy with Copernicus

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

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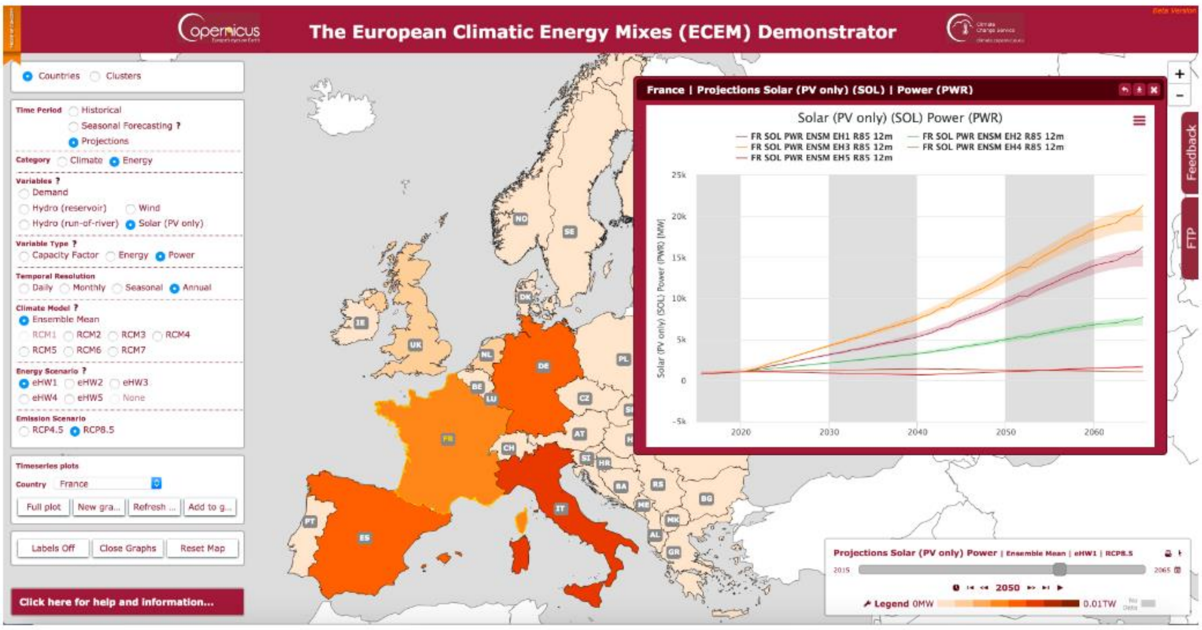
Supply and demand in Europe's energy system are affected by climate variability and long-term changes in the climate. On the demand side, rising global temperatures may lead to a drop in demand for heating in cold seasons, with corresponding growth in demand for cooling in the summer. Likewise, on the supply side, climate variability and the variable nature of renewable energy resources, such as hydro, solar and wind, go hand in hand, presenting a challenge for renewable energy producers.

To manage current and future energy supply and demand effectively, energy producers and distribution system operators need access to high quality data on general climate trends and the specific climate variables relevant to the energy sector. This is where Copernicus, the European Union's Earth Observation Programme, has a key supporting role to play. The Copernicus Climate Change Service (C3S) and the Copernicus Atmosphere Monitoring Service (CAMS), provide a wide range of quality-controlled data on Earth's atmosphere and changing climate, which energy sector stakeholders can use to improve the efficiency of their operations.

C3S and CAMS make their data freely accessible. Copernicus data also forms the basis for other tools, products and services such as C3S' flagship publication - the European State of the Climate report and the CAMS solar radiation service and aerosol forecasts.

Figure 31 Solar power scenarios for the next decades in the C3G Energy Demonstrator



Source: C3S/ECMF

Climate affects all sectors

The climate conditions with significant influence on electricity production are obvious: solar panels and wind turbines produce less energy during times of low wind or solar radiation. However, it is not just the wind and solar energy industries that are influenced by climate. Access to water, whether it be for use as a coolant in power plants, to irrigate biomass, or to produce hydropower, is also a key issue affecting Europe's energy sector.

A report from the Joint Research Centre, the EU's in-house science service, projects that water resources will be under major stress until 2050 at least, primarily due to climate change. This could potentially lead to increased strain in regions where freshwater is key for cooling thermal power plants, where hydropower capacity plays a significant role in the power system, the report notes. Energy infrastructure and networks are also affected by the physical impacts of climate variability and change, and access to accurate climate data helps operators strengthen their resilience.

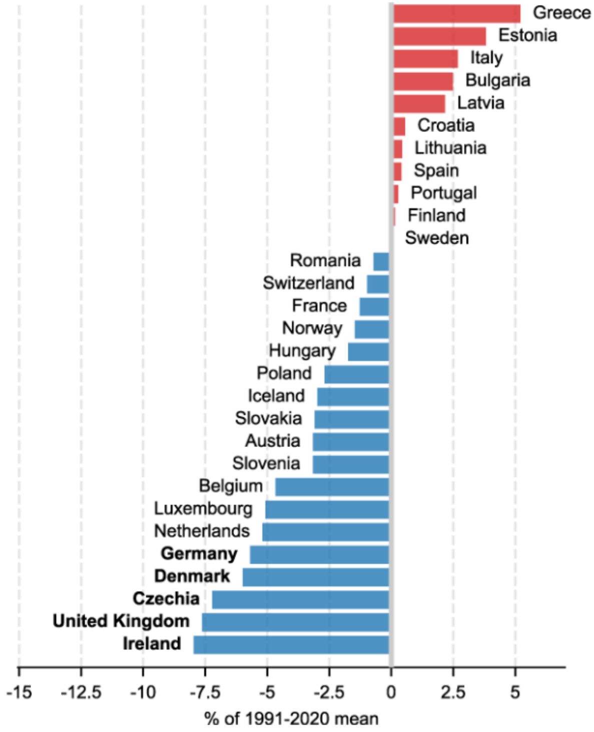
What Copernicus offers

Thanks to their high-quality data, the Copernicus services enable renewable energy stakeholders to manage more effectively all the technologies in the energy mix, all of which are becoming more and more dependent on climate. Data from C3S and CAMS allow producers to plan their infrastructure and to switch from one renewable energy source to another, helping them to deal with climate variability and to make the most of the available resources.

So, how can data from the Copernicus services help operators to manage climate impacts? The core data product produced by C3S is ERA5, the fifth-generation atmospheric reanalysis of the global climate covering the period from January 1950 to the present. ERA5 uses Copernicus data to provide hourly estimates of a large number of atmospheric, land and oceanic climate variables that affect renewable energy production. This information can be further processed, downstream of C3S, to generate high-resolution products that renewable energy producers use in planning their operations.

For instance, the C3S Operational Service for the Energy Sector offers key information for climate-related indicators relevant to the European energy sector, relating to electricity demand and the production of power from wind, solar and hydro sources. This information is readily available through datasets and interactive web applications such as the Climate and Energy indicator for Europe from 2005 to 2100. This dataset provides climate indicators relevant to the energy sector, such as air temperature, precipitation, incoming solar radiation, wind speed at 10 m and 100 m, and mean sea level air pressure, along with energy indicators like electricity demand and power generation from various sources.

Figure 32 Annual onshore wind capacity factor anomalies by country in 2021



Source: C3S/ECMWF

Meanwhile, CAMS combines state-of-the-art atmospheric modelling with Earth observation data to generate information on solar radiation and on atmospheric variables such as clouds, aerosol particles, ozone molecules and water vapour in the atmosphere, all of which affect the productivity of solar panels and which solar plant operators can use to optimise their operations. CAMS also uses information from satellites and its models of the atmosphere to provide historical time series of global and direct irradiance to give solar plant managers, transmission grid operators and policy-makers valuable information on solar radiation at specific locations.

Integration of renewables

As Europe's energy system transitions onto a more sustainable path, with an increased share of renewables in the energy mix, it will become increasingly vulnerable to the impacts of climate change and climate variability. Copernicus helps to mitigate this vulnerability. the Copernicus services allow renewable energy stakeholders across the energy mix to make informed decisions when planning and operating their assets, supporting the green transition of Europe's energy sector.

Climate change impacts on electricity supply in Europe

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Enerdata is an independent research and consulting firm specializing in the analysis and modelling of the global energy world, such as sustainable finance or energy markets. Enerdata assists companies, investors and public authorities in designing their policies, strategies, and business plans at a variety of geographic and sectoral levels.

Climate change will impact supply and demand side of the electricity system

The electrification of our energy system is a key component of climate mitigation to achieve the decarbonization of our society. At the same time, the electricity system itself is subject to climate impacts. The transmission and distribution systems are impacted by extreme weather events such as extreme cold (snowfalls and falling trees), winds and storms (falling trees or lightning) or hot temperatures that reduce the transmission capacities due to the thermal expansion of overhead lines.

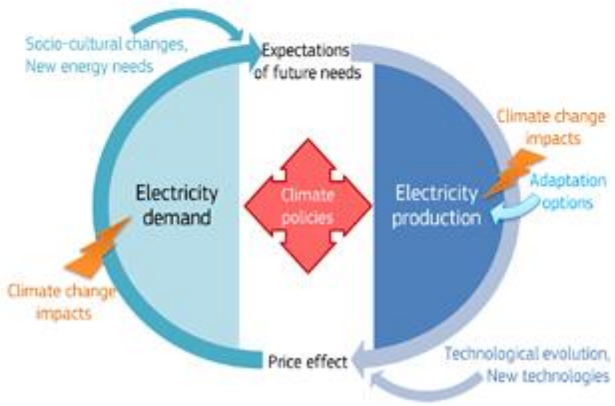
Energy demand is also subject to a great sensitivity to temperatures, with more electricity used for air conditioning in summer but less heating energy used in winter (only part of it being electricity).

Electricity supply has been impacted by climate events across Europe already in the 2022 summer: low Rhine water levels impacting coal transport and thus coal power, high water temperatures impacting thermal power, low dam water levels impacting hydropower. All these phenomena, leading to a lower production availability (independently of the other factors like the gas crisis or nuclear outages in France), are part of a long-term tendency.

Capabilities and limitations of climate energy models

Climate impacts will increase with time, while the power system is also constantly evolving (demand evolution, climate mitigation, new technologies). The climate-energy model POLES[12] (Prospective Outlook on Long-term Energy Systems) combines both aspects (Després et al, 2018[13]) and is regularly involved in scientific exploratory scenario work, as used in the IPCC group III reports.

Figure 33 Multiple interactions in the dynamic POLES model



Source: Després et Adamovic, 2020

Such models are designed to analyze long-term energy markets, policies and emissions, and generally do not consider the feedbacks of energy on the economy, nor the climate system in detail (e.g., hydrology, winds, cloud coverage). Therefore, extreme events (e.g., exceptional droughts) are not included. The model averages across years to give indications of the longer-term trends (here,

[12] The POLES model has been initially developed by IEPE (Institute for Economics and Energy Policy), now GAEL lab (Grenoble Applied Economics Lab).
[13] Després, J., K. Keramidas, A. Schmitz, A. Kitous, and B. Schade, 'POLES-JRC Model Documentation - 2018 Update', 2018. No. JRC113757, doi:10.2760/814959

seasonal features of the changing climate) rather than short-term forecasts (hourly, daily or weekly).

The PESETA IV study carried out with the European Commission Joint Research Centre (JRC) used the same model as the POLES-Enerdata, with inputs from 11 climate models (EURO-CORDEX database), from a hydrological model (LISFLOOD: Bisselink et al, 2018[14]) and from the Power Plant Tracker database by Enerdata. Europe was the focal point, with regions describing weather regimes (South / Central South / Central North / North / UK and Ireland).

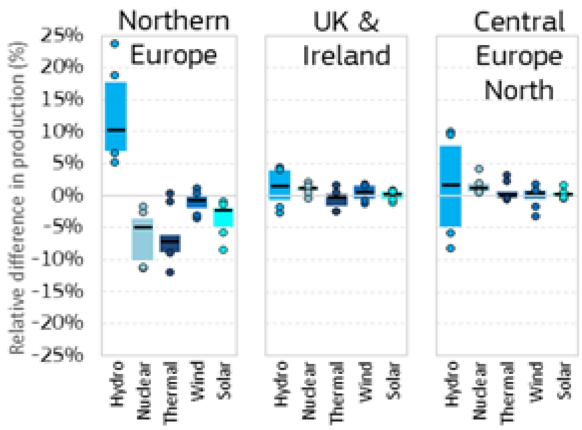
Estimated climate impacts on the European electricity system

At the European scale and in 2050, all else being equal, climate impacts cause an overall increase of water resources and hydro production in EU + UK (median value of +3.3% i.e., +14 TWh, when compared with a scenario without climate impacts), counterbalanced by a decreasing nuclear production (-2.8%; -18 TWh). Other thermal plants are little affected over Europe (-0.6%; -4 TWh). Wind and solar power production increases slightly with climate impacts at EU + UK level (respectively +1.1%; +13 TWh and +0.7%; +7 TWh).

The scenarios represented in Figure 34 are based on 11 climate models, with RCP 4.5 and climate mitigation action consistent with a global warming of 2°C. Dots indicate the four extreme scenarios; colored areas indicate the other seven scenarios, and the line is the median scenario. All effects other than climate impacts on electricity supply are neutralized; only the relative differences of production of each electricity source are shown.

In Northern Europe (Sweden, Finland, Denmark, Baltics states) we note a strong increase in water availability (especially in winter and shoulder seasons), which is correlated with hydro power production (+10% (median) with a range of +5 to +24% depending on the climate model, in 2050, under a 2°C scenario). Since most nuclear plants are located on seashores (Sweden, Finland) with abundant supplies of water, we do not observe any simulated impact on the nuclear production in POLES, despite the presence of hotter days that could still lead to some cooling limitations.

Figure 34 Climate change impacts in 2050 by energy source and region



Source: Després et Adamovic, 202015

On the other hand, thermal plants are indirectly affected (-6%) because the lower marginal costs of hydro power undercut the demand for electricity from thermal electricity sources. The local electricity mix determines which energy source is replaced by hydro for power generation: biomass in Sweden, coal in Finland, oil in Lithuania, gas in Latvia. Coal plants in Estonia are affected by the higher water temperatures but being the main electricity source, they use their spare capacity to compensate.

UK and Ireland face no major impact. The general higher water availability does not impact the power system substantially since the installed hydropower capacity is small. Besides, the temperature and wind speeds effects are negligible.

In Central North Europe (Germany, Poland, Benelux), there is also an increase of hydro production linked to the projected increase in water availability in all seasons and especially winter and shoulder seasons. However, the impact on the power system is small since hydropower only represents 3.6% of the regional electricity mix in 2050. The other electricity sources are marginally impacted (around 1% or less), mainly due to increased temperatures (negative effects on solar efficiency) or lower summer river runoff in some scenarios (impact on availability of German coal because of lower cooling capacity).

Overall, in Northern Europe, Central North Europe, UK and Ireland the wind and solar production are almost not

[14] Bisselink, B., J. Bernhard, E. Gelati, M. Adamovic, S. Guenther, L. Mentaschi and A. De Roo, 'Impact of a changing climate, land use, and water usage on Europe's water resources', , Publications Office of the European Union, Luxembourg, 2018. No. JRC110927, EUR 29130 EN, ISBN 978-92-79-80287-4, doi:10.2760/847068

[15] Després J., Adamovic M., Seasonal impacts of climate change on electricity production - JRC PESETA IV project Task 4, EUR 29980 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-13095-6, doi:10.2760/879978, JRC118155

affected (less than 1 TWh of difference on average for each region).

While the climate impacts in the South and Central-South of Europe are oriented towards drought periods causing unavailability of thermal plants by lack of cooling water in rivers, their overall hydropower production is very variable across climate simulations (in a broad range of -10% to +10%). Wind and solar develop faster in response to the lower availability of thermal plants, but with variable results across scenarios, around +/-5%. This is due to many factors, including uncertainty on future wind speeds.

What can be done to adapt the European power system

Adaptation of the power producing technologies is possible. Electric plants can move from once-through to open recirculating cooling, which reduces the water consumed, or to dry cooling that make the plants independent on the water availability at the expense of a reduced efficiency (linked to the electric consumption of the fans). Sea-water cooling can also be pushed slightly in countries which already have this possibility.

The adaptation options have negligible impacts in Northern Europe, Central Europe North, UK & Ireland. However, this is particularly relevant in countries with drought conditions in summer seasons. For example, it is projected to improve the nuclear availability by 2.8% in France, 4.8% in Czechia, 5.5% in Romania or 7.5% in Spain. This in turn has substitution effects on the production of other electricity sources. This illustrates different ways the electricity system can respond to climate impacts: cooling technologies but also complementarity or substitution.

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