

TOP of MIND

INVESTING IN CLIMATE CHANGE 2.0



Despite mixed progress on global climate action at COP26, a key takeaway emerged: the private sector is stepping up to tackle climate change. But what role should it play? How effective are current investor strategies? And how do these strategies square with asset managers' fiduciary responsibility? For answers, we turn to UN Special Envoy for Climate Action, Mark Carney, Engine No. 1's Chris James, BlackRock's Evy Hambro, PFA's Kasper Lorenzen and GS analysts. Carney believes the private sector has a critical role in providing capital for the green transition, and James and Hambro argue that market-based incentives will be sufficient to align this capital with climate goals. Neither sees a conflict between fiduciary duty and

climate considerations. But Carney also sees a role for policy to create investment incentives, and GS's Jeff Currie goes further, arguing that global, coordinated policies are needed to avoid significant capital misallocation in the pursuit of climate goals, with local policies and ESG investing suboptimal solutions for tackling climate change.



To oversimplify somewhat, the private sector will need to provide the capital investments required to execute the transition, and governments will need to provide the fiscal support to smooth the transition.

- Mark Carney

What's good for stakeholders is ultimately good for shareholders. The only difference between shareholder primacy and stakeholder capitalism is duration.

- Chris James

Fiduciary responsibility and climate considerations are inextricably linked; in order to properly look after clients' capital, asset managers have to invest through a lens that factors in climate risks.

- Evy Hambro

In the absence of policy creating the global carbon market required for the effective comparison of investments, investors will structurally misallocate capital.

- Jeff Currie



Allison Nathan | allison.nathan@gs.com Gabriel Lipton Galbraith | gabe.liptongalbraith@gs.com Jenny Grimberg | jenny.grimberg@gs.com

WHAT'S INSIDE

INTERVIEWS WITH:

Mark Carney, UN Special Envoy for Climate Action and Co-Chair of the Glasgow Financial Alliance for Net Zero (GFANZ)

Chris James, Founder and Executive Chairman, Engine No. 1

Evy Hambro, Global Head of Thematic and Sector Investing, BlackRock

Kasper Lorenzen, Group Chief Investment Officer, PFA

THE RISE OF TWO-SPEED DE-CARBONIZATION
Michele Della Vigna, GS Energy Industry Research

ESG FAILS AS A CARBON TAX SUBSTITUTE
Jeff Currie, GS Commodities Research

Q&A ON CARBON MARKETS
Patrick Street, GS EMEA FICC Sales

OPTIMIZING THE CLIMATE CHANGE SOLUTION
Damien Courvalin, GS Commodities Research

GREEN CAPEX: WHERE, AND HOW, FROM HERE
Brian Singer, GS SUSTAIN

...AND MORE

Investors should consider this report as only a single factor in making their investment decision. For Reg AC certification and other important disclosures, see the Disclosure Appendix, or go to www.gs.com/research/hedge.html.

Macro news and views

We provide a brief snapshot on the most important economies for the global markets

US

Latest GS proprietary datapoints/major changes in views

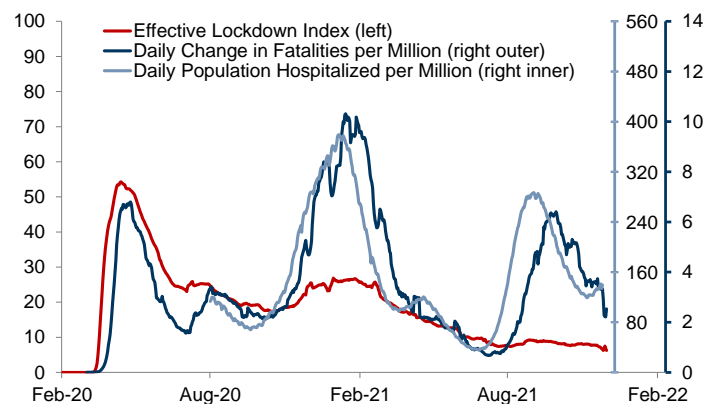
- We recently slightly lowered our 2022 GDP forecast to 3.8%, reflecting a modest drag on spending from the Omicron variant, though we see reduced economic sensitivity to virus spread.
- We recently raised our forecast for the pace of Fed tapering to \$30bn/month starting in January based on higher inflation and FOMC commentary, and now expect liftoff in May 2022.

Datapoints/trends we're focused on

- Omicron inflation impact, which we see as mixed given reduced demand in some sectors but risk of supply disruptions in others.
- Labor mkt gains, which should be sufficient for a May Fed liftoff.

Reduced economic sensitivity to virus spread

Index (lhs); count per mn (rhs)



Source: CDC, BLS, BEA, Goldman Sachs GIR.

Japan

Latest GS proprietary datapoints/major changes in views

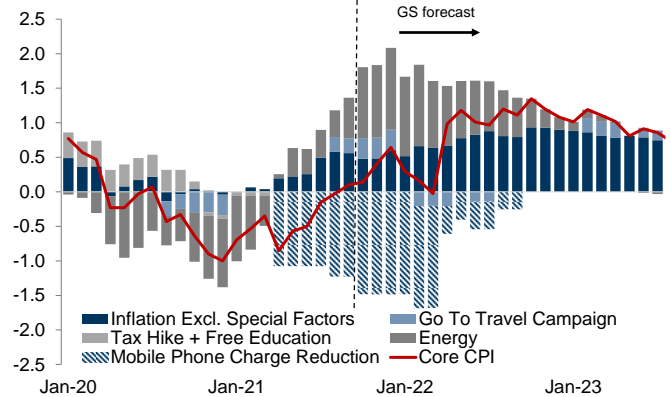
- We modestly lowered our forecast for avg 2022 core CPI to 0.9% to reflect lower mobile phone fees and other factors.

Datapoints/trends we're focused on

- New fiscal package, which at ¥55.7tn (~\$490bn) is the largest ever, though we think the economic impact will be far smaller than the government's estimate of 5.6% of GDP.
- Spending recovery, which has picked up speed as the government has continued to ease virus restrictions.
- Implications of higher commodity prices for corporates, which should be limited given the offsetting impact of a weaker yen.

A gradual increase in core inflation

Core CPI inflation (GSe) and factor decomposition, % change yoy



Source: Ministry of Internal Affairs and Communications, Goldman Sachs GIR.

Europe

Latest GS proprietary datapoints/major changes in views

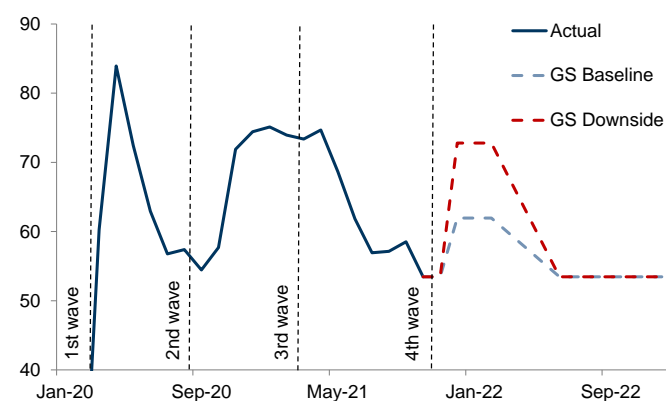
- We recently lowered our 2022 Euro area GDP forecast to 4.3% given the sharp virus deterioration and new restriction measures, and the Omicron variant presents downside risk.
- We now expect the first BoE rate hike in February.
- We now expect a slightly shorter APP bridge to Sep. 2022, but think a residual PEPP envelope after Mar. 2022 could be used as a backstop to potentially respond to downside virus risks.

Datapoints/trends we're focused on

- Virus response, which we see including additional targeted, regional restrictions, but not a return of blanket lockdowns.
- Inflation; we see limited impact from the latest virus wave.

Lockdowns should be less severe

Euro area stringency index, index (January 2020=0)



Source: Oxford University Blavatnik School of Government, Goldman Sachs GIR.

Emerging Markets (EM)

Latest GS proprietary datapoints/major changes in views

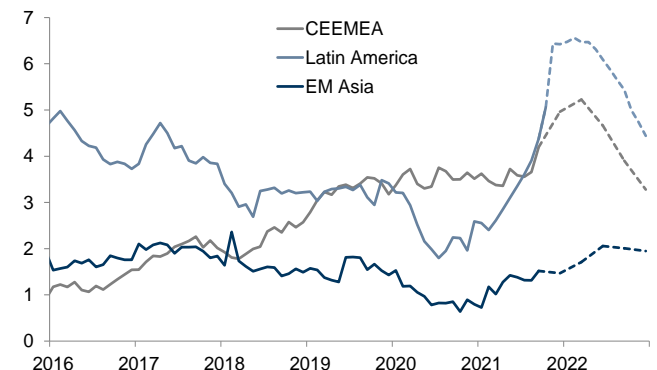
- No major changes in views.

Datapoints/trends we're focused on

- Omicron in South Africa, which the latest data suggests is spreading more rapidly than the Delta wave.
- China policy, which has turned more dovish/pro-growth following the December Politburo meeting.
- Inflation; we expect above-consensus 2022 inflation in almost every EM.
- Oil prices; despite the recent selloff, we see a structural case for further upside, which should support HY oil exporters across EM.

More room to run for EM inflation

Median core CPI inflation, % change yoy



Note: Latin America is average of Brazil and Mexico, dotted lines are GS forecasts. Source: News24, NICD, Goldman Sachs GIR.

Investing in climate change 2.0

Despite mixed progress on global climate action at the recent 26th United Nations Climate Change Conference (COP26) in Glasgow, a key takeaway emerged: the private sector is now stepping up to tackle climate change. But what role should the private sector, and ESG investors in particular, be playing? How effective are current investor strategies in moving the needle on climate goals? And how do these strategies square with asset managers' fiduciary responsibility? As shareholders, customers and the world continue to focus on climate change, the answers to these questions are Top of Mind.

To start to answer them, we speak with Mark Carney, UN Special Envoy for Climate Action and the Co-Chair of the Glasgow Financial Alliance for Net Zero (GFANZ), as well as three investors with distinct perspectives on climate investing: Chris James, Founder and Executive Chairman of Engine No. 1, which led a successful proxy fight to put climate-minded individuals on ExxonMobil's board, Evy Hambro, Global Head of Thematic and Sector Investing at BlackRock, and Kasper Lorenzen, Group CIO at Danish pension fund PFA.

Carney argues that the private sector—and financial institutions in particular—have a critical role to play in providing the capital necessary to achieve the green transition—which will require a total of ~\$4tn per annum through 2050. And he believes that this capital is available given the \$130tn worth of assets on the balance sheets of financial institutions committed to reducing emissions via GFANZ.

James and Hambro then make the case that market-based incentives will direct this capital to align with climate goals. Specifically, James believes that the value creation (and avoidance of value destruction) of aligning company strategies with consumer preferences—which are increasingly shifting towards climate-friendly products and services—will be sufficient to motivate companies to pursue climate-minded strategies. Hambro generally agrees, arguing that the market will naturally move to sources of value creation and returns, including the green transition, and he sees an important role for both active and index funds in enabling investors to tap into this value.

The power of the private sector in the green transition, Hambro says, is already evident with investors rewarding renewable power companies while sending thermal coal companies into bankruptcy. Brian Singer of GS SUSTAIN also notes that investors have rewarded companies invested in the green transition that deliver favorable corporate returns. And Michele Della Vigna, author of the GS Carbonomics series, finds that capital markets' deep engagement in sustainability is driving de-carbonization through a divergence in the cost of capital between high and low carbon investments.

Accordingly, Hambro, Lorenzen and James don't see a conflict between asset managers' fiduciary responsibility and investing with a climate mindset. Hambro argues that while fiduciary duty must be of paramount importance for any asset manager, the risk that climate change poses to portfolios has inextricably linked fiduciary duty and climate considerations. And Lorenzen explains that while reduced policy risk and technological advancement have lowered hurdle rates for climate-related investments, he doesn't see a conflict between returns and

environmental goals in general. James also doesn't believe there's a conflict, arguing that while conflicts may arise over short horizons, what's good for stakeholders is good for shareholders over longer horizons because the performance of a company will ultimately be driven by how well and quickly it mitigates its negative impacts.

While investors are choosing different strategies to facilitate the green transition, Hambro, James and Lorenzen all see value in engaging with companies on their climate goals. Hambro makes the case that excluding businesses based on historical data leads to narrow and undiversified portfolios, and probably doesn't do much to affect positive change—achieving that, he says, requires backing companies in difficult areas that have robust transition plans. And James believes that while divestment was an important early step in bringing awareness to the negative impacts companies can have, giving up your vote squanders the opportunity to move them in the right direction—something he's observing in real time as Exxon shifts its strategy to align with climate goals.

Lorenzen, for his part, supports engaging with companies committed to the green transition. But he makes the point that smaller investors can only credibly do so with a few companies at a time, which has led to a large role for oil & gas sector divestment in PFA's ESG strategy, alongside investment in infrastructure and technology projects that directly contribute to the green transition. We also sit down with Patrick Street, GS Co-Head of EMEA FICC Sales, to discuss how corporates and investors are engaging with climate goals through compliance and voluntary carbon offset markets.

But despite this optimism about the ability of the private sector to lead the way on addressing climate change, Carney still sees an important role for government policy to create the necessary investment incentives, rules and disclosures within the financial sector to provide a common approach for allocating capital to the best climate solutions and orienting markets toward achieving net zero. And he also thinks that clear sector-based policies, such as mandated end dates for internal combustion engines, will go a long way in motivating investment towards efficient solutions and keeping the 1.5 °C goal alive.

Jeff Currie, GS Global Head of Commodities Research, takes this one step further, emphasizing that global, coordinated policies to combat climate change are necessary to prevent significant misallocation of capital that will lead to underinvestment in hydrocarbon sectors and inflationary consequences—some of which we are already witnessing in the global energy markets today—a concern that Della Vigna shares. And Currie and Damien Courvalin, GS Head of Energy Research, argue that in the absence of such global policies, local policies and ESG investing are suboptimal solutions. Both of them underscore that a government mandated carbon tax/price is the most efficient—and perhaps the only—way to solve climate change.

Allison Nathan, Editor

Email: allison.nathan@gs.com
Tel: 212-357-7504
Goldman Sachs and Co. LLC



Interview with Mark Carney

Mark Carney is the UN Special Envoy for Climate Action and the Co-Chair of the Glasgow Financial Alliance for Net Zero (GFANZ). He is also a Vice Chair of Brookfield Asset Management and was previously Governor of the Bank of England and Governor of the Bank of Canada. Below, he argues that COP26 has set the stage for far greater private sector involvement in tackling climate change, which will create a virtuous cycle of public-private de-carbonization efforts.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.



Allison Nathan: To what extent did the COP26 summit in Glasgow represent a step forward for the global climate agenda?

Mark Carney: The summit made progress in several areas. First, the world has coalesced around the goal of limiting the rise in global temperatures to 1.5 °C above pre-industrial levels,

which is a step up from the Paris Agreement six years ago where 1.5 °C was defined as a stretch goal for the end of the century. The final text of the [Glasgow Climate Pact](#) makes clear that 1.5 °C is now the benchmark, and, unlike the Paris Agreement, it doesn't contemplate an overshoot that would require large emissions reductions in the latter half of the century. This more ambitious goal has been backed up by the adoption of explicit net zero targets by 90% of countries, compared to just 20% at the start of 2020. Second, the country commitments and side deals around coal, methane and deforestation reached at COP26, if fully implemented, would limit warming by the end of the century to 1.7-1.8 °C, which keeps the 1.5 °C goal alive, albeit somewhat on life support. That's progress from less than two years ago when existing commitments were consistent with warming in the high twos, likely driven by a growing recognition of the non-linear climate impact of the move from 1.5 to 2 °C of warming.

Third, private sector engagement has taken a quantum leap since Paris. Across a range of heavy-emitting industries as well as finance, the private sector is beginning to lead the public sector in many respects, putting pressure on governments to close the execution gap. Lastly, because of that private sector commitment, companies now have net zero plans and annual reporting requirements against those plans, which will increase transparency and the availability of real-time data to track the pace of progress, reinforcing a positive feedback loop.

Allison Nathan: Given that countries haven't lived up to their Paris commitments, are you concerned that they won't live up to the new, more ambitious ones?

Mark Carney: It's true that countries' policies continue to lag their ambitions, and many still need to establish a track record of execution. And other gaps remain. The agreement on coal, for example, wasn't sufficiently ambitious, and was watered down at the last minute. Another major issue is the financing gap for emerging and developing economies for adaptation and investment. Despite a pledge from advanced economies to provide \$100bn per year by 2020 to emerging markets, they haven't yet lived up to this commitment. A compromise was reached, but emerging and developing economies still need an extra \$1tn to achieve net zero. There's also a need to focus

more on nature and resilience, and achieving a net zero transition in a way that's positive for the planet and addresses the impacts of climate change already in the pipeline, particularly for the world's most vulnerable countries. More certainly needs to be done, but I'm optimistic on the direction of travel, especially given the private sector's increased involvement.

Allison Nathan: As the private sector steps up, do you worry that the public sector is being let off the hook?

Mark Carney: That tension is certainly there, but I would argue that a virtuous cycle has been created, especially post COP26, between the public and private sectors. There's now much more clarity on the goal—limiting warming to 1.5 °C—and a far greater understanding of the transition pathways necessary to achieve it. Countries are fully behind that goal, at least as an objective, if not quite in terms of their actual policies. The financial sector has stepped up and has committed to provide the financial resources and expertise needed to achieve net zero. And as the private sector finances the straightforward parts of the transition, it will then engage in a healthy dialogue with the public sector about what else needs to be done, including putting a price on carbon to support certain industries, investing in breakthrough technologies and providing financing more effectively through the World Bank and other means to emerging and developing economies. So, as with many things in climate, it's a matter of "and" not "or", and right now the public and private sectors are working in tandem to deliver on the world's climate goals.

Allison Nathan: What role do you see GFANZ—the financial sector engagement you've been spearheading—playing in the net zero transition?

Mark Carney: GFANZ combines a series of initiatives from across the financial sector focused on financing the green transition to achieve net zero by 2050 at the latest. The alliance covers the whole waterfront of finance—asset managers, banks, insurance underwriters, infrastructure providers and investment consultants—and aims to set a common ambition in terms of reducing their financed emissions to achieve a fair share of the 50% de-carbonization needed by 2030. After setting their emissions reduction targets, member firms then have to create five-year de-carbonization plans consistent with this pathway. To help in this process, GFANZ created a series of work streams to facilitate and monitor net zero planning. A big development in Glasgow on this front was the substantial progress on mandating mainstream climate disclosure across the financial sector. A new sustainability board, called the International Sustainability Standards Board (ISSB), at the International Financial Reporting Standards Foundation (IFRS) that sets international accounting standards, will be responsible for establishing and monitoring global climate disclosures. And

in the US, the SEC is in the process of developing its own approach. At its core, GFANZ is building an architecture to ensure that the entire financial system is pulling in the same direction in terms of helping companies get the capital they need to de-carbonize the way the world wants.

Allison Nathan: You made headlines at COP26 by announcing that financial firms with \$130tn in funds have pledged to achieve net zero by 2050. What does that figure actually represent in practice?

Mark Carney: The \$130tn represents the collective balance sheets of financial institutions—notably, asset owners, asset managers and banks—who have committed to reducing their share of financed emissions as a part of GFANZ. It's somewhat adjusted for double counting by removing insurance underwriters and around \$10tn of investment consultants because some of their assets are blended in with pension funds and others. These \$130tn in committed assets compare to an estimated \$100-\$125tn in total financing that's needed for the energy transition, which works out to roughly \$4tn per year by 2050, not accounting for the one-third or so of capex typically funded by companies' internal cash flow. So, we have a stock of \$130tn in committed assets and a flow of \$4tn per year that's needed to achieve net zero.

While a big chunk of the \$130tn is already invested, it will steadily be converted into a flow as loans mature, asset managers make daily allocation decisions and large financial institutions face annual reporting requirements to achieve a fair share of the 50% de-carbonization needed by 2030. Much of the flow would ideally be directed towards companies with high emissions today that have plans to reduce their emissions down the road, because that's where you get the biggest bang for your buck. In the end, this is about helping companies transition to lower emissions, which will be capital intensive and take time. So, I'm fully in the engagement camp rather than the divestment camp. While many people don't want to hear it, we can't simply flip a green switch to get to a carbon-free world. Hundreds of billions of dollars of transition financing for bridge fossil fuels are needed in the IEA and IPCC climate scenarios. And, as financial firms increasingly provide this financing, their balance sheets will become more and more aligned with net zero. So, in crunching the numbers, the overall message is clear: the money to achieve the transition is there. All we need to do is set the right horizon for returns on de-carbonization, as with any investment, and companies will move in the right direction.

Allison Nathan: What gives you confidence that returns will be sufficient to compel climate investments?

Mark Carney: Solving an existential risk creates significant value. Ultimately, motivating large-scale investment will require a correlation between the return on de-carbonization and actual financial returns. But we're starting to see signs of that. On a micro level, the cost of capital is increasingly diverging between high and low carbon investments. Right now, that's mostly happening at the extremes—in heavy fossil fuels and renewables—but in short order it's going to be a core feature of the market across all major sectors. And we'll eventually see emissions considerations become one of the key value factors. The only thing that would undo this would be if governments

and society give up on the issue of climate change. But then we'd see pretty serious value disruption, including quite easily a decade of lost GDP growth this century. In my view, we'll see much more evidence of upside returns across the economy as the process of decarbonization plays out across sectors. And that's before you look at returns relative to the counterfactual of the value destruction if we just pretend this isn't an issue.

Allison Nathan: But don't you need rules, regulations and mandates from the public sector to create investment incentives and avoid capital misallocation?

Mark Carney: Yes, governments need to be engaged in two key ways. First, there has to be rules and mandates within the financial sector to share information and create a common approach for allocating capital to the best solutions. An important aspect of that will be clear, consistent and comprehensive climate disclosure. A relatively short period of experimentation with voluntarily disclosure is now coalescing to make mandatory climate disclosure standard, which will make markets function better. We're seeing similar steps with climate stress testing in the financial sector, and there will likely be a growing push to make net zero plans mandatory, as was announced for all publicly-listed UK companies at COP26. These steps create the necessary building blocks within the financial sector to orient markets toward achieving net zero.

Second, countries need clear sector-based policies to incentivize investment and pull forward adjustment. For example, many European countries have mandated the end of the internal combustion engine—by 2030 in the UK and 2035 elsewhere. In Canada, a legislated carbon price will rise from \$30/ton today to \$170/ton by 2030, which allows companies to make capital decisions around the higher price. And in maritime, hydrogen fuel mandates are starting to be put into place to de-carbonize shipping. In all of these cases, the date for the future transition is certain because it has been set by policy. As a result, the financial sector is motivated to push capital to those who are reacting to these policy signals. That creates a very powerful dynamic that will drive strong investment flows, and policymakers are increasingly appreciating that dynamic.

Allison Nathan: Despite all of this progress, are you concerned that we'll have an energy shortage before we have an energy solution, especially given the sharp rise in oil and gas prices over the past several months?

Mark Carney: The principal cause of current energy shortages is the energy glut in the middle of the last decade that contributed to more capital discipline in the energy sector. The shortages shouldn't be conflated with the energy transition. That said, achieving the commitments of the Glasgow Climate Pact will require a massive restructuring of every industry, and frictions will inevitably arise in that process. But those frictions can be lessened through a more consistent approach by the financial sector, which we now have, and active government policy that charts a clear transition path, as well as supports people through it. To oversimplify somewhat, the private sector will need to provide the capital investments required to execute the transition, and governments will need to provide the fiscal support to smooth the transition, including by helping to dampen any ensuing energy market volatility.

Interview with Chris James

Chris James is Founder and Executive Chairman of Engine No. 1, an investment firm using environmental, social and governance data to drive economic value. James previously founded Partner Fund Management, where he served as co-managing partner. Below, he discusses his findings that companies that align the interests of their shareholders and stakeholders are better at creating value over the long term.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.



Allison Nathan: What motivated your move into impact investing?

Chris James: For a long time, I had the mindset that how I made money and what I did philanthropically were two distinct efforts, but a few experiences over the last couple of years changed my mind. One, my kids asked me how I could consider myself an

environmentalist if I invested in energy companies, and I struggled to come up with a good answer. Two, using a database that we built at Partner Fund Management, I was able to determine that most of my money-losing investment decisions involved trying to maximize profits over a very short duration, usually around particular events. And this recurring pattern made me realize that what I was really trying to do was to sneak in under the internalization of a negative externality, like carbon emissions, that wasn't being reflected in the share price.

I didn't have a framework for how to think about this, though, which led me to Oliver Hart's and Luigi Zingales' [paper](#) that had a very simple formula for calculating the total social value of a business: a business's profit minus the damage it inflicts. After I read that paper, it started to make sense that we could build a framework that took advantage of the proliferation of information around ESG criteria—indicators of a business's impact on culture, communities and the environment like net rating scores, Glassdoor metrics, etc.—and perform root cause analysis to determine if ESG criteria directly translated into economic outcomes. I realized the power of this type of analysis when I was working on San Francisco's homelessness problem as part of Tipping Point Community, a nonprofit organization that I helped found. We discovered that the focus on third grade reading levels as a determinant of a child's future success was somewhat misplaced because what really mattered was understanding why students weren't reading at grade level, which often traced back to their parents being unable to earn a living wage. Performing a similar root cause analysis on ESG criteria led us to find a clear linkage between many of these criteria and a company's ability to create value over the long term.

Allison Nathan: If there is a link between long-term value creation and a company's impact on workers, communities and the environment, why haven't investors pushed firms towards a model of stakeholder capitalism until recently?

Chris James: The reason we haven't seen more change is because so many of these discussions get caught up in ideology instead of economics. Better data has allowed investors to understand the impacts companies have on society, and we've found a real linkage between the size of the externality a business generates, especially a negative externality, and its

profitability. But my generation of investors grew up with the Ayn Rand-driven idea that individuals have an incredible impact on the success or failure of society at large—which I view as somewhat of a pushback against communism. And like any cultural change, it's going to take a long time for investors to accept that in today's world characterized by transparency and interconnectedness, it's not just about the individual—greater societal problems can only be solved through working collectively together. I'd add that "society" is a term that does itself a disservice, because society is ultimately customers—they're one and the same. So if management teams start thinking in those terms—that they want to pursue strategies that align with their customers, rather than with "society"—these strategies start to make more sense.

Allison Nathan: But do you see a tradeoff between generating strong returns and pursuing climate goals?

Chris James: Climate risk is business risk, and by ignoring the climate externality, you ignore the reactions to that externality. We call it the path of the impact—a large negative impact by a company leads to innovation to mitigate the externality, increased regulation and changes in consumer behavior as people become more intentional in their decisions when they understand what the impact of a certain action, product, or level of consumption actually is. People started driving the Prius, by many accounts an awful car, because they wanted to make a statement that they care about the environment. And that demand paved the way for the innovation that resulted in Tesla vehicles, which are much better on all accounts. The reason companies like Tesla, Allbirds and Patagonia are successful today is because customers want to align their values with what they buy, and better transparency has made that increasingly possible. So what's good for stakeholders is ultimately good for shareholders. The only difference between shareholder primacy and stakeholder capitalism is duration. Over the long term—say, 10-15 years—the two completely converge. Stakeholder interests will sometimes directly conflict with what has been defined as fiduciary duty over shorter horizons, but I would argue that fiduciary duty should hold over the long term, as there is no end to a company logically, and the long-term success or failure of a company will be driven by how well and quickly it mitigates its negative impacts.

Allison Nathan: Engine No. 1 chose to engage with Exxon on climate by launching a proxy battle that resulted in the firm filling three board seats with climate-minded individuals. Do you believe that engagement is the better strategy relative to divestment for climate-focused investors?

Chris James: Divestment was an important early step in bringing awareness to the negative impacts that companies can have, and in many cases resulted from shareholder frustration with companies' unwillingness to engage on issues that don't fall

under the current narrow and wrong definition of fiduciary duty. Many shareholders also gave up on the idea that their vote could actually affect change, partly due to the byzantine nature of the proxy system, which was an incredibly negative surprise for me as we navigated the Exxon proxy battle.

But if there's anything that brought home the importance of engagement for me, it was watching the last presidential election, where the same people who were promoting the importance of getting out to the ballot box to express discontent with the status quo were quick to aggressively cheer on divestment, which is essentially giving up one's vote. It just broke my brain to think that someone could be espousing such dramatically different actions given a common narrative. The idea of divesting and giving up your vote is wrong, and a recent [paper](#) by Jonathan Berk and Jules van Binsbergen shows that divestment not only has no impact, but also actually gives economic rent to those who care much less about the issue. I don't believe that those who divest want to do that, but the reality is if those of us who actually care about ESG issues sell all of our stock, we won't have much of an opportunity to force large companies to change and account for the impacts they have when they allocate capital. If everyone who worried about Exxon's impact on the environment divested, we certainly wouldn't have won the three board seats that we did.

Allison Nathan: You've argued that Big Oil missed a golden opportunity to invest in the energy transition in 2007 when returns and oil prices were high, so what gives you more confidence now that engagement will produce results?

Chris James: I'm afraid I don't have the answer yet—it's only been six months since we won the proxy battle, and we'll see how long it takes for a company whose governance has been incredibly poor for decades to change. But what we've seen so far gives me hope. Before we launched the campaign, Exxon's goal was to ramp up oil production from 3.7 mb/d to 5 mb/d by 2025. Two months into the campaign, they announced they would instead keep production flat at 3.7 mb/d, and that 1.3 mb/d reduction is worth roughly 220 million tons of carbon annually. Exxon barely mentioned the word "carbon" before we started our campaign, but midway through it, they launched a low-carbon solutions business and are putting more capex towards decarbonizing while substantially slashing overall capex. The company also added two new board members in addition to the three we won, including one with climate experience, and promised to add more board members with climate expertise in the future. And just recently they've announced a more ambitious target for the reduction of company-wide greenhouse gas intensity by 20-30 percent by 2030. I'm confident that none of those changes would've happened without our campaign, and since we launched it, Exxon's stock has outperformed Chevron's by about 30%, likely because people understand there's much more accountability than ever before. We'll see where we go from here, but none of this is a bad start.

Allison Nathan: How do you think about the effectiveness of other types of private sector engagement, like green funds, in pursuing climate goals vs. public sector efforts?

Chris James: Our firm has an US index ETF (ticker VOTE) that has a very transparent voting policy aligned with our beliefs around the relationship between ESG criteria and value creation. Market

mechanisms in general can be effective in moving us towards a system that better allocates capital as more transparency around companies' impacts allows markets to price risk better. For example, more transparency about the risk associated with negative climate externalities should be quickly internalized by leveraged fixed income securities such as CLOs, where tail risk is a key consideration.

As for public sector engagement, many social issues like climate change have a role for a properly functioning government—one that's willing to do what's best for society as a collective over what's better for each of us individually. But governments don't seem to be stepping up. A carbon tax, for example, would've been an effective and simple solution for governments to implement, yet they have gotten too caught up in ideology to do so. And coming from COP26, my conclusion is that the private sector is going to drive the energy transition much more than the public sector. Microsoft's goal to run on 100% renewable energy by 2025 and to become carbon negative by 2030, for example, is the type of effort that's going to drive a much broader ecosystem towards achieving climate goals, which will work much more effectively than nationally-determined contributions from countries to reduce emissions without any near-term deliverables, because near-term targets—over, say, a 2-5-year horizon—are crucial to making progress on the climate agenda.

Allison Nathan: But don't you need public sector mandates to create investment incentives for the private sector?

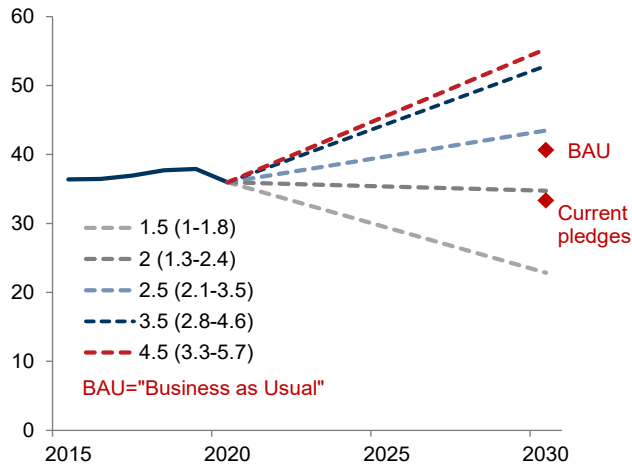
Chris James: I'm skeptical of that. CEOs will pay attention if you tell them that the multiple of their business will expand if they pursue climate-friendly strategies that minimize the negative externalities and enhance the positive externalities of their business. And if they don't pursue these strategies, the multiple is going to contract because the durability and stability of the company's business model is always going to be questioned as long as they have this negative externality, which, if internalized, will impact their earnings. That's why the auto sector is such an easy space for investors to focus on—the move to electric vehicles will reduce scope 3 emissions, and that will create significant value for shareholders, because if automakers decided that they're only going to sell internal combustion engine vehicles, we as investors would assume that they won't sell any cars after 2035. So all we need to do to motivate the private sector is to show companies how aligning their strategy with where their customers want to go translates to value creation—an easy argument to make and one that's absolutely true.

Allison Nathan: How do you respond, though, to the argument that the hype around climate goals has led to substantial greenwashing by companies and asset managers rather than real action to further climate goals?

Chris James: There is certainly some greenwashing going on across legacy investors. Over time, data transparency and investor demands will help end it. Gone are the "Mad Men" days when companies and asset managers could craft and advertise a strategy without their customers and clients finding out who they really are. The costs and risks for firms that do that are significant, and if they think they can still get away with that, then that just shows you what an insular culture it probably exists in, because as we've seen from employee walkouts, leaks, etc., the truth does eventually come out.

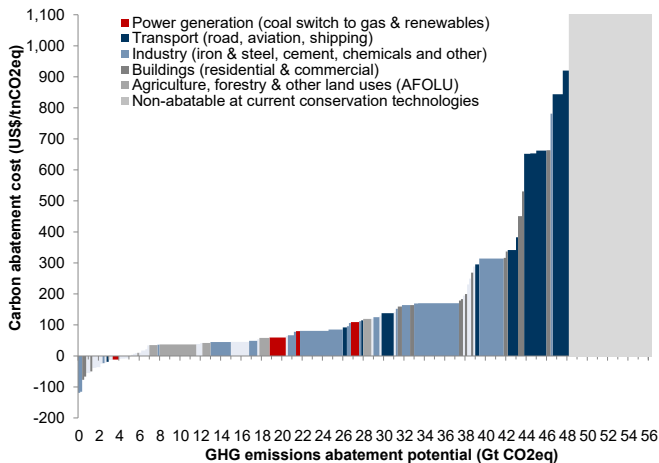
The path to net zero in pics

A sizable gap exists between emissions goals vs current policy...
 IPCC emissions scenarios vs current policy/pledges, Gt CO₂



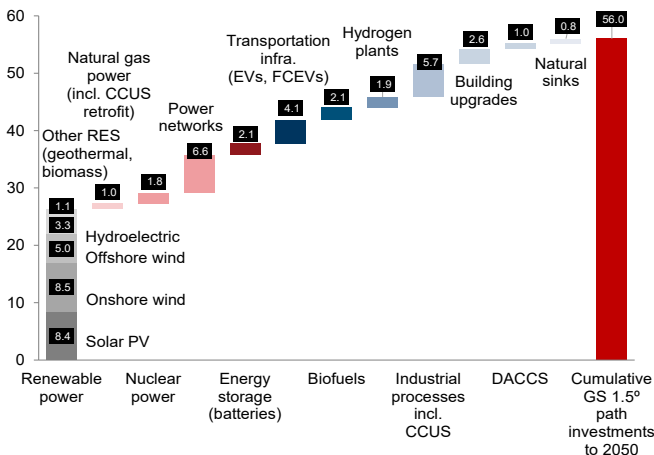
Note: Scenarios based on IPCC Shared Socio-economic pathways; temperature ranges reflect long-term estimate based on emissions path; BAU refers to baseline without new mitigation policies; current pledges based on country-level NDC commitments as of October 2021.
 Source: IPCC, IMF, Goldman Sachs GIR.

Low cost de-carbonization is concentrated in power today...
 2021 carbon abatement cost curve, \$/ton CO₂ eq.



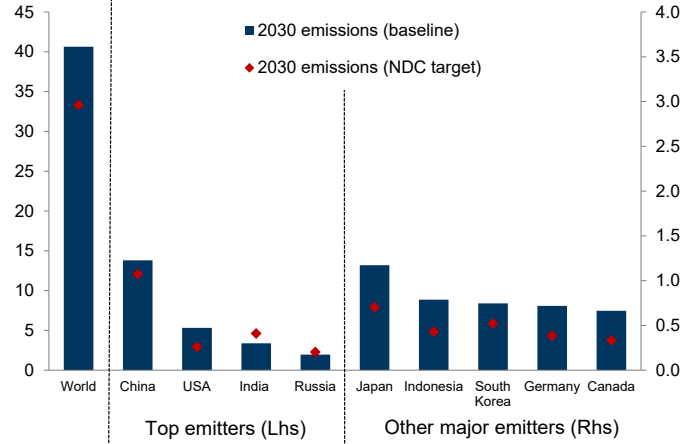
Source: Goldman Sachs GIR.

~\$56tn of investment needed for global Net Zero carbon
 Cumulative infra. investment in GS 1.5 °C net zero model, \$tn



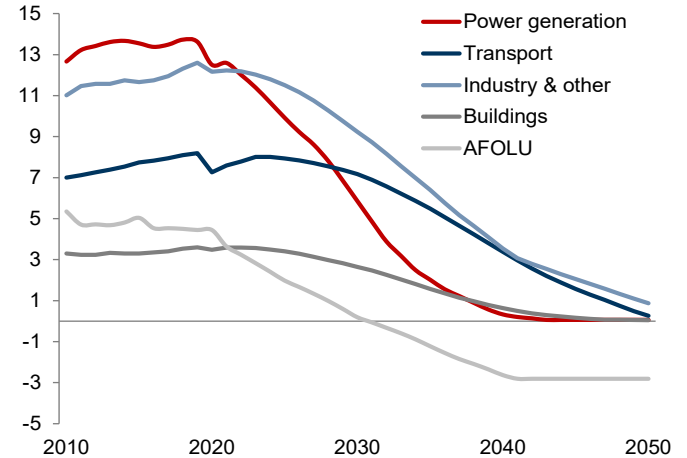
Note: Represents cumulative total figure for global investment by 2050.
 Source: Goldman Sachs GIR.

...requiring large emissions reductions in most economies
 Emissions baseline under BAU vs 2030 targets, Gt CO₂



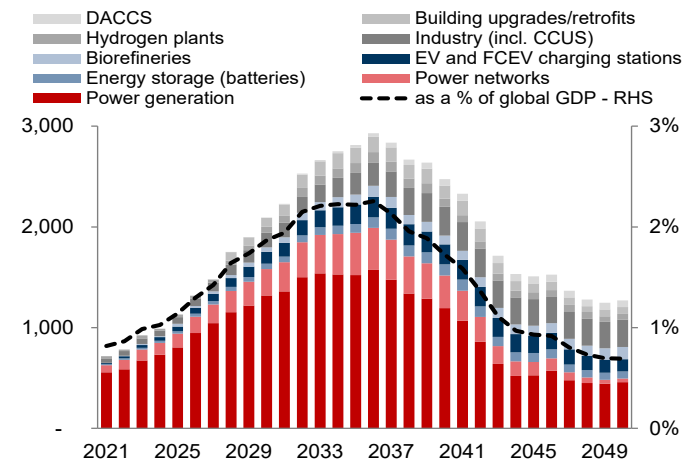
Note: Baseline reflects estimate of total CO₂ emissions in BAU scenario, doesn't include all GHG emissions; NDC targets are the unconditional target or, where available, the average of the conditional and unconditional target; two listed countries' pledges (India and Russia) remain higher than BAU scenario.
 Source: IPCC, IMF, Goldman Sachs GIR.

...requiring steep CO₂ cuts in power in <1.5 °C scenario
 CO₂ emissions in GS 1.5 °C scenario by sector, GtCO₂



Source: Goldman Sachs GIR.

Investment to reach >2% of GDP by 2032 in 1.5°C scenario
 Ann. infra. investment for net zero by 2050, \$tn; as % GDP (rhs)

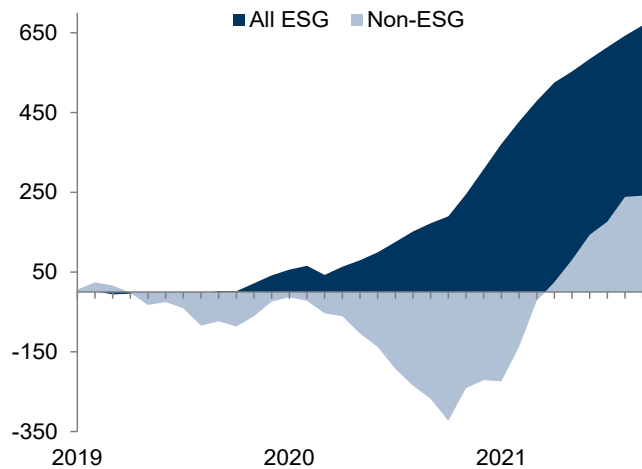


Note: This only reflects incremental investment and doesn't include maintenance/other capex.
 Source: Goldman Sachs GIR.

ESG investing and performance in pics

ESG equity inflows have outpaced non-ESG inflows...

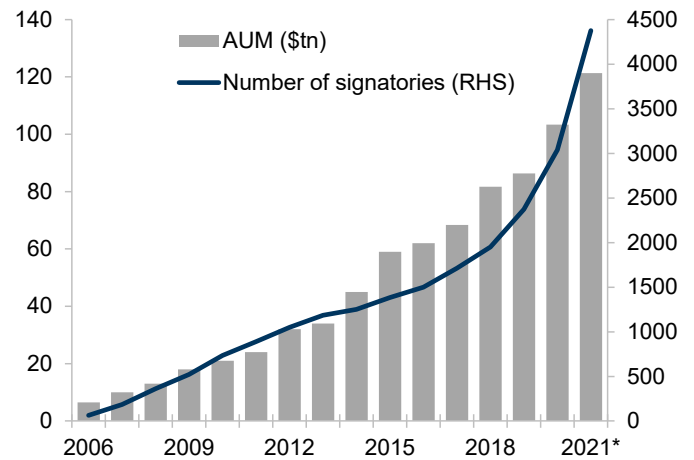
Cumulative mon. global flows for ESG/non-ESG equity funds, \$bn



Source: Morningstar, Goldman Sachs GIR.

...alongside investors' growing commitment to the PRI

PRI signatory growth (rhs) and AUM (lhs, \$tn)

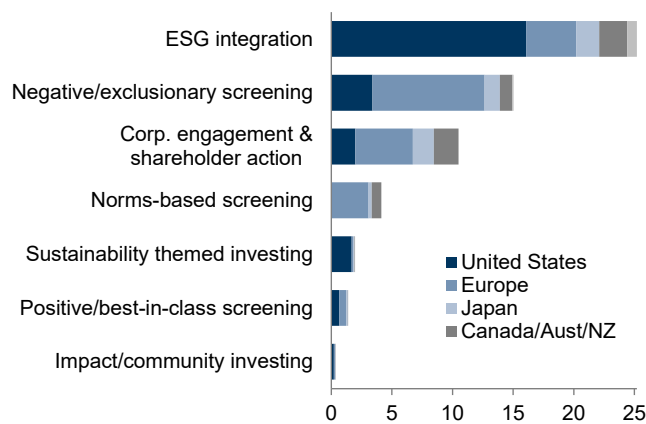


Note: The Principles of Responsible Investment (PRI) have required signatories to incorporate ESG considerations into at least 50% of their AUM since 2020, AUM as of March 30, 2021.

Source: PRI, Goldman Sachs GIR.

ESG integration and screening are the top fund strategies...

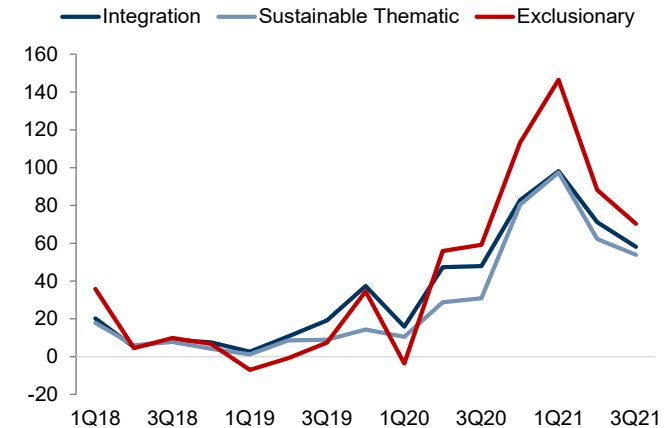
Sustainable investing assets by strategy (2020), \$tn



Source: GSIA, Goldman Sachs GIR.

...but exclusionary strategies have seen larger inflows recently

Global ESG equity fund flows by category, \$bn

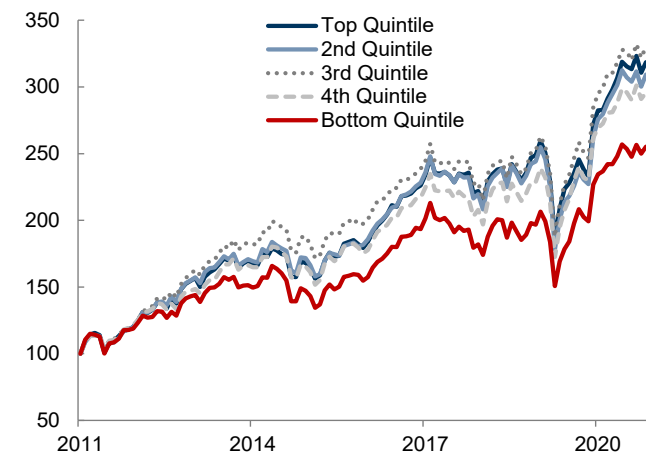


Note: Fund strategies are not mutually exclusive, see [here](#) for more on strategy designations.

Source: Morningstar, Goldman Sachs GIR.

Companies with low E&S scores have underperformed

Cumulative performance by SUSTAIN E&S headline percentiles, %

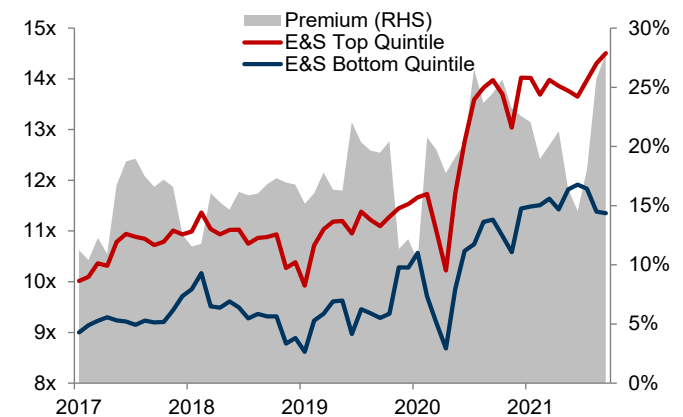


Note: E&S refers to environment and sustainability.

Source: Bloomberg, Refinitiv Eikon, FactSet, MSCI, Goldman Sachs GIR.

The multiple spread between ESG leaders/laggards is growing

12m fwd EV/EBITDA & relative premium (trimmed mean) (lhs), Q1 vs. Q5 SUSTAIN Operational E&S (rhs); E&S disclosure >50%



Note: Reflects 12m forward multiple of top quintile of companies in the GS SUSTAIN E&S headline rank vs that of the bottom quintile; Q5 is 5th quintile.

Source: FactSet, Goldman Sachs GIR.

Special thanks to the GS SUSTAIN team for these charts.

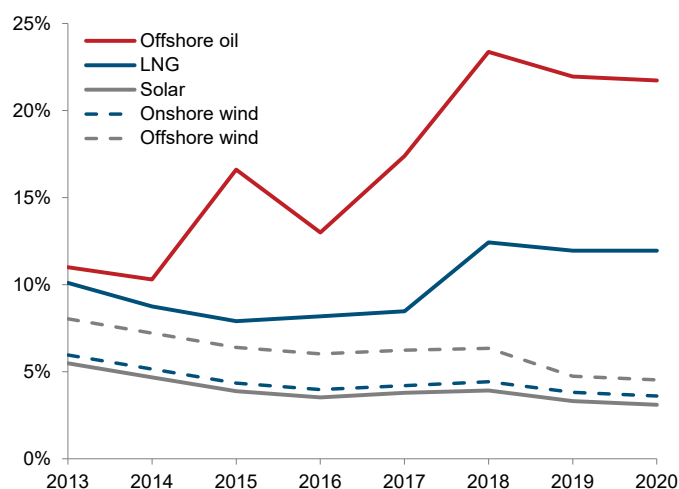
The rise of two-speed de-carbonization

Michele Della Vigna argues that a two-speed de-carbonization process is emerging, driving structural underinvestment in high carbon sectors and a “revenge of the old economy”

Capital markets' deep engagement in sustainability can hardly be overstated. The Principles of Responsible Investment (PRI) now have 3,000+ signatories, representing over \$103tn in global assets under management. Investor focus on climate change is especially strong—the number of climate-related shareholder proposals has doubled over the past decade, with the percentage of investors voting in favor of these proposals tripling over the same period. This intense focus on climate by capital markets is driving de-carbonization through a divergence in the cost of capital between high carbon and low carbon investments. In our Carbonomics study, we estimate that the divergence in the cost of capital between long-life oil and renewable developments has increased to 15pp over the last five years, driving a structural change in capital allocation that has resulted in renewable power investments exceeding oil & gas upstream investments for the first time in history this year.

Capital markets' climate engagement is driving a divergence in cost of capital between high and low carbon investments

Top projects IRR and renewables IRR by year of project sanction, %



Source: Goldman Sachs GIR.

This cost of capital divergence is transforming the Carbonomics cost curve in two important ways, lowering the cost of capital for low carbon developments with good regulatory visibility (lower cost of capital drove around a third of the cost deflation in renewable power over the last decade), while raising the cost of capital for high carbon sectors. This cost of capital divergence implies that investors are discounting a long-term carbon price of US\$40-80/ton in their assessment of long-life energy projects, creating a strong incentive for investors to allocate capital towards lower carbon energy developments. But such efforts by capital markets aren't currently matched by global carbon policies, and aren't enough to achieve net zero.

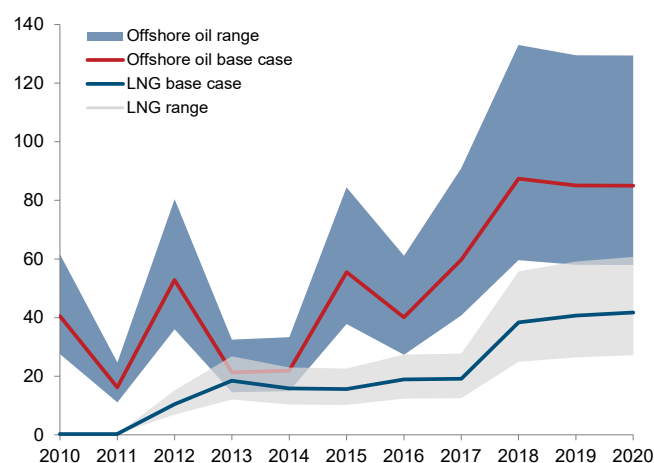
Carbon pricing is key for de-carbonization, but is currently falling short

Carbon pricing is a critical part of any effort to move to net zero emissions, while incentivizing technological innovation and progress in de-carbonization technologies. An estimated \$56tn

in incremental infrastructure investment will be needed to achieve net zero carbon emissions by 2050, which implies average annual investments in de-carbonization of \$1.9tn, as we laid out in our Net Zero Paths Study. We estimate that 50% of de-carbonization is reliant on access to clean power generation, including electrification of transport and various industrial processes, electricity used for heating, and more. The de-carbonization of transport, buildings, and industry will require a complex ecosystem of low carbon technologies, including energy storage (both batteries and clean hydrogen) and carbon capture alongside the supply of clean power. We estimate that clean hydrogen can contribute to around 20% of global de-carbonization, with its addressable market growing 7x from ~75 Mt in 2019 to ~520 Mt pa on the path to net zero by 2050. We also estimate that carbon capture, utilization, and storage (CCUS) can contribute to annual CO₂ abatement of ~7.2 Gt by 2050.

The cost of capital divergence implies a \$40-80/ton long-term carbon price for new hydrocarbon developments

Carbon price implied by the IRR premium for offshore oil/LNG projects compared with renewables, \$/tonCO₂



Source: Goldman Sachs GIR.

But while technology-specific incentives, like subsidies for solar panels, offshore wind and electric vehicles, can go a long way towards incentivizing the necessary investments and technological developments to drive de-carbonization and clean tech innovation, as we have seen across renewable power, electric mobility, and biofuels over the last decade, we believe that explicit carbon pricing schemes can serve as a more efficient, technology-agnostic method to achieve these goals. And properly designed carbon pricing schemes are important for providing the confidence and transparency necessary for voluntary carbon offsets, a powerful instrument for de-carbonization and the only global (although poorly regulated) carbon market at present. Carbon emissions abatement alone is highly unlikely, in our view, to achieve the Net Zero by 2050 ambition, and we believe that carbon offsets are a crucial driver of carbon removal through natural sinks and Direct Air Carbon Capture (DACC), contributing to around 15% to the de-carbonization of harder-to-abate sector emissions by 2050.

The EU Emissions Trading System (ETS)—which covers around 40% of the EU's greenhouse gas emissions—is a powerful example of an early adoption of carbon pricing, having led to the largest reduction in carbon emissions of any major economy. China's introduction of a national carbon trading

scheme this year has provided further momentum for carbon pricing by raising the share of global emissions covered by carbon schemes to above 20% for the first time in history. However, such efforts have so far failed to achieve carbon prices high enough to incentivize de-carbonization, with the current global weighted-average carbon price only \$4.50/ton compared to the \$100-200/ton abatement-weighted average carbon price implied by our Carbonomics cost curve. And the national schemes remain largely uncoordinated on a global basis, which could lead to carbon leakage and unfair competition, hence the current focus on border adjustment mechanisms to ensure a level playing field.

In the absence of global carbon prices, higher hydrocarbon prices can drive de-carbonization

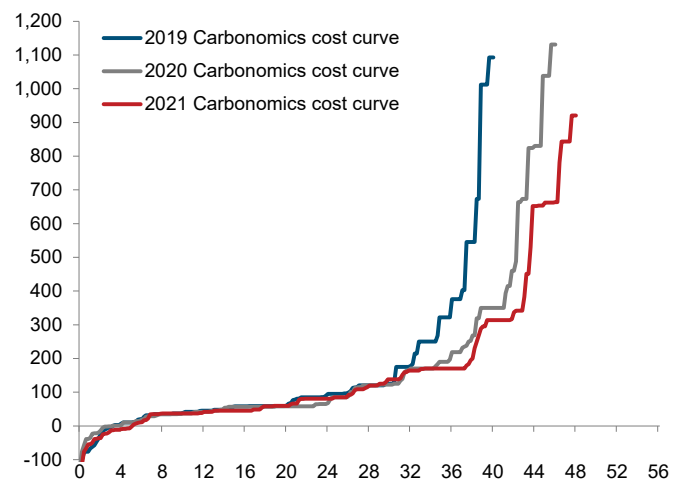
The mismatch between the limited reach of global de-carbonization policies and carbon pricing on one hand and the deep structural change in global capital allocation on the other is driving a two speed de-carbonization process that is severely constraining capital allocation to hydrocarbons and other high-carbon sectors like heavy transport and materials while the development of low carbon alternatives is not yet properly incentivized. These dynamics have led to structural underinvestment in key parts of the economy—energy, materials and heavy transport sectors are all reinvesting around 40% less of their cash flow on average vs. the 10-year average. Policy uncertainty is at the core of this underinvestment. For example, a shipping company that needs to expand its fleet to meet incremental demand will hesitate to order new diesel or LNG-fueled ships, because these assets may become stranded in a rapidly de-carbonizing world. But net zero alternatives such as green methanol or green ammonia-fueled ships are not yet economically viable, leading the company to delay the investment decision and underinvest. Similar decisions are taking place across most other carbon-heavy industries, resulting in a major supply gap and missed opportunity to mobilize capital towards the estimated \$3tn pa investment required to achieve net zero by 2050. In contrast, Electric Utilities is an example of a sector where clear de-carbonization incentives and strategies are actually leading to higher investments than in the past.

This structural underinvestment in high carbon sectors is likely to drive commodity prices higher over the medium-to-longer term, raising affordability concerns, but also increasing the relative attractiveness of de-carbonization technologies. The

current increases in oil, gas and coal prices (vs. 2020 average) imply an increase of \$60/ton (each barrel of oil generates 0.5 tons of CO₂, so the current \$30/bbl move vs. 2020 average is a \$60/ton change in implied pricing) for full-cycle CO₂e emissions from hydrocarbons and have driven two-thirds of the 12% flattening of the 2021 Carbonomics cost curve, compared to 2020. The de-carbonization incentives that have not been provided by global policy and carbon markets have therefore been provided by rising global hydrocarbon prices—through a form of “revenge of the old economy”—driving de-carbonization more forcefully towards clean tech innovation.

Higher commodity prices have driven two-thirds of the flattening of the 2021 Carbonomics cost curve

Greenhouse gas cumulative emissions abatement potential (x-axis, GtCO₂eq) vs. carbon abatement cost (y-axis, \$/tonCO₂eq)



Source: Goldman Sachs GIR.

CO₂ footprint disclosures could also drive de-carbonization

Global consumers today have the information to understand the caloric and nutritional content of packaged food and therefore make better food choices, but not the information on the carbon footprint of the products and services they buy to allow them to choose low-carbon goods. The introduction of such labelling could be another tool to drive de-carbonization, enabling and empowering consumers to put pressure on companies to enhance their de-carbonization strategies, finance carbon offsets, and accelerate the path toward net zero.

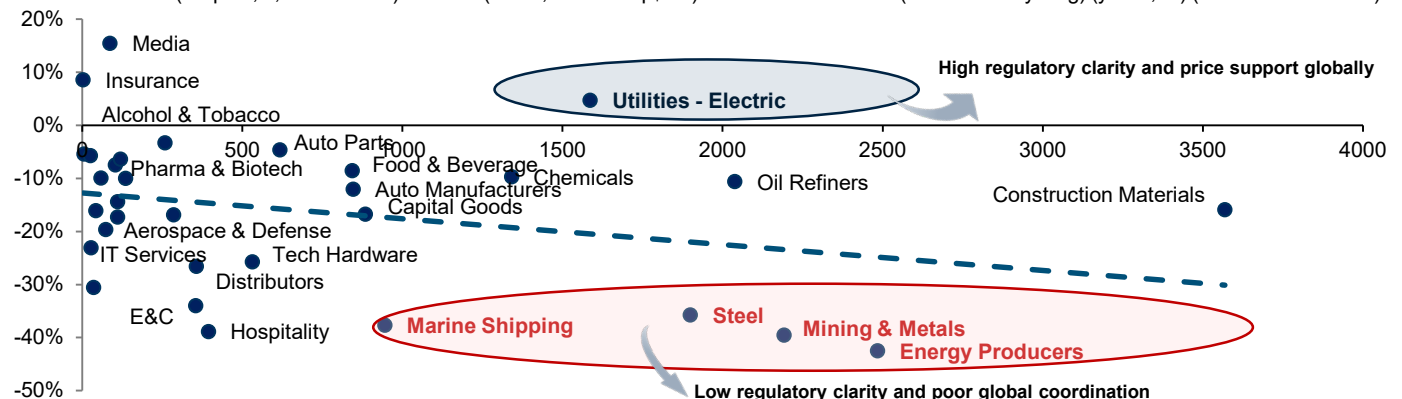
Michele Della Vigna, Head of Energy Industry Research

Email: michele.dellavigna@gs.com
Tel: 44-20-7552-9383

Goldman Sachs International

Shareholder pressure and lack of policy coordination have led to structural underinvestment in key parts of the economy

Carbon intensities (scope 1, 2, 3 emissions)/revenue (x-axis, tonCO₂eq/\$mn) vs. reinvestment ratio (2022E vs. 10yr avg) (y-axis, %) (data excludes 2020)



Source: Company data, Goldman Sachs GIR.

Interview with Evy Hambro

Evy Hambro is the Global Head of Thematic and Sector based investing and team leader for the Natural Resources team within BlackRock's Active Equity Group. Below, he argues that fiduciary responsibility and climate considerations are inextricably linked, and that investors have a critical role to play in facilitating the green transition.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.



Allison Nathan: What role should investors be playing in the transition to a low carbon world, especially given the increased focus on private sector engagement post COP26?

Evy Hambro: First and foremost, investors should always be fiduciaries of the capital that they look after on behalf of their clients—climate and

ESG considerations don't change that. And, as part of that fiduciary responsibility, investors should always seek the best financial outcome for their clients. At the same time, it's increasingly clear that the risks to portfolios from climate change are real. So fiduciary responsibility and climate considerations are inextricably linked; in order to properly look after clients' capital, asset managers have to invest through a lens that factors in those risks and their potential for value destruction. That said, the climate transition also presents a big investment opportunity; investors have a significant role to play in allocating the enormous amount of capital—in the trillions of dollars—required to achieve the green transition in the coming decades.

Allison Nathan: Within your Thematics investment universe, how do you think about divestment versus engagement strategies in your capital allocation decisions?

Evy Hambro: Some areas we simply don't invest in—thermal coal and firearms, for example. But we've generally been moving away from a strategy of exclusion towards one that tries to work with companies to understand their plans for moving their businesses forward as part of the green transition. Excluding businesses based entirely on historical, backward-looking data leads to incredibly narrow and undiversified portfolios, and probably won't do much to affect positive change. Achieving that requires backing companies in difficult areas that have robust transition plans, which will ultimately be much more effective in making progress towards climate goals.

Allison Nathan: So how do you embed climate and ESG considerations into your investment process in practice?

Evy Hambro: In terms of the nuts and bolts, our Sustainable Investing team collates all available climate and ESG-related data, and provides in-house proprietary tools that allow portfolio managers like myself to analyze the data and build it into our investment processes. And, importantly, we directly engage with companies on their strengths and weaknesses revealed by the data. If companies don't respond to the weaknesses we've identified, don't have clear plans for the future, or simply aren't thinking about these risks to their business, that's a red flag. On the other hand, companies that initially screen poorly but have strong plans to improve often represent the best investment opportunities since they've likely already been marginalized by

investors focused on exclusion, which creates value both in terms of price and the social benefit if they deliver on their transition plans.

Allison Nathan: Are large asset managers like BlackRock able to meaningfully engage on climate with all of the companies they're invested in—or considering investing in—given the sheer size of their portfolio?

Evy Hambro: Absolutely. Any asset manager, regardless of its size, has to regularly engage with the companies it's invested in, or interested in investing in, to determine whether or not they're creating value for clients, and there's no reason climate engagement should be any different. If anything, BlackRock benefits from its scale because it enables active managers like me to engage with companies across a wide range of ESG issues. And our size has also allowed us to create the largest global stewardship team in the business, which engages directly with companies on governance issues and votes investors' shares. Last proxy year, we voted on more than 165k management proposals across 71 voting markets, and around 40% of the time that involved voting against management on at least one proposal. So, the power of those two things—the discretion of our active portfolio managers and our focused stewardship efforts—is incredibly useful for clients in terms of making sure companies are creating value and accounting for sustainability risks. And we've found companies are generally moving in the right direction—of the 244 companies we identified last year as having inadequately addressed their exposure and management of climate risk, around 65% have made meaningful progress to close the gap. Those results speak for themselves.

Allison Nathan: So what does your engagement with companies actually look like?

Evy Hambro: It takes many forms—from meeting with management teams and boards of directors to on-the-ground research. Although the pandemic has hampered us a bit, in general we spend a substantial amount of time visiting the sites of the assets of companies we're invested in, such as oil fields and mines, and meeting with the management teams running them on a day-to-day basis to understand how they're thinking about the evolution of their operations. We ask that companies we invest in establish a baseline of how they plan to align with the global aspiration to reach net zero carbon emissions by 2050, including short-, medium- and long-term emissions reductions targets. To do so, they must provide data on their scope 1 and scope 2 emissions, and articulate how they plan to de-carbonize their value chains and make progress in disclosing scope 3 emissions and targets. In instances where company disclosures are insufficient, or they indicate a company hasn't created a credible plan to transition its business model, we often vote against board directors that we view as responsible

for the oversight of climate risk. In the 2020-21 proxy year alone, BlackRock Investment Stewardship voted against 255 directors and 319 companies based on climate-related concerns. More often than not, our site visits also include meeting with local communities and governments to gain the perspective of different stakeholders and make sure the businesses have the social licence to operate beyond a simple legal right. This has long been part of our investment process; my first visit to West African gold mines in the 1990s revolved around these issues well before they were in focus for global investors.

Allison Nathan: For your natural resources funds in particular, how do you curate a list of companies to invest in given all of these considerations?

Evy Hambro: Look, there's no achieving the climate transition without natural resources. Good luck building wind turbines without steel, electrifying the world without copper, or keeping the lights on in the near term without fossil fuels. So, commodity exposures deserve a place in investors' portfolios, and which ones we include always comes back to value. We have to deliver on what our clients hired us to do—provide exposure to the natural resources space while achieving superior total returns on the capital invested through the cycle. That requires a layered investment process involving both portfolio construction and company research, where ESG plays a particularly important role in risk management.

The fact that many fossil fuel companies aren't investing to sustain current production levels because of the risks to the long-term demand outlook for these fuels factors into how we build our portfolio. In our mining fund, we've dramatically shifted the portfolio towards metals like copper that will likely benefit from higher-demand growth in coming decades given the massive need for electrification. We've also invested in businesses with larger shares of their power coming from renewables, because that's eventually going to be a big differentiator. For example, it's likely that the price of copper produced using thermal coal power isn't always going to trade at the same level as copper produced using hydropower. And that extends to a whole range of other commodities, goods and services, because consumers will make decisions about how they buy things that don't just involve price, but also the environmental impact of the production process of what they're consuming. Regulators will also increasingly affect prices by requiring higher levels of transparency on emissions and imposing carbon-related taxes and/or other policies that will impact how companies operate. All of this is to say that we think critically about how climate considerations create value for investors in the natural resources space—as in all areas—and help deliver superior returns over the cycle.

Allison Nathan: As a long-time commodity investor, are you concerned that commodity shortages and price volatility are an inevitable part of the green transition?

Evy Hambro: Volatility is a constant in markets; it's always there—sometimes higher, sometimes lower. Will price outcomes differ from expectations during this transition? Absolutely. Will some commodities, like copper, end up in shortage? Without a doubt. Will fossil fuel prices trade at higher levels than expected owing to under-investment in production

capacity? That's likely. But will this period of higher prices and volatility last forever? No. Demand for these commodities—and fossil fuels in particular—will likely fall as the energy transition gathers speed and we pass the point of peak consumption.

Allison Nathan: Are government regulations or even mandates necessary for efficient capital allocation by investors to achieve this transition?

Evy Hambro: Without a doubt, regulation has a role to play. But the market will naturally move to where the returns are coming from. If value is being generated from the energy transition, then capital will flow to make it happen. This is already happening to a large extent with the incredible share price performance generated by renewable power companies over the past several years. On the opposite side of the ledger, all you have to look at is the countless bankruptcies of thermal coal companies to see the direction of travel. Sure, there's been a slight price rebound for heavy carbon emitters this year, but that won't last. Some investors will likely be late, and they will still be chasing returns generated by fossil fuels and missing the bigger picture. And then there will be a lot of volatility as everyone tries to leave the party at the same time. But the demand side of the equation will ultimately be the most powerful factor in driving this transition. For example, if customers are all moving their home electricity supply to renewables, that will be a very powerful force in accelerating the move away from fossil fuels. But regulators can help that along by incentivizing businesses to transition towards renewables or providing a better and more efficient grid.

Allison Nathan: Do you worry, though, that the strong flows into anything and everything that seems "green" right now could lead to capital misallocation that proves counterproductive to real progress on climate goals?

Evy Hambro: That's exactly why the role of an active investor is so important, because simply reverting to exclusionary or green screens will miss opportunities or fail to discriminate between them. Those opportunities include avoiding value destruction and not overpaying for companies trading at large premiums today. They also include spotting value in businesses that are beneficiaries of the green transition. This is just the tip of a new frontier for active investors given the breadth of opportunities that exists across sectors. Again, we're in an environment where trillions of dollars will be spent to fund this transition, and both massive value destruction and creation will result.

Allison Nathan: Does index investing also have a role to play in the green transition, or should clients be warier of ESG-focused indices given the potential for greenwashing?

Evy Hambro: The index side does a brilliant job of describing to clients exactly how the index is constructed and what it includes. It's then up to investors to decide if they want to own that exposure. This differs from the active side, where portfolio managers make decisions on behalf of investing clients. All that said, index investing has an important role to play in the green transition given that it's a huge part of capital markets, and can deliver important solutions to clients at scale in a very impactful way. So, both active and index strategies have a critical role to play in achieving the green transition that the world urgently needs.

Interview with Kasper Ahrndt Lorenzen

Kasper Ahrndt Lorenzen is Group Chief Investment Officer at PFA, one of Denmark's largest pension funds. He is the former Chief Investment Officer and Head of Portfolio Construction at ATP. Below, he discusses how PFA's investment strategies have evolved to incorporate climate considerations, and what that means for investor returns.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.



Allison Nathan: Denmark has been hailed as a paragon of the global climate agenda given its commitment to achieve a 70% reduction in CO2 emissions by 2030. How have the investment strategies of PFA—a major national pension fund and the country's largest life insurer—evolved to reflect these climate goals?

Kasper Lorenzen: PFA is a commercial life insurer, with about a third of all Danes as clients. More and more of our clients, especially the younger ones, care about the environment and expect us to do the same. So, climate has increasingly become a key consideration in our portfolio construction process in recent years. We start with the recognition that there's a very large climate liability sitting out there, and all investible assets carry part of that liability to varying degrees, even if it's not immediately reflected in their price. We don't want to be invested in companies that carry a higher participation in that liability. And let's face it, oil and gas companies do, so we're very comfortable generally reducing our exposure to the sector.

Given the reputational and commercial risks of owning oil and gas companies today, for those that we do own, we feel we must justify this ownership through real engagement on the steps they are taking to transition towards cleaner companies. Since we're a relatively small organization, we can only credibly do so with a handful of companies. In other words, we can't just say that we have active dialogues with dozens of oil and gas companies and have them in the portfolio. All of these considerations led us in 2020 to reduce the number of oil and gas companies in our main market-based PFA Plus Product from 20 to 2. And, as a way to mobilize and engage with our clients that are increasingly focused on climate issues, last year we launched a second market-based product, PFA Climate Plus, which has no exposure to oil and gas investments at all, and aims to be CO2-neutral by 2025 and CO2-negative by 2030.

“We start with the recognition that there's a very large climate liability sitting out there, and all investible assets carry part of that liability to varying degrees, even if it's not immediately reflected in their price. We don't want to be invested in companies that carry a higher participation in that liability.”

“Given the reputational and commercial risks of owning oil and gas companies today, for those that we do own, we feel we must justify this ownership through real engagement on the steps they are taking to transition towards cleaner companies. Since we're a relatively small organization, we can only credibly do so with a handful of companies.”

Allison Nathan: Some people argue that divestment is harmful to achieving climate goals because energy companies need funding to make the green transition. What's your response?

Kasper Lorenzen: We firmly believe that the right oil and gas majors have an important role to play in the green transition, because they have the expertise and experience necessary to build out the infrastructure required to create and transport green energy around the world. That's why we're happy to engage with companies that commit themselves to the energy transition, and have an active ownership dialogue as an equity holder. To be clear, we only engage with oil and gas companies on the equity side. When it comes to credit, our strategy is divestment, because fewer opportunities exist to engage with companies on the debt side given where debt investors sit in the capital structure.

The two oil and gas companies we're currently invested in represent what we view as the industry leaders in terms of how they're allocating R&D and new capex spending between fossil fuel and alternative investments, and we monitor their progress and commitment to their transition through key metrics, active dialogues and high-frequency touch points across the entire organization—from the ESG team, to the investment team, to the C-suite. As more and more companies credibly commit to the green transition over the next several years, we may choose to engage with more oil and gas majors. But, again, we can only credibly do this with a handful of companies, which dictates that the number of companies we own in this sector is small. And, if at some point we determine that active dialogues have failed, and we no longer believe these companies are committed to a meaningful transition, we would divest from these companies as well.

Allison Nathan: Oil and gas equities have performed strongly this year, so how do you square your fiduciary responsibility to maximize returns for your investors with your desire to be part of the climate solution by reducing your exposure to the sector?

Kasper Lorenzen: Sometimes not owning the sector won't be a good decision for the equity portfolio; of course, if you are underweight commodities and then they rise, you'll end up losing relative to a market cap-weighted portfolio, and you won't have the inflation protection provided by such ownership. That's just the way it is. But that's an exposure that can be dealt with in other ways; portfolios can be constructed to include inflation hedges without being exposed to the companies that carry a higher participation in the carbon externality, for example, by using inflation swaps. And we've had some success with that. In general, we don't view our return goals and climate goals as conflicting with one another—we believe that good returns will increasingly go hand-in-hand with helping the environment.

“ In general, we don't view our return goals and climate goals as conflicting with one another—we believe that good returns will increasingly go hand-in-hand with helping the environment.”

Allison Nathan: How else is PFA using its investment platform to help achieve Denmark's ambitious climate goals?

Kasper Lorenzen: Our climate strategy has two sides; first is the one we've been discussing, which is the boring part of the story because it's all about limiting our liability to carbon mainly through oil and gas sector divestment. But the other one entails actually investing in infrastructure and technology that directly contribute to the green transition, which is a more exciting narrative. To that end, we have ownership stakes in projects that differentiate Denmark as a leader in the energy transition, such as the creation of two “energy islands” to scale up the country's offshore wind capacity. One of the islands, Bornholm in the Baltic Sea, already exists, but the other one in the North Sea still has to be built. PFA was part of the first consortium to announce that it was planning a bid for the island's construction and operation, and has commissioned a Danish engineering company to study the possibilities for, among other things, establishing Power-to-X facilities, which convert renewable electricity into storable fuels, on the island. If they're successfully scaled to their intended capacity of 12 gigawatts—10 gigawatts from the North Sea energy island and 2 gigawatts from Bornholm—the islands would represent a more than 50% increase in Europe's current offshore wind capacity.

PFA has been involved in similar projects before—we became a co-owner of the world's biggest offshore wind farm in 2017 as part of Ørsted's energy transition. That transition, which entailed Denmark's state-owned electric company—Dong

Energy—going from 15% to 75% green energy within a decade, and then rebranding as a renewable energy company, Ørsted, is a good example of how both the public and private sector in Denmark became more comfortable investing in the green transition. It also underscores that while many opportunities for green investment are available in the private markets, listed companies like Ørsted also provide ways to engage via public markets. Hopefully, the Danish case—and PFA's role in it—can offer a case study for the rest of the world to replicate.

Allison Nathan: How do the returns for projects like the energy islands compare to those of more traditional investments?

Kasper Lorenzen: The required returns for such investments have declined, but for good reasons. One is that political risks around these types of projects, at least in our part of the world, have fallen as governments are increasingly trusted to maintain the subsidies and the regulatory frameworks that incentivize companies to invest in renewable energy projects. And technological risks have also declined as clean energy technologies have progressed. Given this reduced risk, we can live with lower expected returns, especially if returns are still expected to be solid over the longer term and may come with inflation protection. And, at the same time, fixed income is also expensive. Taken together, these considerations leave us comfortable switching somewhat from investing in government bonds to investing in these types of public-private partnerships.

Allison Nathan: What would help PFA allocate green capital more efficiently?

Kasper Lorenzen: Our investment process would be much easier if there was more transparency around the social cost of fossil fuel exposures and carbon emissions. For example, if governments actually taxed companies according to their carbon footprint, investors would be able to make better investment decisions around climate goals. The EU taxonomy, which classifies the environmental sustainability of different investments, is a helpful step in that direction, and more understanding and discussion of how carbon should be a part of the national accounting is also useful, but we can't hold our breath waiting for more data, because it just doesn't exist yet.

So investors have to create their own stories and lean into them. Again, we believe that the social cost of fossil fuel exposures is high and lean into that by not investing in fossil fuel companies unless we believe that they can make the transition to green energy, and by providing capital for projects that we believe will make a real difference in how the world produces energy. We're also taking a bit more risk on some of these projects on the margin, because so much is happening now that makes us believe in the green transition. One of my key takeaways from the COP26 summit was that people and value chains across both the private and public sectors are mobilizing to actively engage and participate in the transition, which means investors like us can probably take a bit more risk in green projects and technologies, because demand for them will surely grow in the years to come.

ESG fails as a carbon tax substitute

Jeff Currie argues that the lack of a global carbon price/tax has led to fragmented local climate policies and ESG investing—suboptimal and green inflationary solutions for tackling climate change

It is tempting to blame the failure of COP26 to make more progress on the climate agenda on everything from the UN's inability to enforce policy, to its impractical requirement of unanimous agreement among the 192 country participants. But the reality is that making progress toward climate goals just requires leadership from three blocs—China, the US and the EU—that combined produce 60% of global emissions. This situation is reminiscent of the 1945 Yalta Conference, when the three superpowers of the day—the US, Britain and the USSR—agreed to shape the post-WWII map, and all other nations fell in line. But Glasgow was like a Yalta where Roosevelt and Churchill couldn't agree and Stalin didn't show up.

At the core of this policy failure is the US's inability to pass a federally mandated carbon tax/price and China's unwillingness to agree to limit the rise in global temperatures to 1.5 °C, rather than 2 °C, above pre-industrial levels, which they view as an unrealistic goal. While some compromise on this goal seems achievable, the US problem is harder to solve, given that it is rooted in domestic political opposition against taxation—particularly gasoline taxes and tax revenues that go to foreigners—which dates back 250 years to the Boston Tea Party. And without all three emitters agreeing on an enforceable, global carbon price/tax, countries that do adopt such policies risk making their economies uncompetitive.

In a perfect world, the big three emitters would create uniform cross-border rules around de-carbonization that would adequately internalize the social cost of carbon, i.e. make consumers of hydrocarbons pay for emitting carbon. These rules would be enforceable on a global basis and have punishments for noncompliance. The global price of carbon would be raised over time until the world was weaned off of hydrocarbons, and the revenue generated would be used to invest in the green economy and subsidize the higher energy costs for poorer populations, where appropriate. In such a world, the "E" in ESG investing wouldn't be necessary, as governments, rather than investors, would police companies. Instead, investors would allocate capital in the way that they always have—to the projects with the highest returns and the ideas with the most potential to solve the problem.

This isn't a pipe dream. The Acid Rain problem of the 1970s—another global environmental problem involving sulphur emissions that the wind can carry very far distances (though not as far as carbon)—was solved in such a manner. So why can't we mimic this success with carbon emissions? Acid rain severely damaged the local environment, which created local political coalitions that were motivated to swiftly solve the problem. Beyond raging fires in the US West—blue states that are already pro-environmental—such reminders that create the fervor to find solutions are mostly absent in the rest of the US. So where does that leave us? With a massive policy failure that doesn't solve the market failure of internalizing the cost of

carbon to guide investors' asset allocation decisions. The lack of global pricing/taxation policies to address climate change has forced localities to enact their own policies, which will create costs and delays in solving the global climate change problem. For example, a lack of standardization in regulation inhibits the take-up of new green technologies, slowing their path to achieving economies of scale, and keeping the energy transition more expensive for longer.

ESG is taxation without representation, and revenue

This inability to create a globally coordinated policy response has also given rise to ESG investing, which in itself creates new market failures. While ESG investing raises the cost of capital for emitter firms and reduces it for green enterprises, resulting in higher hydrocarbon prices that act as a carbon price or tax, it fails to collect any revenue raised through a tax. And the "tax revenue" from higher oil, gas and coal prices in the form of profits, dividends and share buybacks goes to the emitters and to countries like Russia and Saudi Arabia that produce hydrocarbons. Furthermore, the excess capital now going to green investments will ultimately lead to overinvestment and poor returns in these sectors. In a world with a carbon tax, the tax revenues would be used to help pay for these expensive green investments and keep investors whole. Instead, the excess returns on hydrocarbon investments are going to the shareholder of oil and gas companies and the oil and gas producing nations who may or may not reinvest these proceeds into green investments.

Green inflation is a regressive tax

Another consequence of ESG investing creating a private tax via "green inflation" is that such a tax is regressive and doesn't create any revenue with which to compensate lower-income households. Such a tax is therefore a dynamic market failure—by making lower-income households pay today, the political will to take further action against climate change tomorrow is weakened, lowering the overall likelihood of success.

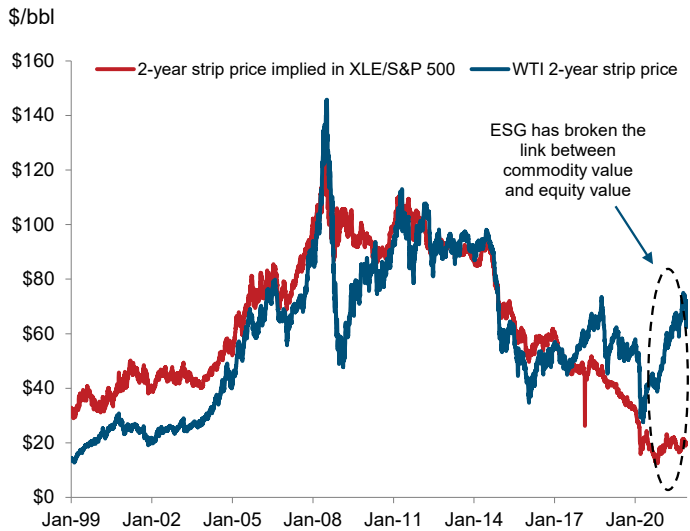
ESG also can't precisely penalize a good for its carbon content like a tax can. It only penalizes the firm that produces the good. And as prices are set at the margin, the most polluting firms become the price setter for the entire industry. For example, in the aluminum industry today, the natural gas shortage in Europe is driving up costs, setting the global price of aluminum. Yet, it is the consumer who pays this cost through higher prices. The failure stems from the regressive nature of using prices—rather than taxes—to incentivize the transition. As consumers of all incomes face the same price, those with lower incomes invariably pay proportionally more as these prices inflate. Since revenues are not collected, they can't be redistributed to subsidize lower-income groups.

A tax acts at the product level, while ESG acts at the industry level

ESG investing is a blunt instrument that, without fine-tuning, creates inefficiencies. In the absence of policy creating the global carbon market required for the effective comparison of investments, investors will structurally misallocate capital, over- and under-investing in assets whose prices do not reflect their true social value. The key here is that ESG investing breaks the link between commodity price and asset price, which doesn't occur with a carbon tax. To incentivize additional supply

investments (via higher asset prices), hydrocarbon prices now have to rise to higher levels than would otherwise be the case—that is, ESG makes their supply more inelastic. In other words, a tax acts on the individual production process, while ESG underweighting hits the entire market.

ESG investing breaks the link between oil prices and asset values, which makes oil supply more inelastic



Source: Bloomberg, Goldman Sachs GIR.

When this happens, consumers end up paying more ($P_{ESG} - P^*$) to achieve the optimal level of production (Q^*). This additional price acts like a tax on consumers—one the government can't fully control and whose revenues it never collects. But a tax can set supply to the optimal level, and collecting the revenue gives the government money to further invest in solving climate change, and at a lower price for consumers. This consumer price impact rises as the transition becomes more energy-intensive.

Policymakers create markets, investors allocate capital

While it is often said that one of the main reasons ESG funds have exploded in size is that many investors want to be

invested for social reasons, it's equally probable that they believe they will make money, which recently has proven to be the case. But tackling climate change is likely the most expensive endeavor humans have ever consciously undertaken, and somebody will eventually have to pay for it. Will these investors still be committed should Tesla's valuation normalize?

The scale of de-carbonization investment required for the new green economy is becoming increasingly clear—an extra \$2.8tn/year, equivalent to China's entire 2000's investment, for a total of \$6 trillion per year this decade. With such a large amount of capital needing to be deployed, the lack of an effective policy framework to channel those investments represents a structural risk to the long-term value of ESG investments this decade.

US policymakers must pass a carbon tax

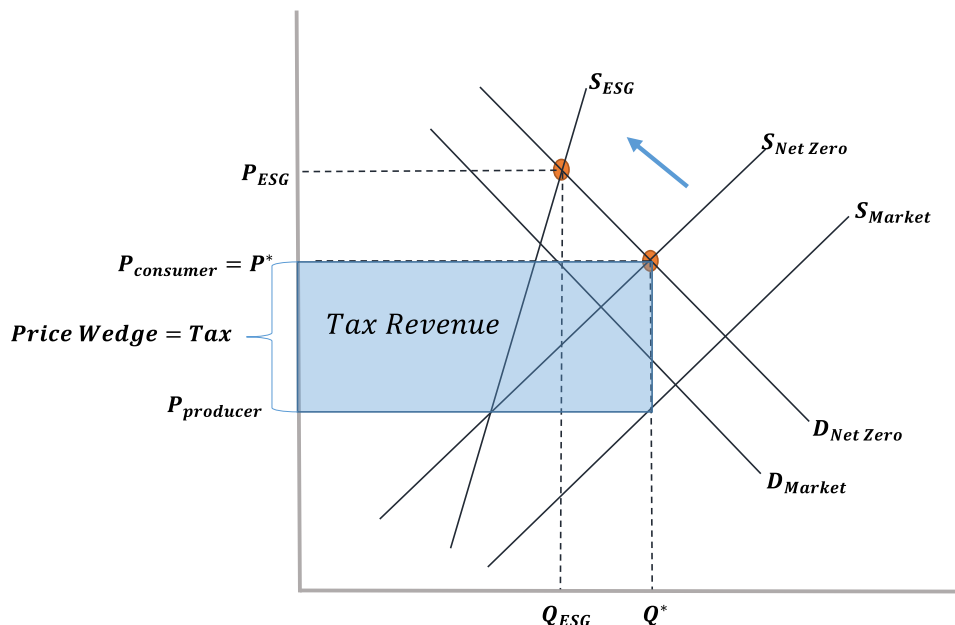
There is a growing irony embedded within today's US carbon policy. For a country founded on the idea of no taxation without representation, and one where national carbon taxes are seen as politically unfeasible, the lack of such a tax is leading to taxation without representation. With gasoline prices nearing \$4/gallon, US consumers are already paying a carbon tax to the Saudis and the Russians, with nothing to show for it. In an effort to solve the issue, the Biden Administration recently authorized 50mb of crude oil to be released from the Strategic Petroleum Reserve (SPR), which only further reduces the incentives of oil companies to produce needed supplies, compounding the structural undersupply problem of the oil market. Such issues will keep cropping up in a world without globally coordinated carbon policy. Leaving ESG investors to fill the void is both inefficient and time consuming—time the world doesn't have.

Jeff Currie, Global Head of Commodities Research

Email: jeffrey.currie@gs.com
Tel: 44-20-7552-7410

Goldman Sachs International

By making hydrocarbon supply more inelastic, ESG investing raises costs for consumers, and the tax revenue is lost



Source: Goldman Sachs GIR.

Q&A on carbon markets



Patrick Street, co-head of EMEA FICC Sales where he helps oversee Goldman Sachs' carbon market solutions for corporates and investors, answers key questions on carbon markets and their role helping to achieve global de-carbonization goals.

Q: How do carbon markets fit into the world's de-carbonization drive?

A: Under the Paris Climate Agreement, countries have committed to specific emissions reductions to work towards the goal of limiting global warming to well below 2°C, and preferably below 1.5°C, compared to pre-industrial levels. Current commitments suggest a baseline reduction of [~21-27 GtCO₂e globally by 2050](#) and were confirmed or in some cases even doubled down on in Glasgow. These nationally determined contributions (or NDCs) are the target against which countries have to execute to achieve that goal. Putting a price on carbon, which economically compels emitting industries on their soil to reduce their carbon footprint, is one way countries can do this. There's also been some progress on a mechanism that enables countries to transfer carbon credits between themselves to achieve their NDCs (via Article 6.2 of the Paris Agreement)—so that, for example, a country emitting above their target can purchase credits from a country emitting below their target—and between themselves and individual projects (via Article 6.4), but these are still both in their early days. So, carbon markets are an important part of the process—both nationally and globally—for reducing carbon emissions.

Q: What are the main ways to put a price on carbon?

A: A carbon price can be established either through a tax or through market-based mechanisms. Carbon taxes are a pure policy instrument that set a tax rate based on carbon content. Market-based mechanisms allow the demand and supply for carbon allowances or credits to determine the price of carbon. There are two main types of carbon markets: compliance and voluntary. All of these schemes are tools in a countries' toolbox for reducing emissions and achieving their NDCs. And they can choose between implementing all or some of them based on their own objectives and priorities. They can place a tax on all or certain carbon emissions, issue allowances and enable the market to find a solution, or leave it up to corporates to offset their footprints via voluntary markets.

Q: What are the main differences between compliance and voluntary markets?

A: Compliance markets are the most widely known markets and are often referred to as Emissions Trading Schemes (ETS) or cap-and-trade schemes. They are created through laws or regulation that mandate companies within a certain set of industries participate. The regulator creates a limited number of allowances or permits to pollute—which generally allow 1tCO₂ of emissions—and then distributes these to market participants through free allocations or by selling them in auctions. At the end of each year, regulated companies need to have enough allowances to cover their emissions in that year, which are verified by a third party auditor. To the extent they have a shortfall, polluters can buy additional allowances from the market and vice versa if they have a surplus. The sanction for non-compliance is severe—typically both a large fine and a requirement to carry the allowance shortfall in the following year. Compliance markets typically also allow participation from players that are not regulated by the scheme, such as banks and investors who provide liquidity to the market and help polluters manage their market risk.

In voluntary carbon markets, participants also trade certificates representing 1tCO₂. However, voluntary carbon credits—also widely known as carbon offsets—are not a pollution permit created by a regulator. They are instead a certificate representing that a verifiable action has been taken somewhere to compensate or offset emissions elsewhere. The starting point of the voluntary market is projects that either reduce CO₂ or remove CO₂ from the atmosphere through various means that are validated and verified by independent auditors, which a registry then issues carbon offset certificates against. The project developer can then sell those carbon credits to polluters who are looking to offset their scope 1-3 emissions. Given participation in this market is entirely voluntary, there are no restrictions on who can trade the certificates, and participants currently include project developers, corporates, investors and various intermediaries.

Q: How should we think about supply and demand in compliance markets?

A: The supply of allowances in a compliance carbon market is largely determined by the rules of each scheme, which are in turn designed by the applicable regulators—the regulators ultimately decide how many allowances are created as well as how many are retired each year. And it's through this process that over time they can drive down the amount of permitted emissions. The demand side in some sense is more anchored to the real economy, as demand from polluters in the scheme will depend on their annual output—which will be a balance between the cost of continuing to pollute and the cost of improving the efficiency of their operations from a carbon footprint perspective. However, over the past few years, investors have also become an important part of the demand picture. Although investors are not end-consumers of allowances, they can buy them up and keep them out of circulation for an extended period of time, which creates scarcity and drives prices higher. The EU ETS, for example, traded 8 billion Mt of CO₂ in 2020, but the underlying emissions covered are around 1.5bn.

Q: What are the largest compliance markets in the world?

A: The largest compliance markets in the world include the EU, California, RGGI, Korea and China. In terms of annual emissions covered, China is the largest at ~4bn Mt CO₂, with the EU next at 1.5bn Mt. China is critical to global de-carbonization efforts because it represents more than 2x the emissions of the US and 4x the EU, and therefore any realistic effort to achieve net zero will require it to make significant progress towards its goals. But while China's ETS is a positive step, it only launched this year and hasn't yet seen very active trading. The most actively traded compliance markets are the EU ETS, followed by the California ETS.

Q: Can you walk us through the EU ETS in a bit more detail?

A: The EU ETS was launched in 2005 and operates in all EU countries. Today, it covers emissions from industrial installations, power generation and aviation, which make up about 40% of the block's emissions. The ETS is designed so that every year the number of available allowances decreases, in an effort to reduce the overall emissions in the covered industries. Allowances are distributed through auctions or, in some cases, through free allocations to level the playing field for industries that are at risk of international competition from more carbon-intensive producers. EUAs—European Union Allowances—trade at the highest price of any ETS in the world today—having peaked at more than \$100 per tCO₂. Given the maturity of the EU ETS, there is very good liquidity in EUAs both in the futures space and OTC, so these products are widely and easily traded.

Q: What does the demand-side of the voluntary market look like? Who is buying carbon offsets?

A: Carbon offset demand is primarily driven by corporates who have set net zero or carbon neutrality targets. The starting point is clearly a credible plan to reduce emissions, but many companies are additionally looking to use offsets as a tool in their de-carbonization strategy as they offer a way to start acting now on emissions they cannot yet eliminate. Companies most active in this market include those from the technology and consumer sector who have already addressed most of their direct emissions and are now looking to address indirect emissions from their supply chain, together with corporates from hard-to-abate sectors like transportation and oil & gas, where opportunities for reducing direct emissions in the near term are more limited. Demand for offsets has increased significantly in the last few years on the back of the rapidly increasing number of sustainability commitments from corporates. In 2020, 95mn tCO₂ offsets were retired (+36% vs. 2019); 2021 demand is annualizing to ~140mn, 45% higher YoY. That said, compared to compliance markets, the voluntary market is still quite small, with the notional of current daily trading volumes amounting to around \$7.5mn a day compared to roughly \$3bn a day just in the EU ETS.

Q: What about the supply side of the voluntary offset market?

A: The supply of voluntary offsets is very fragmented—while all certificates nominally represent 1tCO₂ avoided or removed, in practice they have many differing quality levels and attributes. Carbon offsets are currently centered around a number of independent standards and associated registries, with each of them having a wide range of methodologies to verify for avoidance and removal projects. Registries play an important role in the voluntary carbon market because they dictate which methodologies are acceptable to assess a carbon offset project and are also in charge of issuing the actual credits and keeping track of credit ownership. To give you a sense of the fragmentation, there are 20+ global independent standards/registries that combined have 700+ verification methodologies and have issued carbon offsets from 10,000+ projects. While carbon offsets come in many different flavors, supply is starting to consolidate somewhat in terms of registries, with four large registries accounting for 85% of transacted volume. The largest of these registries, Verra (VCS), accounts for 60% of the market.

Q: What are some of the different carbon offset project types, and what are the main differences between them?

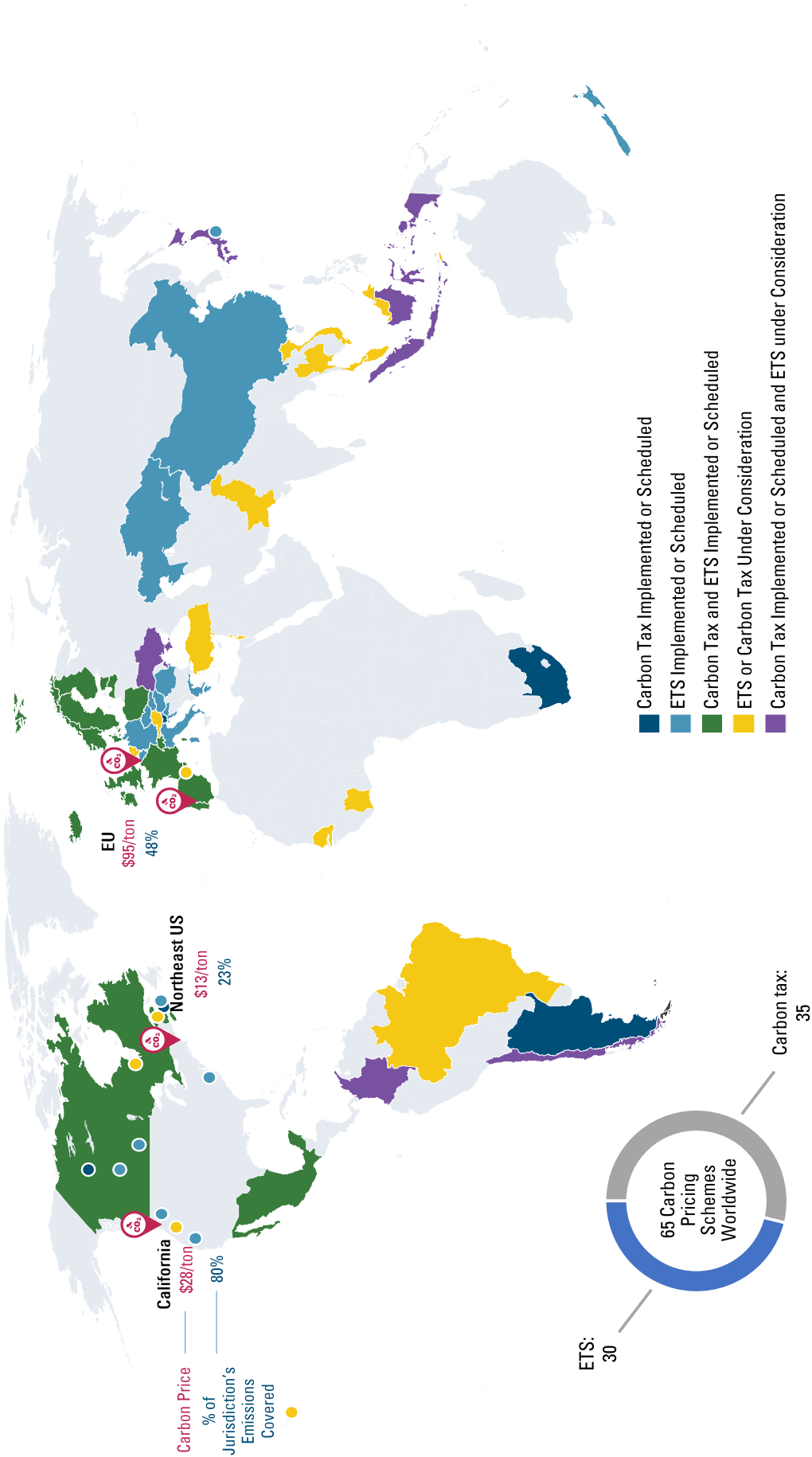
A: Offset projects can broadly be split into avoidance projects, which reduce or avoid the emission of greenhouse gases, and removal projects, which remove existing greenhouse gases from the atmosphere. Within those two broad categories are many different project types, but another useful split is to think about nature-based vs. engineered solutions. For instance, in the avoidance space, there are avoided deforestation projects vs. waste management projects that reduce methane emissions. In the removal space, there is afforestation and reforestation vs. direct air capture projects. Removal offsets have become a big focus for the market in the last few months with academic papers like the Oxford Principles or scientific guidelines on offsetting such as the Science Based Targets Initiative becoming more widely accepted. While most net zero targets are 10-30 years away and hence this shouldn't be an immediate issue for the market, demand for these offsets has increased markedly in recent months.

Q: How are carbon offsets traded and how do they price?

A: Carbon offsets are still largely traded OTC through brokers and intermediaries. However, some platform-based liquidity is starting to emerge through spot trading platforms like CBL. CME also recently launched two carbon offset futures, but their liquidity is still relatively thin, and so there is not yet a well-developed forward market. In practice, it's still very difficult for many investors to get access to the market because it requires them to have an account at the registries that oversee the standards for each offset, and so the main conduit at the moment remains through banks and brokers who can provide market access or synthetic exposure. In terms of pricing, prices tend to reflect the quality of the offset as well as the underlying costs of the project, and can price anywhere from a few dollars per tCO₂ to 100s of dollars for some of the more nascent engineered solutions like direct air capture. The market has rallied significantly in the last few months on the back of the strong interest in the de-carbonization theme. For instance, avoided deforestation credits—one of the most commonly traded offset types—currently price upwards of \$14 per tCO₂, more than double where they were at the beginning of the year.

A map of carbon pricing initiatives

65 carbon pricing initiatives cover ~12Gt of emissions, representing nearly a quarter of annual GHG emissions



Note: Carbon prices may not be comparable among countries, due to differences in sectors covered, allowances distributed, and exemptions applied; schemes and emissions data as of April 1, 2021; pricing data current, sourced from California Air Resources Board (California), ICE (EU), RGGI, RGGI (Northeast).

Source: California Air Resources Board, ICE, RGGI, World Bank, Goldman Sachs GIR.

Optimizing the climate change solution

Greenhouse gas emissions and their warming impact are a “negative externality”, an activity that imposes costs on society, but not on the individual or entity engaging in it. Theoretically, the optimal solution to internalizing such externalities is the introduction of a tax that aligns the cost to individuals (marginal private costs) with those to society (marginal social cost). Not only do carbon taxes shift the supplying firms' marginal cost curve upwards—aligning the optimal price and quantity of emissions for individuals and society—but the revenues from them can also be redistributed to households, or re-invested in new technologies or efforts to offset the damage from previous emissions. The reality, of course, is that despite progress in some countries, the implementation of this straightforward solution largely remains hindered by a lack of political commitment and global cooperation.

Localized solutions, global problem

Given the lack of global carbon pricing, solutions have become increasingly localized, like the European carbon compliance market, or voluntarily self-imposed by investors and corporates. From the perspective of these agents, internalization of their carbon footprint can be viewed as adding another equation to their optimization exercise, requiring an additional constraint like ESG to solve. The consequence of such local optimization will be a sub-optimal and more onerous solution than would otherwise be accomplished through globally coordinated action. In particular, the main problem with this second-best approach is the duration mismatch between the investor and corporate reaction functions; investors allocate capital toward long-duration solutions, such as renewable equities, while fossil fuel companies stop investing today to reduce their emissions, at the social cost of undersupplying energy. Only carbon markets can help bridge this mismatch.

From an investor's perspective, optimizing for carbon has led to the introduction of ESG as an additional portfolio constraint, allocating risk capital based on ESG scoring of producing firms that assess these firms' carbon footprint. But this local optimization has three limitations in solving the global emission challenge. First, ESG remains a blended metric of many considerations beyond climate that far exceeds the carbon footprint of producing firms, creating a very wide range of inferred carbon costs or subsidies. For example, our Carbonomics equity analysts estimate that this embedded carbon cost ranges from \$40 to \$80/tnCO₂eq (see pgs. 10-11 for details). Second, ESG investing remains a predominantly public market optimization, which leaves out, for example, spending on academic research aimed at determining efficient solutions to climate change. In the US, R&D spending of public firms only accounts for ~50% of private research spending. Third, the average time horizon over which equities are valued of c. 20 years leaves ESG allocation pricing in a decarbonizing future unconstrained by the current stock of polluting production.

From a corporation's perspective, the lack of clear government rules that lay out a path to de-carbonization leaves them under-investing in the required energy transition. This is a rational response to the challenge of investing under uncertainty that leads to two perverse outcomes—capex is either delayed in the hope of clearer rules in the future, or is instead directed toward short-cycle investments, as is already happening in both coal and oil. In coal, the market cap of US producers has fallen by 90% in the last 10 years despite the share of power generation still at 10% (and up 15% globally over that period). This is also clearly visible in oil, with a collapse in long-cycle offshore investments due to the highly uncertain long-term demand outlook, but strong investment in shale, which remains the only short-cycle source of global supply. Another corporate response is to self-impose a carbon tax through voluntary carbon offset markets (see pgs. 18-19 for details). While such markets are indeed suitable for offsetting emissions, especially indirect scope 3 emissions, they remain voluntary and limited in scale. Further, such offset markets have so far mostly focused on low-cost nature-based solutions, forestry in particular, with technology-based capture solutions still trading at prohibitively high offset prices.

Carbon prices/taxes solve an unvirtuous cycle

Bridging the maturity and capital allocation mismatch of simultaneously scaling up and down two energy systems requires accounting for GHG emissions and implementing either carbon taxes or cap-and-trade systems. Specifically, carbon compliance markets set a declining cap on total emissions, leading firms to invest to meet their future allowances. The resulting floating carbon price (since it is the volume that is fixed) then reflects the present value of such de-carbonization solutions. In Europe for example, while the EUA market is oversupplied today, it nonetheless trades at record-high prices given the difficult path of meeting future caps. Carbon taxes instead set a direct price on carbon (leaving the emission reduction implied), which typically target the social cost of carbon, the present value of estimated environmental damages over time caused by current marginal emissions. As a result, both of these carbon pricing initiatives help connect the investor and corporate optimization solutions, although they are both still far from guaranteeing a fast enough path to de-carbonization.

If global carbon pricing schemes fail to emerge quickly, and this mismatch is sustained, resulting sharply higher energy prices would eventually help producers overcome both the uncertain path of the energy transition as well as the higher cost of capital ESG investing inflicts on them. Sharply higher energy prices would drive inflation higher, and, in turn, interest rates. This would help solve the current duration and maturity mismatch as higher interest rates would shift investor preferences back towards the sector with shortest duration—oil and gas. This is consistent with the economics of an extraction industry, as the marginal cost of extracting today is not only the actual cost of production, but the opportunity cost of not having the same resource to extract in the future. Higher interest rates lead one to discount the future more heavily, leading one to extract at a faster rate. The economics of extraction can, in fact, be seen as the mirror image of the economics of investment as high interest rates discourage investment, as they increase the cost of capital. While this would help reignite spending in what the world needs short term, it would reduce the value of long-duration de-carbonization solutions such as renewable energy, further hindering the global de-carbonization process.

- **Damien Courvalin, Head of Energy, GS Commodities Research**
damien.courvalin@gs.com
 1-212-902-3307

Green Capex: where, and how, from here

Brian Singer discusses where the necessary funding for the green energy transition could come from, and what that means for investors

Green Capex will likely be the dominant driver of global infrastructure investment, with \$6tn of spend needed annually to decarbonize the world, address water needs, and shore up transportation and other critical systems. So where will that funding come from, and what does that mean for investors?

Green Capex needs are significant, and corporates aren't on track to meet them

We estimate that the world needs to invest \$6tn annually this decade to align with the goal of reaching net zero by 2050 and meet the Infrastructure and Clean Water UN Sustainable Development Goals (UN SDGs), representing a \$2.8tn increase vs. the 2016-2020 average and 2.7% of GDP. An all-in approach will be needed to achieve these goals in terms of the products, services and technologies required—not just solar, wind and electric vehicles, but also energy efficiency, carbon capture, hydrogen, nuclear, ports, bridges and broadband. Investment needs are particularly urgent in “Greenablers”—sectors like semiconductors, copper/aluminum, electricity transmission and cybersecurity that are critical building blocks for the green transition given their vital roles in energy efficiency, automation and electrification and long project lead times (2-12 years).

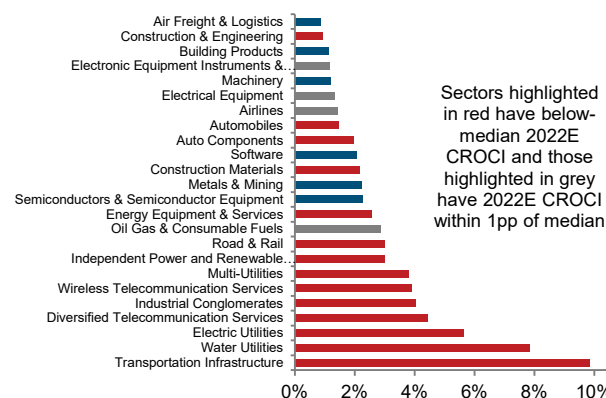
Corporates aren't currently on track to meet these needs, though. Global capex and R&D for the nearly 7,000 publicly traded companies in our GS SUSTAIN universe is ~\$4tn, and is expected by Factset consensus to rise ~3.3% yoy in 2022 and 2% in 2023. Assuming longer-term capex growth of 2.5% annually and an increased weighting of Green Capex of ~1.5% per year—consistent with new forecasts by our analysts—annual incremental Green Capex this decade would average ~\$0.4tn from publicly traded companies. We estimate privately held companies could add another \$0.4tn, based on a 20% CAGR from annualized raises in 2021 for Climate, Water, and Infrastructure private equity and venture capital funds. This leaves a large gap to reach the \$2.8tn in additional investment needed to align with net zero and the UN SDGs.

Public companies have capacity, but not always the returns, to increase Green Capex

Over the last decade, the share of operating cash flow that public companies have reinvested into capex and R&D has fallen from 60-70% to 50% in 2022E. Such lower reinvestment rates have in part resulted in greater free cash flow and stronger balance sheets, creating \$1tn in annual spare capacity that can be directed to Green investment. Much of this spare capacity is concentrated in the oil and gas, metals and mining and semiconductor sectors that are not usually considered “green” but that have an important role to play in driving new investments in Green Capex. But many of the sectors critical to achieving Green Capex goals have below-average corporate returns, which may make managements and investors more cautious about supporting an increase in Green Capex. To achieve higher returns, companies may need innovation, policy support, or to raise prices—we estimate that a 100bp increase in corporate returns would require a company to increase prices for their goods or services 1-4%.

Sectors with below-average returns may need to raise prices

Revenue increase required for a 1% increase in corporate returns



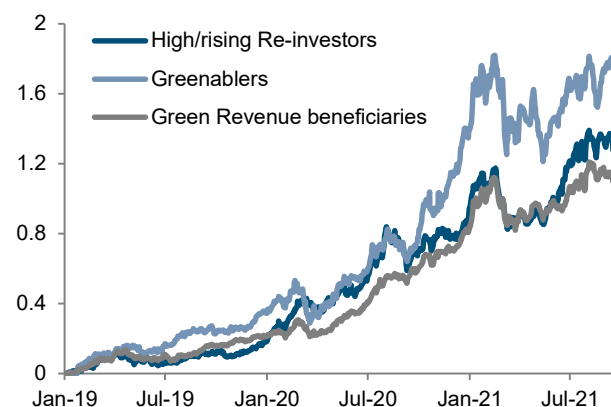
Source: Goldman Sachs GIR.

Investing in Green Capex pays

Investors have rewarded companies invested in/exposed to the Green transition that deliver favorable corporate returns. Specifically, we have seen outperformance vs. benchmarks of companies with above-average corporate returns that are also: (1) Green Revenue beneficiaries (stocks with revenue exposure of at least 25-30% to net zero, Infrastructure and Clean Water goals); (2) High/rising Re-investors (Green Revenue beneficiaries that are reinvesting cash flow into capex and R&D at an increasing/high rate); and (3) Greenablers. We believe this outperformance will translate to investors continuing to reward companies allocating more capital towards Green Capex that maintain above industry average corporate returns

Green Capex stocks have outperformed their benchmarks

Performance relative to respective benchmarks



Source: Refinitiv, Goldman Sachs GIR.

We also think an increasing focus on product impact, driven by more urgent demands for addressing UN SDGs and the rise of regulatory frameworks like the EU Taxonomy, will likely result in ESG investors that today are overweight in final product/pure-play sectors like solar, wind, water and aquaculture expanding their weightings in a wider group of industries and companies earlier in the Green supply chain, including industrials, service providers, technology and basic materials companies, as well as Greenablers. We see compelling investment opportunities across the supply chain.

Brian Singer, GS SUSTAIN

Email: brian.singer@gs.com

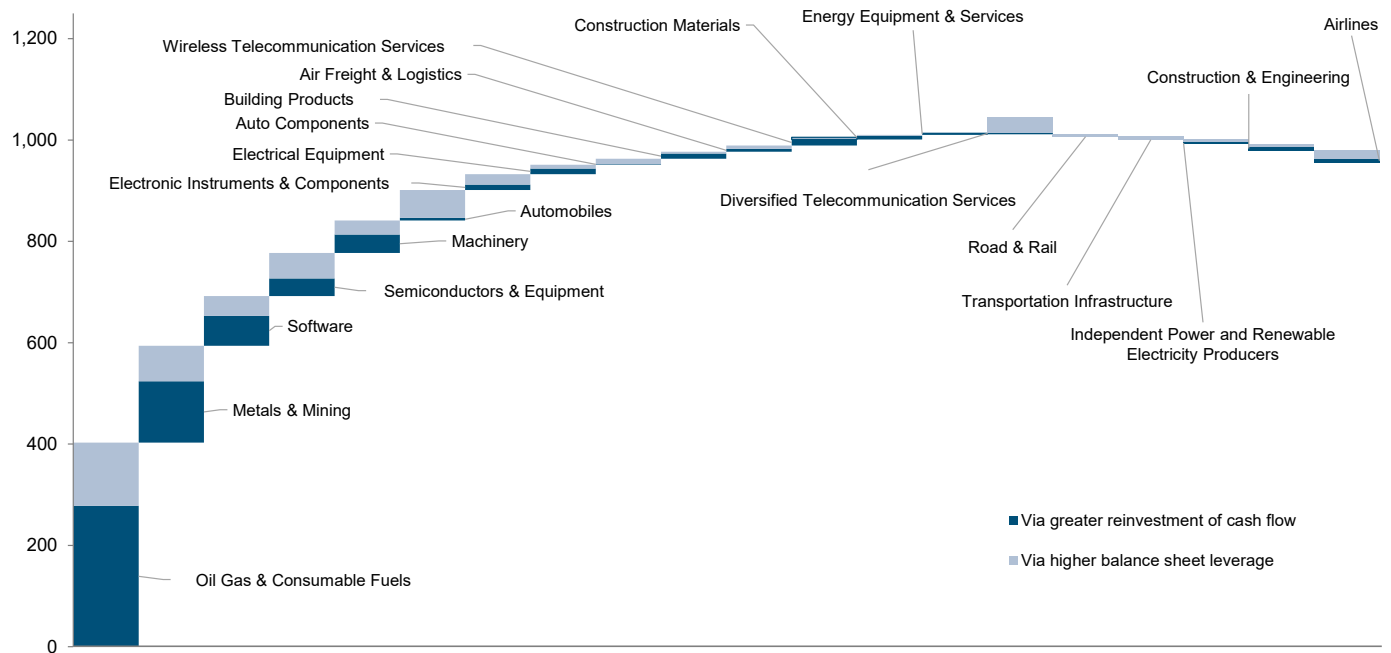
Tel: 1-212-902-8259

Goldman Sachs and Co. LLC

Where could Green Capex come from?

We estimate public companies have \$1tn of annual spare capacity that can be directed into Green investment, much of it concentrated in sectors not usually considered "green"

Green Capex spare capacity from key relevant sectors, based on 70% reinvestment rate and 1.5x leverage, \$bn

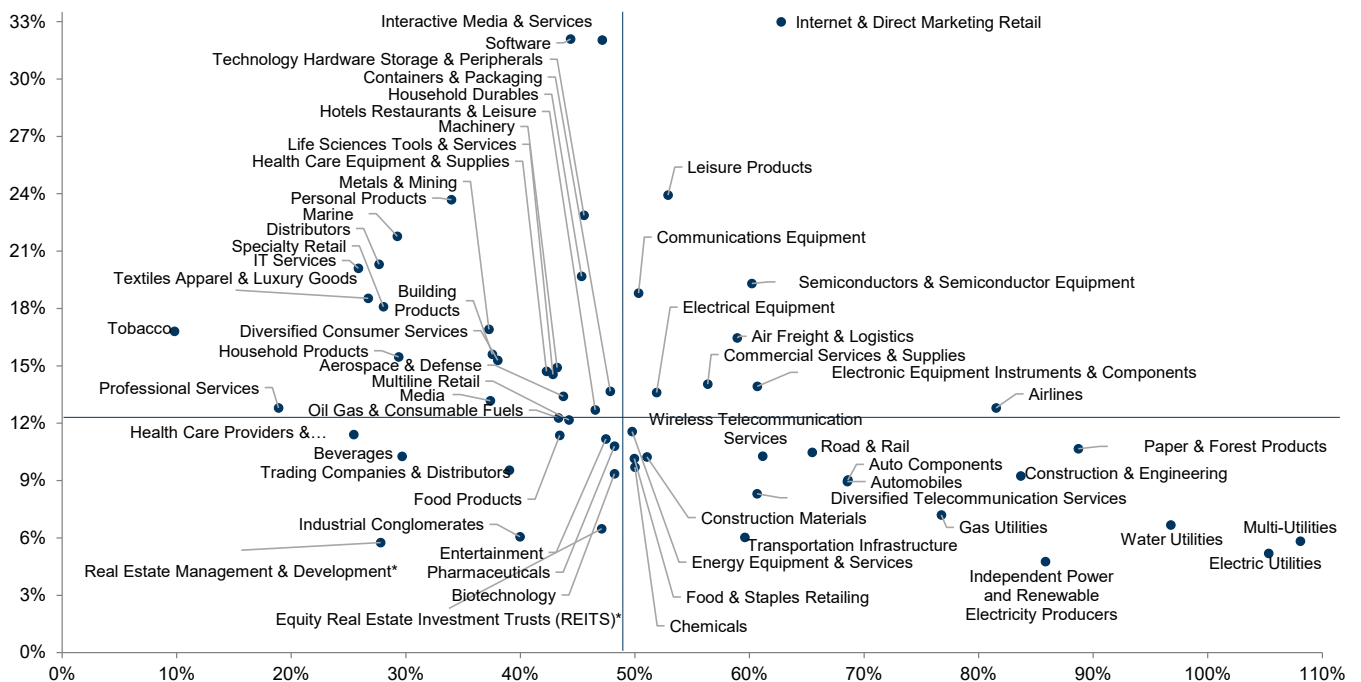


Note: Spare Green Capex capacity considers potential for shift in reinvestment and tolerance for leverage. Reinvestment capacity is based on incremental capex/R&D capacity to achieve a 70% 2022E reinvestment rate of cash flow. Leverage capacity is based on annual incremental spending over remainder of decade based on the difference between 2022E net debt/EBITDA and 1.5x; some sectors like Diversified Telecommunication Services have positive excess capacity from reinvestment that is cancelled out by leverage impact.

Source: Goldman Sachs GIR.

Not all sectors needed to meet net zero, infrastructure and clean water goals have above-average corporate returns, suggesting a need for innovation, policy support, or higher prices

Reinvestment rate (x-axis) vs. cash return on cash invested (y-axis) by sector for companies covered by GS Research, 2022E



*We view real estate cash return on cash invested as less comparable than other sectors.

Source: FactSet, Goldman Sachs GIR.

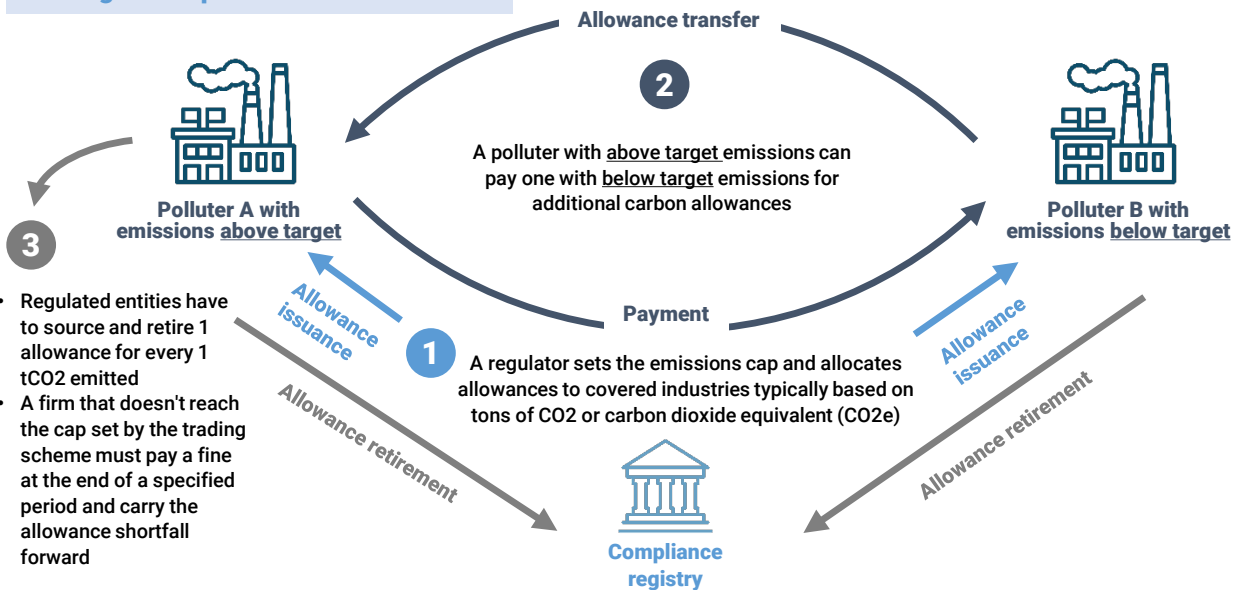
Carbon markets: an overview



Compliance carbon markets

- A market-based policy instrument where a cap is set on total emissions and the cap is reduced over time so that emissions fall
- A regulator allocates or sells allowances up to the limit set by the cap and every year entities must retire enough allowances to cover all of their emissions
- The price on carbon is market-based as entities with low emissions can sell surplus allowances to larger emitters
- Compliance carbon markets provide flexibility as emissions can be reduced wherever it's cheapest, but there's limited incentive to reduce emissions beyond the amount set by the cap
- Other market participants can also trade emissions allowances OTC or in some cases via futures

Trading in compliance carbon markets:

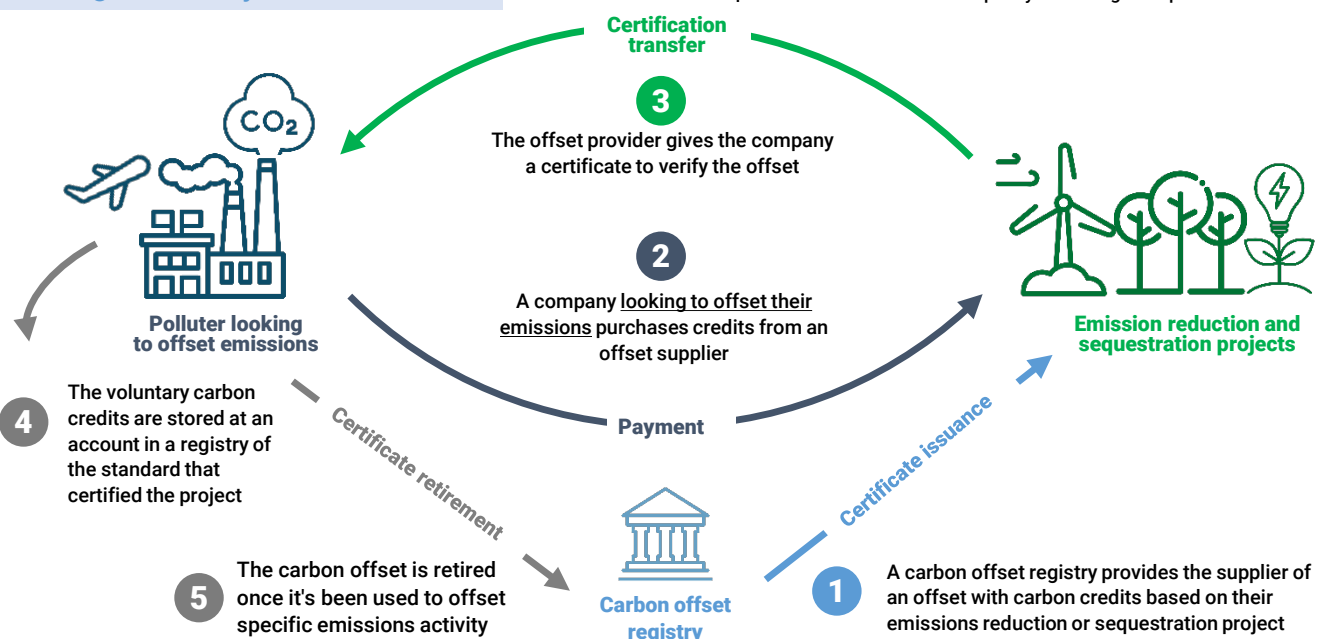


- Regulated entities have to source and retire 1 allowance for every 1 tCO2 emitted
- A firm that doesn't reach the cap set by the trading scheme must pay a fine at the end of a specified period and carry the allowance shortfall forward

Voluntary carbon markets

- A market-based solution to reduce carbon emissions
- Relies on consumers and corporates' voluntary actions
- The price on carbon is market-based and depends on the supply and demand of carbon offsets
- Types of offsets include reduction and avoidance offsets, such as renewable energy and deforestation avoidance, and removal offsets, such as reforestation and carbon capture/storage
- Voluntary carbon markets are generally not considered a replacement for directly reducing emissions
- Carbon offsets are largely traded OTC once they're issued, though platform-based and futures liquidity is starting to improve

Trading in voluntary carbon markets:



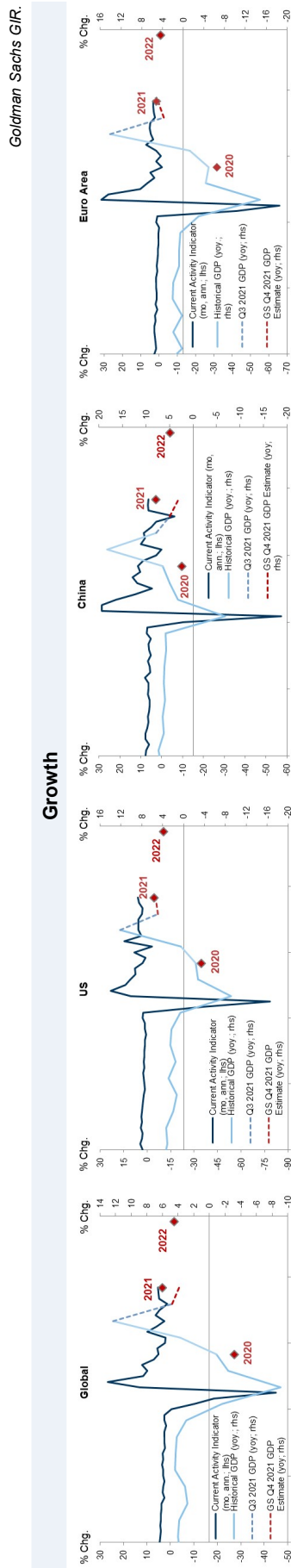
Source: Goldman Sachs Global Markets Division, Goldman Sachs GIR.

Summary of our key forecasts

GS GIR: Macro at a glance

Watching

- **Globally**, we expect full-year growth of 6.0% in 2021 and 4.5% in 2022, more than 1pp above potential, thanks to continued medical improvements, a consumption boost from pent-up savings, and inventory rebuilding, but the prospect of a winter COVID wave and a drag from the Omicron variant pose downside risk.
- **In the US**, we expect full-year growth of 5.6% in 2021 and 3.8% in 2022. We expect a modest drag on growth from the Omicron variant in 1Q22 and see a gradual slowdown next year as the positive impulses from continued reopening, pent-up savings and inventory restocking contend with a steady headwind from diminishing fiscal support. We expect core PCE inflation will continue to rise to 4.5% by end-2021 before falling to 2.3% by end-2022. We expect the unemployment rate to fall to 4.1% and 3.5% by the end of 2021 and 2022, respectively.
- **The Fed** has started to taper asset purchases at a pace of \$15bn per month, and we expect it will announce at this month's meeting that it's doubling the pace to \$30bn per month starting in January. We expect the first rate hike in May, followed by additional hikes in July and November. On the fiscal policy front, we expect the passage of additional spending of around \$1.75-\$2tn focused on infrastructure, social benefits, and long-term investment.
- **In the Euro area**, we expect full-year growth of 5.1% in 2021 and see risks skewed toward the downside amid the recent sharp rise in COVID case growth and the emergence of the Omicron variant. But we remain constructive on the outlook for the latter part of next year and expect growth of 4.3% in 2022 given a likely easing of industrial bottlenecks, significant catch-up room for services spending, and persistent fiscal support. We expect core inflation to fall sharply in January 2022 as base effects wash out, and reach 1.4% by December 2022.
- **The ECB** recently reiterated that it continues to view current inflationary pressures as transitory, and we think officials will keep rates unchanged until 3Q24. We expect the ECB to end PEPP in March and opt for a temporary "APP" bridge to September 2022 at its December meeting, but think a residual PEPP envelope after March 2022 could be used as a backstop to potentially respond to downside virus risks.
- **In China**, we expect below-consensus real GDP growth of 7.8% in 2021 and 4.8% in 2022. While recent dovish/pro-growth signals from policymakers have reduced the left-tail risk to our 2022 growth forecast, property market developments remain a key downside risk to watch in the coming months.
- **WATCH CORONAVIRUS.** The Omicron variant poses near-term risks to the global medical and economic outlook. Although the range of possible outcomes remains wide given remaining uncertainty about the transmissibility, degree of protection from vaccines and prior infections, and disease severity of the new variant, medical evidence so far suggests that Omicron is transmitting more quickly than Delta, but is evading immunity against hospitalizations only slightly more.



Source: Haver Analytics and Goldman Sachs Global Investment Research. Note: GS CAI is a measure of current growth. We have recently revised our methodology for calculating this measure. For more information on the methodology of the CAI please see "Lessons Learned: Re-engineering Our CAIs in Light of the Pandemic Recession," Global Economics Analyst, Sep. 29, 2020.

Forecasts

Economics	2021				2022				Markets				Equities												
	GS	Mkt.	GS	Mkt.	GS	Mkt.	GS	Cons.	Last	E2021	E2022	FX	12m	S&P 500	E2021	E2022	GS	Cons.	GS	Cons.	YTD	E2021 P/E			
GDP growth (%)	6.0	5.8	4.5	4.4	US	1.48	1.70	2.00	EUR/\$	1.13	1.15	Price	4,700	--	5,100	--	5,100	--	S&P500	8.0	25.0	23.3x			
Interest rates 10Yr (%)	5.6	5.5	3.8	3.9	Germany	-0.36	-0.10	0.30	GBP/\$	1.33	1.34	EPS	\$209	\$207	\$226	\$223	\$226	\$223	MXAPJ	14.0	-4.0	15.2x			
Policy rates (%)	7.8	8.0	4.8	5.3	Japan	0.05	0.10	0.20	\$/JPY	113	115	Growth	47%	45%	8%	8%	8%	Topix	14.0	9.0	21.6x				
	5.1	5.1	4.3	4.2	UK	0.64	1.10	1.35	\$/CNY	6.4	6.35	6.2						STOXX 600	11.0	19.0	16.6x				
					Commodities				Credit																
					Crude Oil, Brent (\$/bbl)	75	90	85	USD	IG	96	103	US	7.0	4.1	3.0	3.5	3.5	3.5	Unemp. Rate	Q1	Q2	Q3	Q4	
					Nat Gas (\$/mmBtu)	3.93	3.65	3.55	HY	302	285	350	Euro area	2.5	7.5	2.5	2.5	7.1	7.1	7.1	--	--	--	--	
					Copper (\$/mt)	9,507	10,500	11,500	IG	114	107	112	China	0.9	--	2.7	--	12.1	12.6	7.7	7.7	7.7	7.7	7.7	7.7
					Gold (\$/troy oz)	1,780	2,000	2,000	HY	342	330	365													

Source: Bloomberg, Goldman Sachs Global Investment Research. For important disclosures, see the Disclosure Appendix or go to www.gs.com/research/hedge.html. Market pricing as of December 10, 2021.

Glossary of GS proprietary indices

Current Activity Indicator (CAI)

GS CAIs measure the growth signal in a broad range of weekly and monthly indicators, offering an alternative to Gross Domestic Product (GDP). GDP is an imperfect guide to current activity: In most countries, it is only available quarterly and is released with a substantial delay, and its initial estimates are often heavily revised. GDP also ignores important measures of real activity, such as employment and the purchasing managers' indexes (PMIs). All of these problems reduce the effectiveness of GDP for investment and policy decisions. Our CAIs aim to address GDP's shortcomings and provide a timelier read on the pace of growth.

For more, see our [CAI page](#) and [Global Economics Analyst: Trackin' All Over the World – Our New Global CAI, 25 February 2017](#).

Dynamic Equilibrium Exchange Rates (DEER)

The GSDEER framework establishes an equilibrium (or "fair") value of the real exchange rate based on relative productivity and terms-of-trade differentials.

For more, see our [GSDEER page](#), [Global Economics Paper No. 227: Finding Fair Value in EM FX, 26 January 2016](#), and [Global Markets Analyst: A Look at Valuation Across G10 FX, 29 June 2017](#).

Financial Conditions Index (FCI)

GS FCIs gauge the "looseness" or "tightness" of financial conditions across the world's major economies, incorporating variables that directly affect spending on domestically produced goods and services. FCIs can provide valuable information about the economic growth outlook and the direct and indirect effects of monetary policy on real economic activity.

FCIs for the G10 economies are calculated as a weighted average of a policy rate, a long-term risk-free bond yield, a corporate credit spread, an equity price variable, and a trade-weighted exchange rate; the Euro area FCI also includes a sovereign credit spread. The weights mirror the effects of the financial variables on real GDP growth in our models over a one-year horizon. FCIs for emerging markets are calculated as a weighted average of a short-term interest rate, a long-term swap rate, a CDS spread, an equity price variable, a trade-weighted exchange rate, and—in economies with large foreign-currency-denominated debt stocks—a debt-weighted exchange rate index.

For more, see our [FCI page](#), [Global Economics Analyst: Our New G10 Financial Conditions Indices, 20 April 2017](#), and [Global Economics Analyst: Tracking EM Financial Conditions – Our New FCIs, 6 October 2017](#).

Goldman Sachs Analyst Index (GSAI)

The US GSAI is based on a monthly survey of GS equity analysts to obtain their assessments of business conditions in the industries they follow. The results provide timely "bottom-up" information about US economic activity to supplement and cross-check our analysis of "top-down" data. Based on analysts' responses, we create a diffusion index for economic activity comparable to the ISM's indexes for activity in the manufacturing and nonmanufacturing sectors.

Macro-Data Assessment Platform (MAP)

GS MAP scores facilitate rapid interpretation of new data releases for economic indicators worldwide. MAP summarizes the importance of a specific data release (i.e., its historical correlation with GDP) and the degree of surprise relative to the consensus forecast. The sign on the degree of surprise characterizes underperformance with a negative number and outperformance with a positive number. Each of these two components is ranked on a scale from 0 to 5, with the MAP score being the product of the two, i.e., from -25 to +25. For example, a MAP score of +20 (5;+4) would indicate that the data has a very high correlation to GDP (5) and that it came out well above consensus expectations (+4), for a total MAP value of +20.

Top of Mind archive



Issue 103
Inflation: here today, gone tomorrow?
November 17, 2021



Issue 87
Roaring into Recession
March 24, 2020



Issue 102
Europe at a Crossroads
October 18, 2021



Issue 86
2020's Black swan: COVID-19
February 28, 2020



Issue 101
Is China Investable?
September 13, 2021



Issue 85
Investing in Climate Change
January 30, 2020



Issue 100
The Post-Pandemic Future of Work
July 29, 2021



Special Issue
2019 Update, and a Peek at 2020
December 17, 2019



Issue 99
Bidenomics: evolution or revolution?
June 29, 2021



Issue 84
Fiscal Focus
November 26, 2019



Issue 98
Crypto: A New Asset Class?
May 21, 2021



Issue 83
Growth and Geopolitical Risk
October 10, 2019



Issue 97
Reflation Risk
April 1, 2021



Issue 82
Currency Wars
September 12, 2019



Issue 96
The Short and Long of Recent Volatility
February 25, 2021



Issue 81
Central Bank Independence
August 8, 2019



Issue 95
The IPO SPAC-tacle
January 28, 2021



Issue 80
Dissecting the Market Disconnect
July 11, 2019



Special Issue
2020 Update, and a Peek at 2021
December 17, 2020



Issue 79
Trade Wars 3.0
June 6, 2019



Issue 94
What's In Store For the Dollar
October 29, 2020



Issue 78
EU Elections: What's at Stake?
May 9, 2019



Issue 93
Beyond 2020: Post-Election Policies
October 1, 2020



Issue 77
Buyback Realities
April 11, 2019



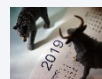
Issue 92
COVID-19: Where We Go From Here
August 13, 2020



Issue 76
The Fed's Dovish Pivot
March 5, 2019



Issue 91
Investing in Racial Economic Equality
July 16, 2020



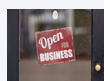
Issue 75
Where Are We in the Market Cycle?
February 4, 2019



Issue 90
Daunting Debt Dynamics
May 28, 2020



Issue 74
What's Next for China?
December 7, 2018



Issue 89
Reopening the Economy
April 28, 2020



Issue 73
Making Sense of Midterms
October 29, 2018



Issue 88
Oil's Seismic Shock
March 31, 2020



Issue 72
Recession Risk
October 16, 2018

Source of photos: www.istockphoto.com.

Disclosure Appendix

Reg AC

We, Allison Nathan, Jenny Grimberg, Gabe Lipton Galbraith, Damien Courvalin and Jeff Currie, hereby certify that all of the views expressed in this report accurately reflect our personal views, which have not been influenced by considerations of the firm's business or client relationships.

We, Brian Singer and Michele Della Vigna, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

Regulatory disclosures

Disclosures required by United States laws and regulations

See company-specific regulatory disclosures above for any of the following disclosures required as to companies referred to in this report: manager or co-manager in a pending transaction; 1% or other ownership; compensation for certain services; types of client relationships; managed/co-managed public offerings in prior periods; directorships; for equity securities, market making and/or specialist role. Goldman Sachs trades or may trade as a principal in debt securities (or in related derivatives) of issuers discussed in this report.

The following are additional required disclosures: **Ownership and material conflicts of interest:** Goldman Sachs policy prohibits its analysts, professionals reporting to analysts and members of their households from owning securities of any company in the analyst's area of coverage.

Analyst compensation: Analysts are paid in part based on the profitability of Goldman Sachs, which includes investment banking

revenues. **Analyst as officer or director:** Goldman Sachs policy generally prohibits its analysts, persons reporting to analysts or members of their households from serving as an officer, director or advisor of any company in the analyst's area of coverage. **Non-U.S. Analysts:** Non-U.S. analysts may not be associated persons of Goldman Sachs & Co. LLC and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with subject company, public appearances and trading securities held by the analysts.

Additional disclosures required under the laws and regulations of jurisdictions other than the United States

The following disclosures are those required by the jurisdiction indicated, except to the extent already made above pursuant to United States laws and regulations. **Australia:** Goldman Sachs Australia Pty Ltd and its affiliates are not authorised deposit-taking institutions (as that term is defined in the Banking Act 1959 (Cth)) in Australia and do not provide banking services, nor carry on a banking business, in Australia. This research, and any access to it, is intended only for "wholesale clients" within the meaning of the Australian Corporations Act, unless otherwise agreed by Goldman Sachs. In producing research reports, members of the Global Investment Research Division of Goldman Sachs Australia may attend site visits and other meetings hosted by the companies and other entities which are the subject of its research reports. In some instances the costs of such site visits or meetings may be met in part or in whole by the issuers concerned if Goldman Sachs Australia considers it is appropriate and reasonable in the specific circumstances relating to the site visit or meeting. To the extent that the contents of this document contains any financial product advice, it is general advice only and has been prepared by Goldman Sachs without taking into account a client's objectives, financial situation or needs. A client should, before acting on any such advice, consider the appropriateness of the advice having regard to the client's own objectives, financial situation and needs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests and a copy of Goldman Sachs' Australian Sell-Side Research Independence Policy Statement are available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Brazil:** Disclosure information in relation to CVM Resolution n. 20 is available at <https://www.gs.com/worldwide/brazil/area/gir/index.html>. Where applicable, the Brazil-registered analyst primarily responsible for the content of this research report, as defined in Article 20 of CVM Resolution n. 20, is the first author named at the beginning of this report, unless indicated otherwise at the end of the text. **Canada:** Goldman Sachs Canada Inc. is an affiliate of The Goldman Sachs Group Inc. and therefore is included in the company specific disclosures relating to Goldman Sachs (as defined above). Goldman Sachs Canada Inc. has approved of, and agreed to take responsibility for, this research report in Canada if and to the extent that Goldman Sachs Canada Inc. disseminates this research report to its clients. **Hong Kong:** Further information on the securities of covered companies referred to in this research may be obtained on request from Goldman Sachs (Asia) L.L.C. **India:** Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (India) Securities Private Limited, Research Analyst - SEBI Registration Number INH000001493, 951-A, Rational House, Appasaheb Marathe Marg, Prabhadevi, Mumbai 400 025, India, Corporate Identity Number U74140MH2006FTC160634, Phone +91 22 6616 9000, Fax +91 22 6616 9001. Goldman Sachs may beneficially own 1% or more of the securities (as such term is defined in clause 2 (h) the Indian Securities Contracts (Regulation) Act, 1956) of the subject company or companies referred to in this research report. **Japan:** See below. **Korea:** This research, and any access to it, is intended only for "professional investors" within the meaning of the Financial Services and Capital Markets Act, unless otherwise agreed by Goldman Sachs. Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (Asia) L.L.C., Seoul Branch. **New Zealand:** Goldman Sachs New Zealand Limited and its affiliates are neither "registered banks" nor "deposit takers" (as defined in the Reserve Bank of New Zealand Act 1989) in New Zealand. This research, and any access to it, is intended for "wholesale clients" (as defined in the Financial Advisers Act 2008) unless otherwise agreed by Goldman Sachs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests is available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Russia:** Research reports distributed in the Russian Federation are not advertising as defined in the Russian legislation, but are information and analysis not having product promotion as their main purpose and do not provide appraisal within the meaning of the Russian legislation on appraisal activity. Research reports do not constitute a personalized investment recommendation as defined in Russian laws and regulations, are not addressed to a specific client, and are prepared without analyzing the financial circumstances, investment profiles or risk profiles of clients. Goldman Sachs assumes no responsibility for any investment decisions that may be taken by a client or any other person based on this research report. **Singapore:** Goldman Sachs (Singapore) Pte. (Company Number: 198602165W), which is regulated by the Monetary Authority of Singapore, accepts legal responsibility for this research, and should be contacted with respect to any matters arising from, or in connection with, this research. **Taiwan:** This material is for reference only and must not be reprinted without permission. Investors should carefully consider their own investment risk. Investment results are the responsibility of the individual investor. **United Kingdom:** Persons who would be categorized as retail clients in the United Kingdom, as such term is defined in the rules of the Financial Conduct Authority, should read this research in conjunction with prior Goldman Sachs research on the covered companies referred to herein and should refer to the risk warnings that have been sent to them by Goldman Sachs International. A copy of these risks warnings, and a glossary of certain financial terms used in this report, are available from Goldman Sachs International on request.

European Union and United Kingdom: Disclosure information in relation to Article 6 (2) of the European Commission Delegated Regulation (EU) (2016/958) supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council (including as that Delegated Regulation is implemented into United Kingdom domestic law and regulation following the United Kingdom's departure from the European Union and the European Economic Area) with regard to regulatory technical standards for the technical arrangements for objective presentation of investment recommendations or other information recommending or suggesting an investment strategy and for disclosure of particular interests or indications of conflicts of interest is available at <https://www.gs.com/disclosures/europeanpolicy.html> which states the European Policy for Managing Conflicts of Interest in Connection with Investment Research.

Japan: Goldman Sachs Japan Co., Ltd. is a Financial Instrument Dealer registered with the Kanto Financial Bureau under registration number Kinsho 69, and a member of Japan Securities Dealers Association, Financial Futures Association of Japan and Type II Financial Instruments Firms Association. Sales and purchase of equities are subject to commission pre-determined with clients plus consumption tax. See company-specific disclosures as to any applicable disclosures required by Japanese stock exchanges, the Japanese Securities Dealers Association or the Japanese Securities Finance Company.

Global product; distributing entities

The Global Investment Research Division of Goldman Sachs produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Public Communication Channel Goldman Sachs Brazil: 0800 727 5764 and / or contatogoldmanbrasil@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Canal de Comunicação com o Público Goldman Sachs Brasil: 0800 727 5764 e/ou contatogoldmanbrasil@gs.com. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by either Goldman Sachs Canada Inc. or Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom.

Effective from the date of the United Kingdom's departure from the European Union and the European Economic Area ("Brexit Day") the following information with respect to distributing entities will apply:

Goldman Sachs International ("GSI"), authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA, has approved this research in connection with its distribution in the United Kingdom.

European Economic Area: GSI, authorised by the PRA and regulated by the FCA and the PRA, disseminates research in the following jurisdictions within the European Economic Area: the Grand Duchy of Luxembourg, Italy, the Kingdom of Belgium, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Finland, Portugal, the Republic of Cyprus and the Republic of Ireland; GS - Succursale de Paris (Paris branch) which, from Brexit Day, will be authorised by the French Autorité de contrôle prudentiel et de résolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de résolution and the Autorité des marchés financiers ("AMF") disseminates research in France; GSI - Sucursal en España (Madrid branch) authorized in Spain by the Comisión Nacional del Mercado de Valores disseminates research in the Kingdom of Spain; GSI - Sweden Bankfilial (Stockholm branch) is authorized by the SFSa as a "third country branch" in accordance with Chapter 4, Section 4 of the Swedish Securities and Market Act (Sw. lag (2007:528) om värdepappersmarknaden) disseminates research in the Kingdom of Sweden; Goldman Sachs Bank Europe SE ("GSBE") is a credit institution incorporated in Germany and, within the Single Supervisory Mechanism, subject to direct prudential supervision by the European Central Bank and in other respects supervised by German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and Deutsche Bundesbank and disseminates research in the Federal Republic of Germany and those jurisdictions within the European Economic Area where GSI is not authorised to disseminate research and additionally, GSBE, Copenhagen Branch filial af GSBE, Tyskland, supervised by the Danish Financial Authority disseminates research in the Kingdom of Denmark; GSBE - Sucursal en España (Madrid branch) subject (to a limited extent) to local supervision by the Bank of Spain disseminates research in the Kingdom of Spain; GSBE - Succursale Italia (Milan branch) to the relevant applicable extent, subject to local supervision by the Bank of Italy (Banca d'Italia) and the Italian Companies and Exchange Commission (Commissione Nazionale per le Società e la Borsa "Consob") disseminates research in Italy; GSBE - Succursale de Paris (Paris branch), supervised by the AMF and by the ACPR disseminates research in France; and GSBE - Sweden Bankfilial (Stockholm branch), to a limited extent, subject to local supervision by the Swedish Financial Supervisory Authority (Finansinspektionen) disseminates research in the Kingdom of Sweden.

General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by our Global Investment Research Division. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (<https://www.sipc.org>).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

We and our affiliates, officers, directors, and employees, will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research, unless otherwise prohibited by regulation or Goldman Sachs policy.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is focused on investment themes across markets, industries and sectors. It does not attempt to distinguish between the prospects or performance of, or provide analysis of, individual companies within any industry or sector we describe.

Any trading recommendation in this research relating to an equity or credit security or securities within an industry or sector is reflective of the investment theme being discussed and is not a recommendation of any such security in isolation.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors. Investors should review current options and futures disclosure documents which are available from Goldman Sachs sales representatives or at <https://www.theocc.com/about/publications/character-risks.jsp> and https://www.fiadocumentation.org/fia/regulatory-disclosures_1/fia-uniform-futures-and-options-on-futures-risk-disclosures-booklet-pdf-version-2018. Transaction costs may be significant in option strategies calling for multiple purchase and sales of options such as spreads. Supporting documentation will be supplied upon request.

Differing Levels of Service provided by Global Investment Research: The level and types of services provided to you by the Global Investment Research division of GS may vary as compared to that provided to internal and other external clients of GS, depending on various factors including your individual preferences as to the frequency and manner of receiving communication, your risk profile and investment focus and perspective (e.g., marketwide, sector specific, long term, short term), the size and scope of your overall client relationship with GS, and legal and regulatory constraints. As an example, certain clients may request to receive notifications when research on specific securities is published, and certain clients may request that specific data underlying analysts' fundamental analysis available on our internal client websites be delivered to them electronically through data feeds or otherwise. No change to an analyst's fundamental research views (e.g., ratings, price targets, or material changes to earnings estimates for equity securities), will be communicated to any client prior to inclusion of such information in a research report broadly disseminated through electronic publication to our internal client websites or through other means, as necessary, to all clients who are entitled to receive such reports.

All research reports are disseminated and available to all clients simultaneously through electronic publication to our internal client websites. Not all research content is redistributed to our clients or available to third-party aggregators, nor is Goldman Sachs responsible for the redistribution of our research by third party aggregators. For research, models or other data related to one or more securities, markets or asset classes (including related services) that may be available to you, please contact your GS representative or go to <https://research.gs.com>.

Disclosure information is also available at <https://www.gs.com/research/hedge.html> or from Research Compliance, 200 West Street, New York, NY 10282.

© 2021 Goldman Sachs.

No part of this material may be (i) copied, photocopied or duplicated in any form by any means or (ii) redistributed without the prior written consent of The Goldman Sachs Group, Inc.