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Can the Energy Transition Happen? And if Not, What Does That Mean for Asset Allocation?

A fast energy transition incurs social and political costs that will probably be deemed unacceptable. It is imperative for investors to consider the ramifications of an energy transition that exceeds a timeframe beyond 2050. The power demand of artificial intelligence (AI) in developed markets, coupled with continued growth in emerging markets limit the speed of adjustment. Moreover, any agenda of de-growth will also be unacceptable to populations in democratic societies, and is arguably not even morally justifiable. Thus, the transition will take a lot longer than investors generally anticipate. Consequently, it seems increasingly likely that temperatures will rise above the level assumed by most mainstream investors. The consequence is a significantly increased "path risk" in the overall investment environment and a greater risk of non-linear outcomes. We argue that this has profound investment implications, requiring a significantly greater level of diversification than is generally assumed. It also may require a very material reallocation into real assets, although these also come with a host of climate-related issues.

This research note is not a call to exclude certain stocks or adopt some permutation of environmental, social and governance (ESG) portfolios. Instead, it is an attempt to be realistic about the political and social limits of a rapid energy transition. This increases uncertainty for macroeconomic variables—and in a bad climate outcome implies that investors might need to prepare for higher volatility, but still requiring a given level of real return. Thus, addressing climate change requires a shift in asset allocation.

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The investment industry has got itself into a funk about environmental inputs into investing, so much so that many investors seem frightened to even talk about it. There are fundamental questions about potential conflicts that some past ESG approaches have had with fiduciary duty as well as their efficacy. We are going to leave that debate to one side in this note and focus on something that we think is more fundamental for the long-run health of end-investors' portfolios.

Our appeal to investors is to think differently about how plausible the case for a quick energy transition is. What is the real meaning of a slower transition for investment praxis? This exercise has nothing to do with deciding whether or not to exclude a given company or whether or not engaging with corporations is in the interests of investors. Instead, the debate is more fundamental—about how to protect the long-run purchasing power of investors. This debate raises difficult questions of strategic asset allocation (SAA), how to achieve diversification in the presence of much greater path risk, whether diversification is even possible and governance. It is still right for investors to be exposed to an energy transition as there is considerable scope for further capital to be deployed in this area. We also want to draw attention to the cross-asset implications of this topic.

We outline a view that it will likely be socially or politically unacceptable to engineer an energy transition within a time frame compatible with restraining temperature increases to 1.5°C to 2°C versus pre-industrial levels. Yes, there has been rapid progress in building capacity in renewable-power generation, and its price has fallen dramatically. However, it is much harder to decarbonize industrial processes and transport, progress on carbon sequestration is slow, and enforcing changes in behaviors is difficult. This challenge ultimately leads to a core debate in contemporary political philosophy. A de-growth agenda would try to tackle this by an outright reduction in growth, but this approach raises difficult moral questions, not to mention being politically impossible in democracies. Calls to reform the nature of capitalism are intellectually interesting but will take time. Impairing standards of living will not be regarded as politically, socially or morally acceptable in advanced economies, nor will preventing an improvement in standards of living for those living in extreme poverty in emerging economies. This is all happening in parallel to other forces such as deglobalization and declining size of working-age populations in developed markets and China, which plausibly raise equilibrium inflation and reduce growth rates.

We are not taking a normative approach to investment advice in this note; instead, we attempt to outline the implications of a slower energy transition on temperature and then, in turn, what they would means for macroeconomic variables of growth and inflation. The scale of uncertainties in the temperature prognosis, not to mention the impact of a given climate outcome, make this a macro force that is fundamentally different from the other contemporaneous forces of deglobalization and demographics—not least because of the risk of non-linearities. This situation leads climate to have a different role when it comes to setting forecasts and resulting asset allocation.

This point does not seem to be reflected in many industry approaches to asset allocation. The bottom line is a significant increase in path risk, and hence a much greater need for diversification. However, with government bonds unlikely to be reliable diversifiers, how is this diversification to be achieved? A key response lies in asset allocation. A deeper question is whether diversification, in the traditional meaning of the word, is even possible in the context of a "bad" outcome of climate change. This points to a need to rethink governance and regulation rather than just asset allocation. Another conclusion is that there is a greater need for real assets, but some of these might also be exposed to higher costs, such as insurance. We consider what this means for portfolios.

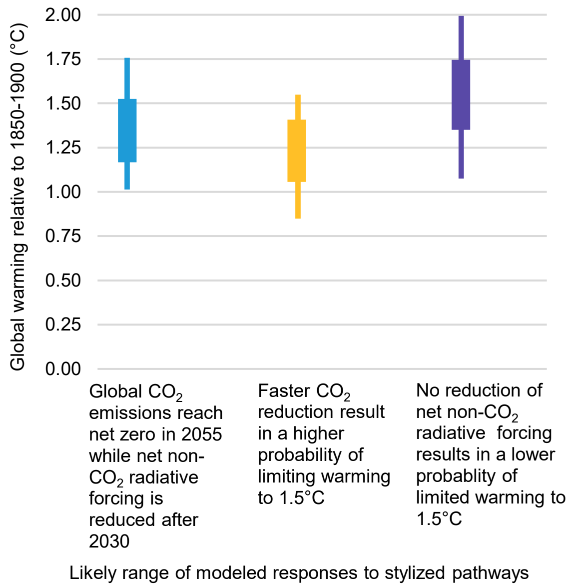
Part I: Can the energy transition happen?

Assessing the speed of decarbonization required

We start this note with the link between an energy-transition process and the likely future path of temperature. *Display 1* shows the range of likely temperature pathways associated with different levels of CO_2 emission. The error bars in these kinds of forecasts are wide, but Intergovernmental Panel on Climate Change (IPCC) numbers show the current best projection of the range in temperature given a rapid transition away from carbon, versus a future with no net reduction in carbon emissions.

The path of decarbonization needed to achieve the 1.5°C outcome is associated with this via a "strong interpretation" of the Paris agreement. This interpretation requires CO_2 emissions to fall to 45% by 2030 and reach net zero by 2050 (*Display 2*).

DISPLAY 1: OBSERVED GLOBAL TEMPERATURE CHANGE AND MODELED RESPONSES TO STYLIZED ANTHROPOGENIC EMISSION AND FORCING PATHWAYS

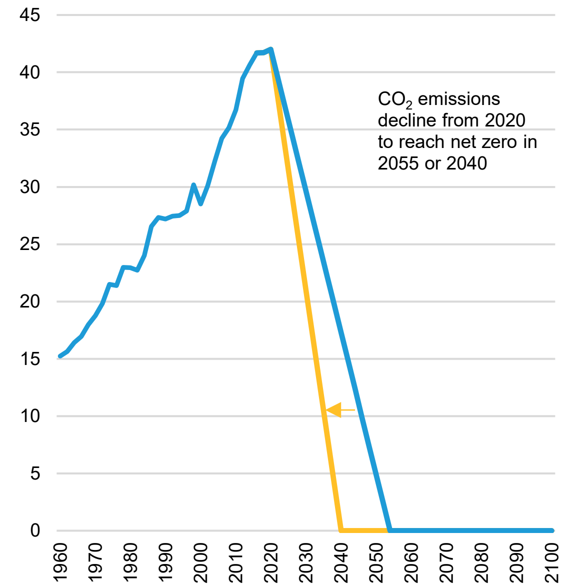


Historical analysis does not guarantee future results.

Through May 24, 2022

Source: IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24, doi: 10.1017/9781009157940.001 and AB

DISPLAY 2: STYLIZED NET GLOBAL CO2 EMISSION PATHWAYS
BILLION TONNES CO2 PER YEAR (GTCO$_2$ / YR)



Historical analysis does not guarantee future results.

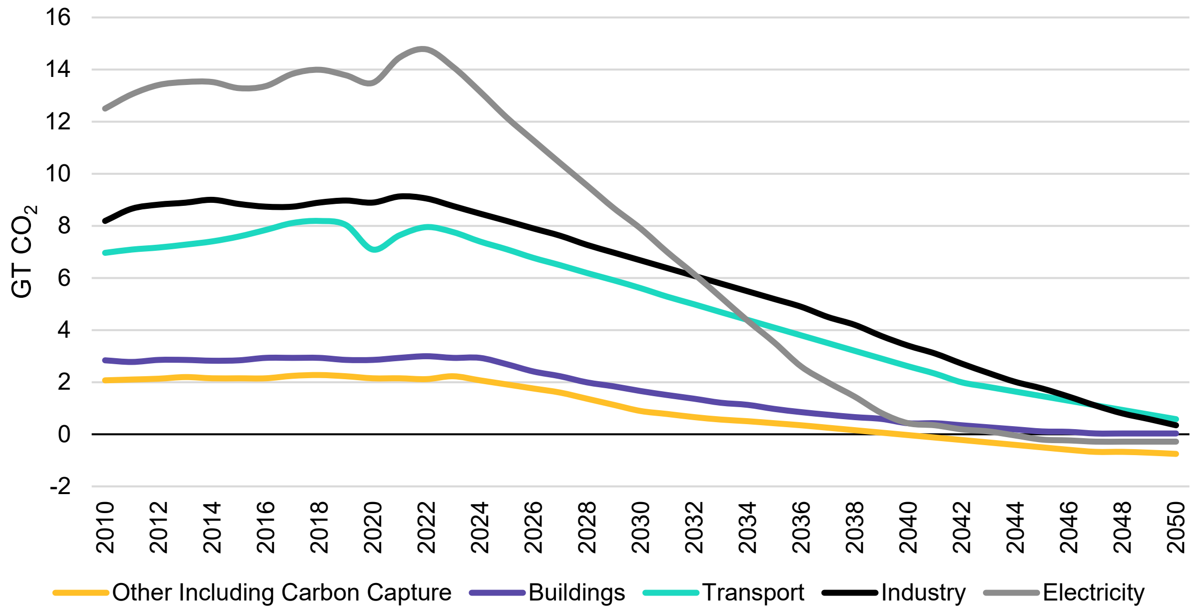
As of May 24, 2022

Source: Source: IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24, doi: 10.1017/9781009157940.001 and AB

How could this strong interpretation of the Paris Agreement be achieved? It essentially assumes some combination of decarbonization of electricity, decarbonization of non-electrical primary energy, efficiency/mitigation and carbon capture. *Display 3* shows one such commonly used breakdown that assumes:

1. A very rapid decarbonization of electricity
2. Decarbonization of other primary sources of power for industry and transport, such as via electrification
3. Other emission reduction efforts, eg greener buildings and change in consumption habits
4. Carbon sequestration

DISPLAY 3: CHANGE IN EMMISIONS BY SOURCE REQUIRED TO MEET NET ZERO BY 2050



Current analysis and forecasts do not guarantee future results.

Other includes atmospheric CO2 removals through direct air capture and storage as well as bioenergy with carbon capture and storage.

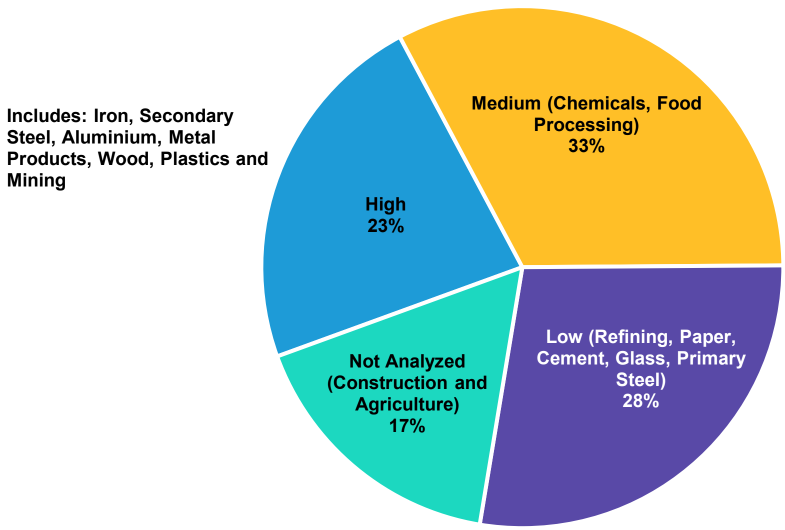
As of September 23, 2023

Source: "Net Zero Roadmap – A Global Pathway to Keep the 1.5°C Goal in Reach, 2023 Update", International Energy Agency and AB

Why progress on decarbonization is hard

Some of these aspects are progressing faster than others. The growth of decarbonized electricity generation has been rapid, though the development of grid infrastructure is slow. When other sources of primary emissions that are not primarily electrified are included, the stats are much less encouraging. Areas that stand out as particularly hard to decarbonize are cement (around 8% of global CO_2 emissions) and shipping (3% of global CO_2 emissions). *Display 4* shows energy use in the US broken down by how easy it is to electrify—its electrification potential. Moreover, global coal use is still not declining, with China and India the two largest users (*Display 5*).

DISPLAY 4: US INDUSTRIAL ENERGY USE BY ELECTRIFICATION POTENTIAL



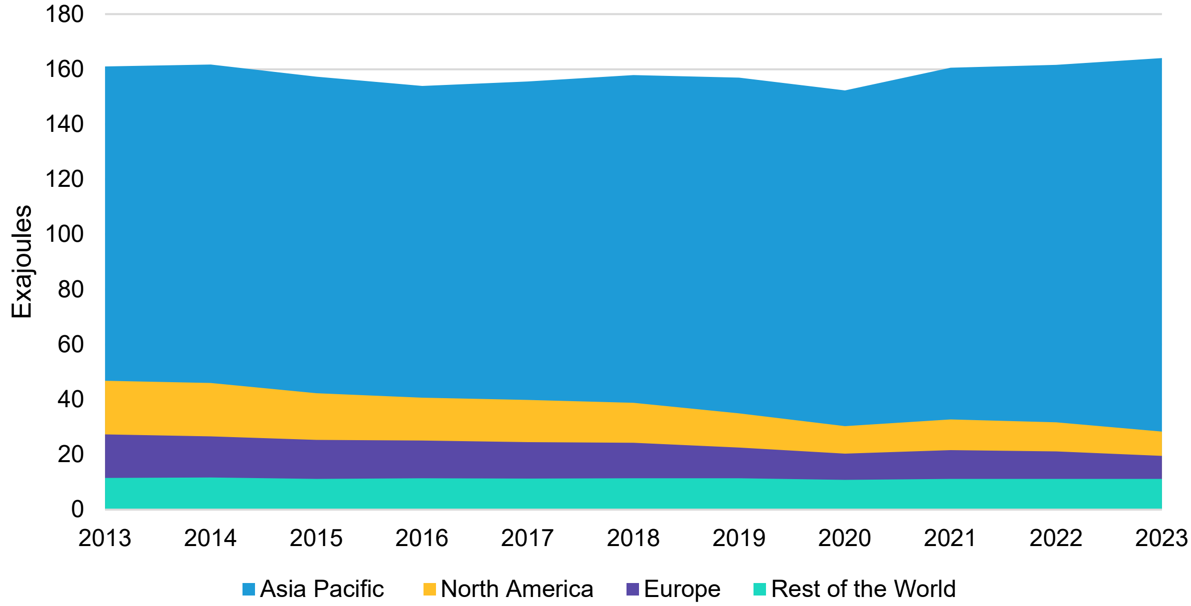
Current analysis and forecasts do not guarantee future results.

Classifying sectors by their potential ease of electrification. Areas correspond to proportion of US energy use.

As of March 26, 2018

Source: Jeff Deason, Max Wei, Greg Leventis, Sara Smith and Lisa Schwartz. Electrification of buildings and industry in the United States: Drivers, barriers, prospects, and policy approaches. Lawrence Berkeley National Laboratory, March 2018 and AB

DISPLAY 5: COAL USE HASN'T YET STARTED TO DECLINE, WITH CHINA AND INDIA THE LARGEST TWO COUNTRY USERS



Current analysis and forecasts do not guarantee future results.

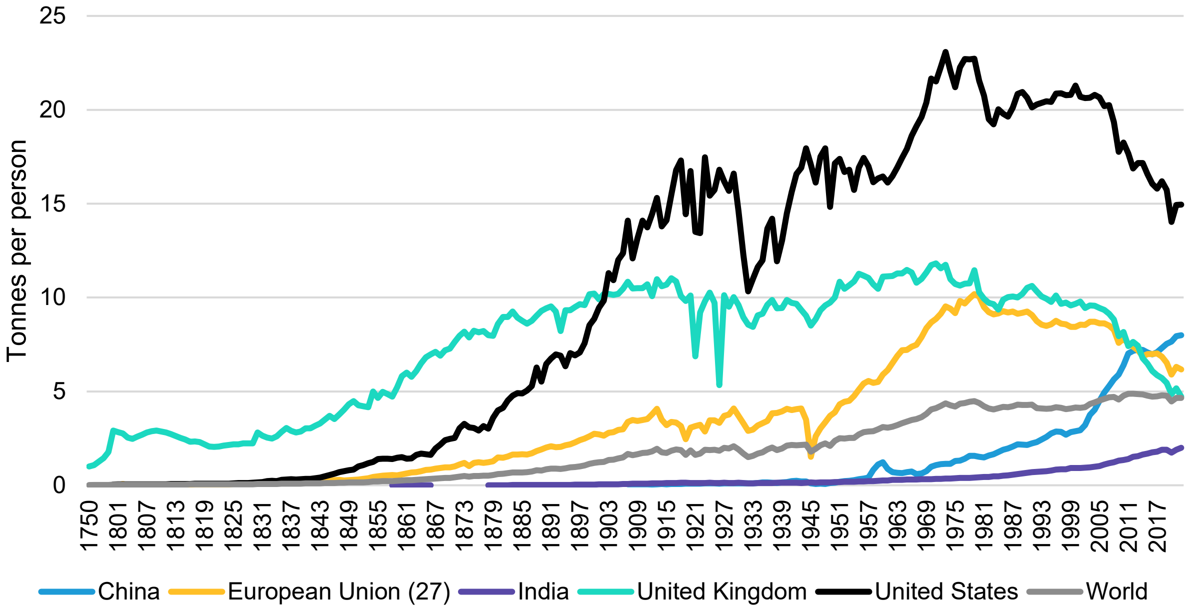
As of June 20, 2024

Source: https://www.energyinst.org/statistical-review and https://www.visualcapitalist.com/rise-in-global-coal-consumption-by-region-1965-2023/ and AB

Another key element for projections of how to reach net zero is a change in behaviors—the change in sources of heat in domestic settings, for example. Using Germany as an example, the country's government has had to backtrack on a proposed plan for an aggressive transition to heat pumps, because the required extra cost to each household ended up making the effort politically impossible

In *Display 6,* we show that global per-capita CO_2 emissions (the grey line) are not yet declining, mainly because of the speed of increasing emissions in China and India and, despite recent drops, the very high level of CO_2 emission per capita in the US. Advanced economies have seen some declines in energy emissions per capita. However, the fact that these declines started in the 1970s and 1980s point to globalization and de-industrialization in those economies as a likely factor, rather than decarbonization per se. In other words, the carbon emissions were, in part, exported.

DISPLAY 6: PER-CAPITA CO_2 EMISSIONS



Current analysis and forecasts do not guarantee future results.

Carbon dioxide (CO_2) emission from food fuels and industry. land use charge is not included.

As of June 20, 2024

Source: Global Carbon Budget (2023); Population based on various sources (2023) – with major processing by Our World in Data (https://ourworldindata.org/grapher/co-emissions-per-capita) and AB

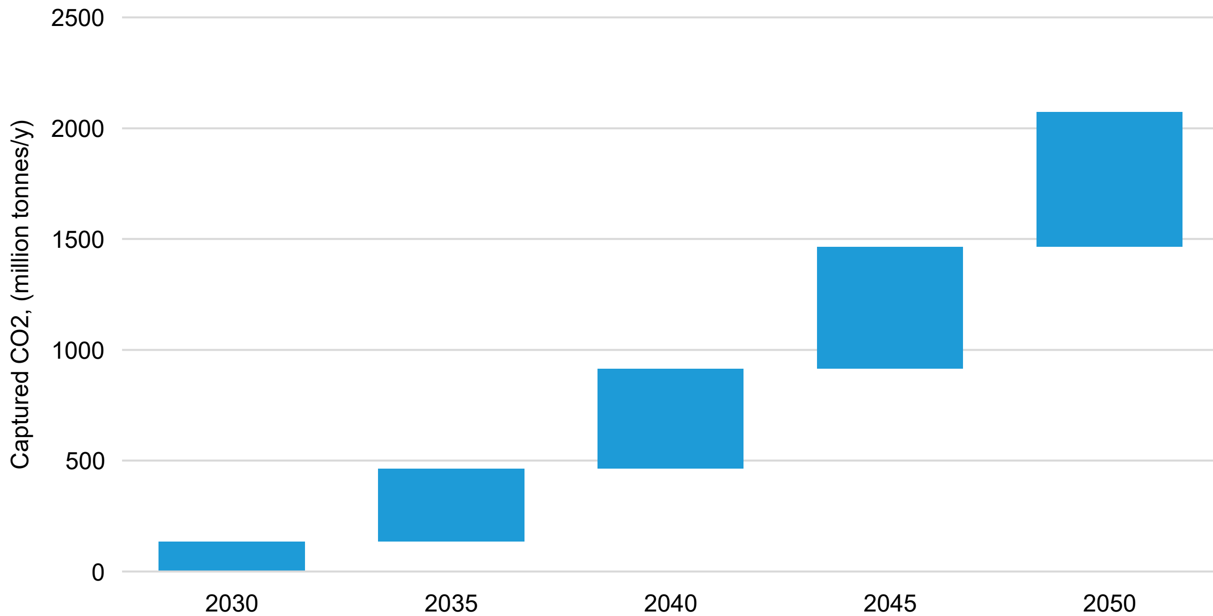
Carbon sequestration could face a shortfall

The last leg of plans to decarbonize involve carbon capture and sequestration. It is unclear at this stage whether the required capacity for capture and sequestration is indeed possible. There could be serious limits to the ability to invest capital, build capacity and even the viability of available technology. The scale of the required amount depends on the assumed level of CO_2 emissions that would be allowed to continue. Most assumptions for achieving net zero by 2050 assume that carbon capture occurs at scale by 2030, followed by rapid growth. Some specific forecasts on this front assume a need for 1.7Gt of CO_2 capture globally by 2035[1] and 250–600 Mt CO_2 for the US by 2035 [2]. Achieving this goal would require considerable capital and a buildout of physical infrastructure. For example, it would require 19,000km of new pipeline by 2030 (and 100,000km by 2050) to transport carbon (*Display 7*). At that stage, the volume of CO_2 flow in the US would have to be 1.3x current US oil production. This requirement would have to be met by a process that does not exist on any meaningfully large scale today.

[1] "Net Zero Roadmap – A Global Pathway to Keep the 1.5°C Goal in Reach, 2023 Update", International Energy Agency

[2] https://netzeroamerica.princeton.edu/the-report

DISPLAY 7: IS THE ENERGY TRANSITION ACHIEVABLE? SEQUESTRATION CARBON CAPTURE REQUIRED TO MEET NET ZERO BY 2050. RANGE OF CARBON CAPTURE REQUIRED (US)



Current analysis and forecasts do not guarantee future results.

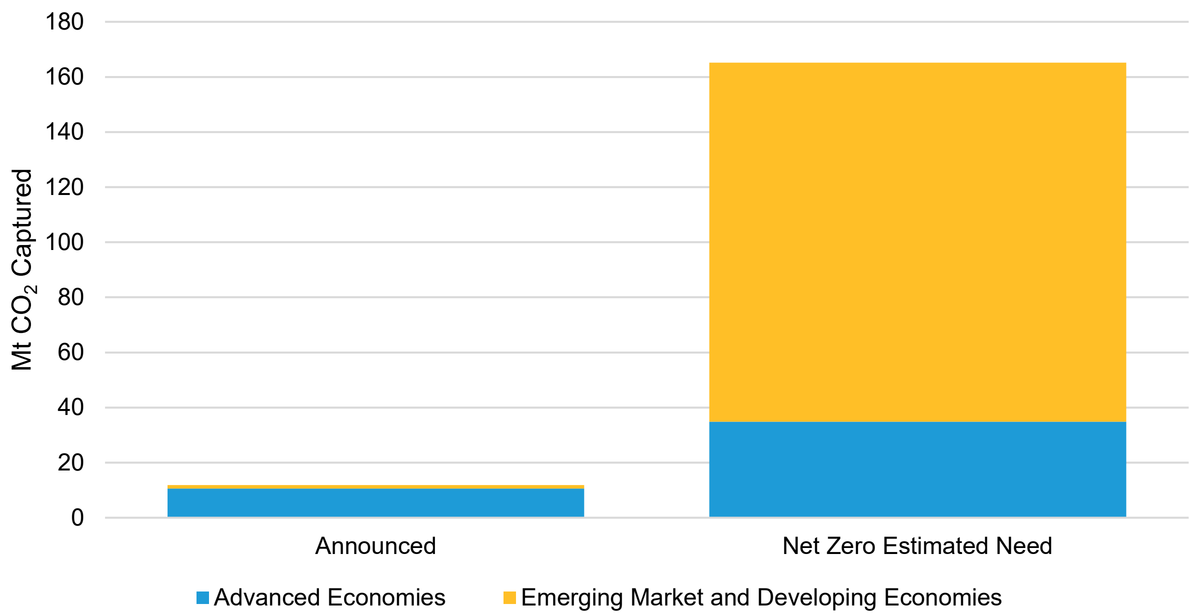
Carbon capture has to begin at significant scale by 2030 followed by rapid growth. Lower bound assumes aggressive end-use electrification, but energy-supply options are relatively unconstrained for minimizing total energy-system cost to meet the goal of net-zero emissions in 2050. Upper bound also assumes aggressive end-use electrification; on the supply-side, wind and solar rate of increase is constrained to 35 GW/y (~30% greater than historical maximum single-year record). More CO_2 storage is allowed to enable the option of more fossil fuel use.

As of October 29, 2021

Source: Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Princeton University, October 29, 2021 and AB

Adding up the current announced projects for carbon capture and comparing this to the amount required for achieving net zero by 2050 shows a jarring gap (*Display 8*).

DISPLAY 8: IS THE ENERGY TRANSITION ACHIEVABLE? ANNOUNCED CARBON SEQUESTRATION VS. NZE SCENARIO REQUIREMENTS



Current analysis and forecasts do not guarantee future results.

As of September 23, 2023

Source: Net Zero Roadmap – A Global Pathway to Keep the 1.5°C Goal in Reach, 2023 Update, International Energy Agency and AB

Alongside this, a major avenue for sequestering carbon is via the world's forests. There are wide error bars around assessments of the degree to which forests can be a carbon sink, but it is worth laying out the numbers so that they can be put into scale alongside other emissions and possible sequestration routes.

Johnston et al (2019) show that global forests were a net carbon source of approximately 3.6 $GtCO_2$/year in 1992, ie deforesting activity released carbon. The authors suggest that forests could become a net carbon sink of 1.5 $GtCO_2$ by 2030. However, this assumes that net deforestation ends at that point. They go on to suggest that forests could become a potential sink of 6.8 $GtCO_2$/year by 2065, assuming that forests have expanded to an area greater than their 2010 total by 2050.

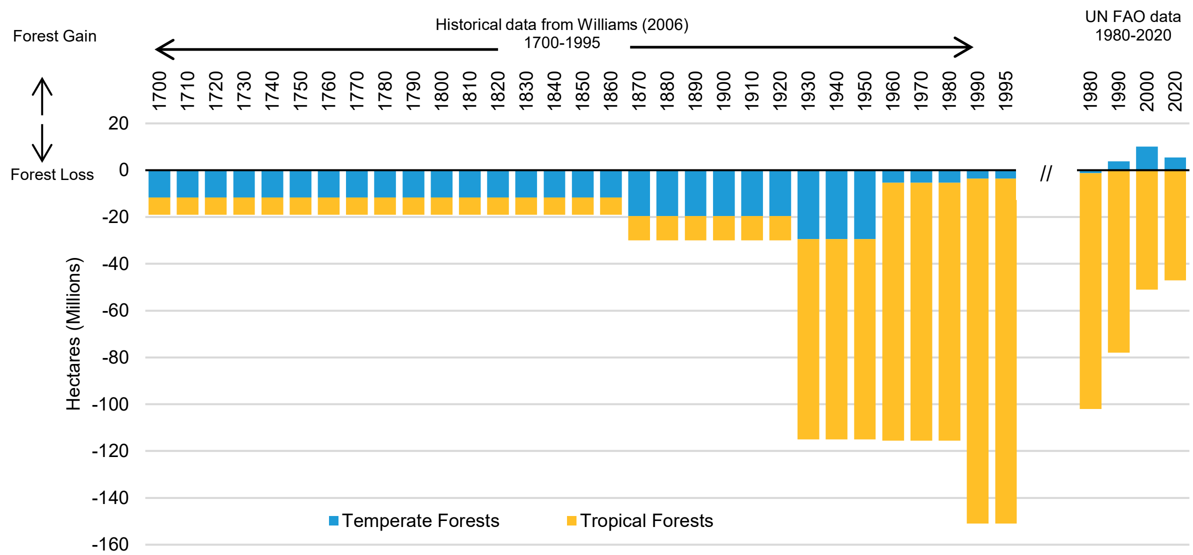
Is the world on track to achieve this outcome? The answer seems to be "not even close." In *Display 9*, we show that deforestation reached its peak in the 1980s and 1990s; since then, the rate of forest loss each year has declined. However, since 2001, there has still been a net loss of 12% of tree cover and the current reforestation efforts continue to be dwarfed by deforestation. There would have to be an enormous level of political energy, both in emerging and developed markets, to achieve a net balance of forestation this decade. It is not clear that this is politically possible.

Moreover, in parallel to anthropogenic deforestation, the rate of forest loss due to fire has increased—presumably due in part to global warming itself. In 2023, fires accounted for 42% of tree loss (*Display 10*). A recognition that the hoped-for role of forests in sequestering carbon will, at the very least, be delayed is starting to be recognized in forecasts. For example, we note that the latest iteration of Network for Greening the Financial System scenarios has reduced the assumed net-carbon sequestration by 2$GtCO_2$ pa by 2050 from its previous assumption.[3]

[3] Network for Greening the Financial System (NGFS) ngfs_climate_scenarios_for_central_banks_and_supervisors_phase_iv.pdf, 2023

The bottom line is that forests could be a potential net sink of carbon within the next decade, but that would require a huge level of political will that does not seem present today. Therefore, it seems that we should not assume that forests can act as a net carbon sink for this coming decade.

DISPLAY 9: REFORESTATION ATTEMPTS ARE STILL A DROP IN THE OCEAN COMPARED WITH CONTINUED TREE LOSS



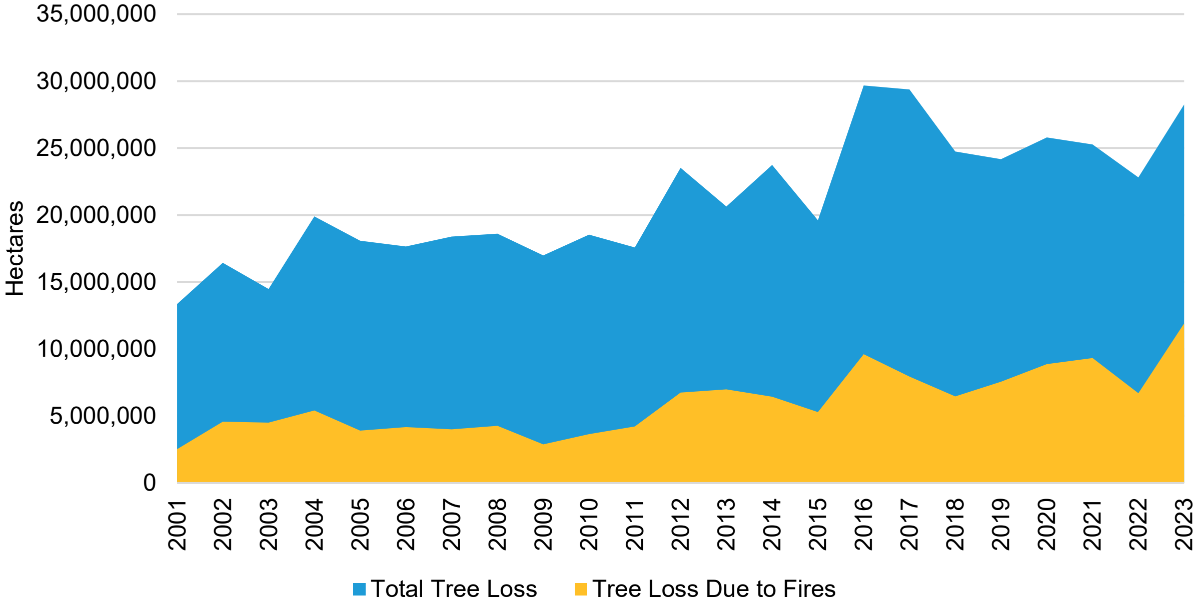
Current analysis and forecasts do not guarantee future results.

As of May 2024

Pre-1995 data from Williams (2006). Deforesting the Earth. Second series is based on data from UN FAO Global Forest Resources Assessments

Source: Hannah Ritchie (2021) - "Deforestation and Forest Loss" Published online at OurWorldinData.org. Retrieved from: https://ourworldindata.org/deforestation and AB

DISPLAY 10: TREE LOSS DUE TO FOREST FIRES HAS BEEN INCREASING, NOW ACCOUNTING FOR 42% OF ALL TREE LOSS



Current analysis and forecasts do not guarantee future results.

As of December 31, 2023

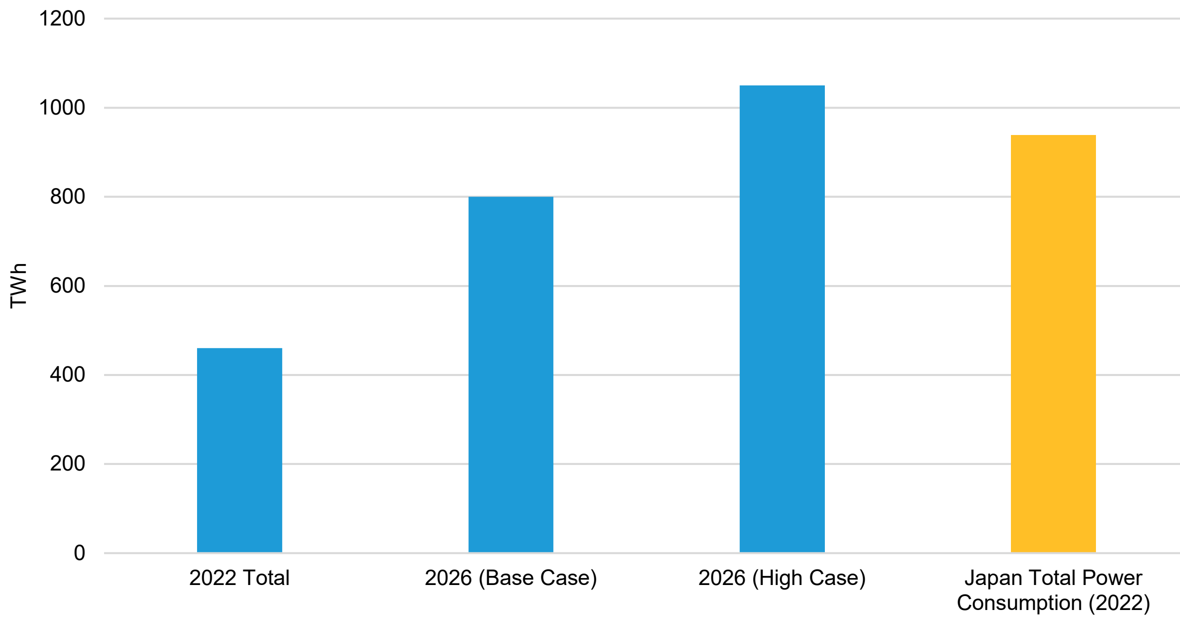
Source: www,globalforestwatch.org and AllianceBernstein (AB)

Artificial Intelligence (AI) and growing energy needs

The likely path of CO_2 emissions could be even further from the required path to limit temperatures than the data discussed above suggest. Most approaches to the energy transition have accepted that energy demand for emerging markets will continue to grow strongly if standards of living are to rise, while they might disagree on whether energy demand in developed markets is set to plateau or fall. However, there is an assumption in much of the work on decarbonization that the growth in developed market energy demand might at least slow.

What if it actually accelerates instead? The onset of AI looks set to cause a material increase in power demand, this could lead to a shift in the possible trajectories for emissions. The International Energy Agency recently added up the power consumption of existing data centers and crypto mining as well as likely demand for new AI data centers (*Display 11*). The agency concluded that total power demand for data centers could reach more than 1,000 TWh by 2026. To put this in context, this level exceeds Japan's power consumption of 939 TWh, a staggering number. Adding power demand at the same scale of a G3 economy hardly seems consistent with curtailing energy demand.

DISPLAY 11: AI ELECTRICITY DEMAND: GLOBAL ELECTRICITY DEMAND FROM DATA CENTERS, AI AND CRYPTOCURRENCIES



Current analysis and forecasts do not guarantee future results.

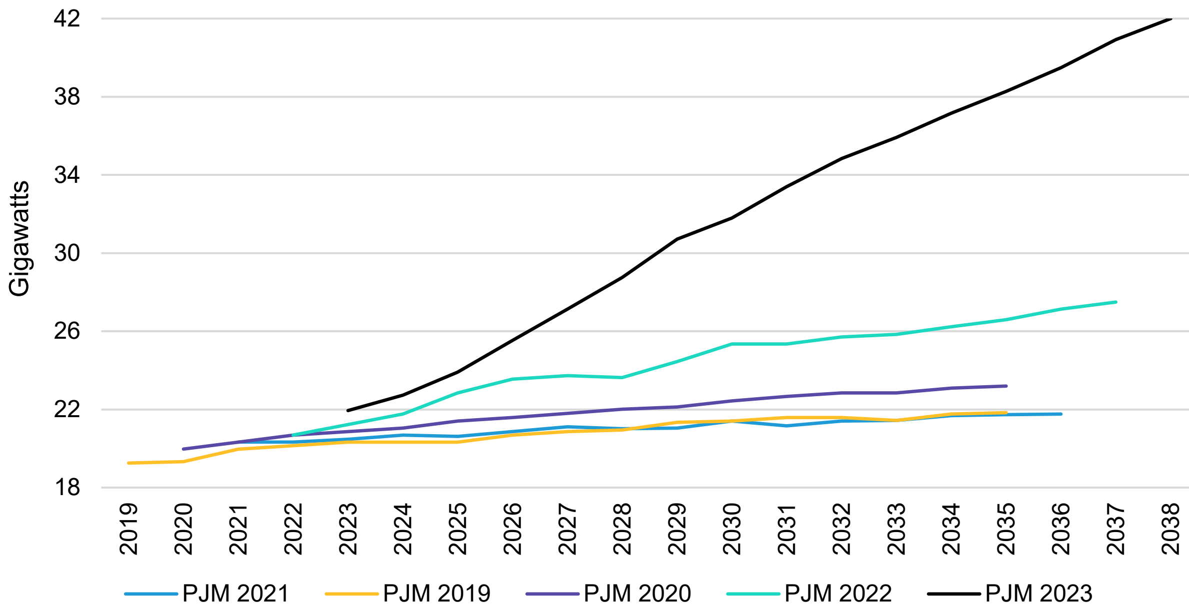
Forecast is based on IEA (2024), Electricity 2024, IEA, Paris https://www.iea.org/reports/electricity-2024, Licence: CC BY 4.0

As of May 9, 2024

Source: Enerdate, IEA and AB

Dramatic macro forecasts such as this are also being borne out on a bottom-up basis by demand projections for individual power distributors. For example, PJM, a regional power transmission organization in the US that operates in 14 eastern states, regularly produces forecasts of power demand for the next decade. In 2020, PJM projected regional demand in 2030 of 22GW (*Display 12*). By 2023, that 2030 forecast had been revised up to 32 GW, an increase of more than 45%. The vast majority of this increase came from data center power demand. It should be noted that this is a region that has a higher penetration of data center development than usual, so one should not extrapolate this for the whole country. Nevertheless, it is a tangible, “bottom up” example of increased power demand.

DISPLAY 12: DATA CENTERS HAVE SIGNIFICANTLY INCREASED EXPECTED POWER DEMAND: PROGRESSION OF PJM POWER-DEMAND FORECASTS FOR DOMINION RESOURCES



Current analysis and forecasts do not guarantee future results.

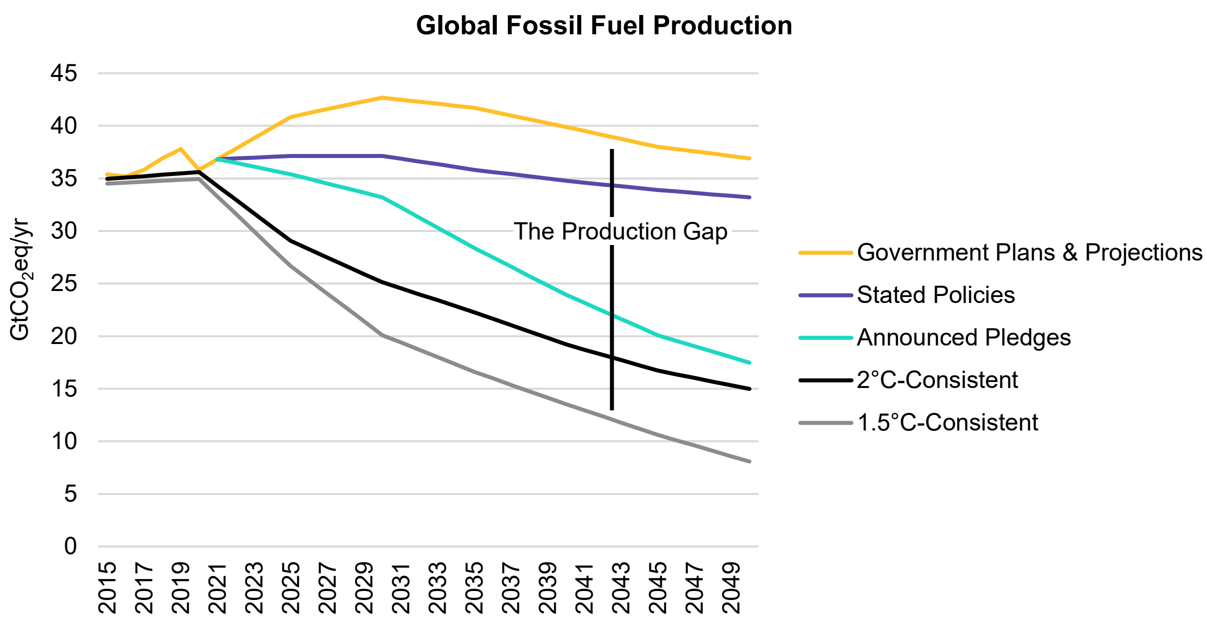
As of January 28, 2024

Source: PJM 2023, Power Demand Outlook, January 28, 2024 and AB

Social constraints on reducing net emissions and what they mean for political philosophy

Bringing this section together, there is profound political and social difficulty in trying to achieve an energy transition. That challenge is reflected in a significant gap between the path of CO_2 emissions that seem likely based on current stated policies and those that are consistent with a 1.5°C or 2°C temperature increase outcome. *Display 13* below shows an estimate of the size of this gap from the United Nations.

DISPLAY 13: CURRENT GOVERNMENT PLANS ARE VERY FAR FROM THE LEVEL IMPLIED BY 1.5 OR 2°C OUTCOMES



Current analysis and forecasts do not guarantee future results.

As of November 8, 2023

Source: SEI, Climate Analytics, E3G, IISD, and UNEP. (2023). The Production Gap: Phasing down or phasing up? Top fossil fuel producers plan even more extraction despite climate promises. Stockholm Environment Institute, Climate Analytics, E3G, International Institute for Sustainable Development and United Nations Environment Programme https://doi.org/10.51414/sei2023.050 and AB

At this point in such narratives, an earlier generation of ESG-inspired research tended to digress into a normative discussion of what needs to be done. Here, we take a humbler approach which is also a more positive one (in the sense of a contradistinction to normative). The key allocation question is: As the required transition path to limit global warming to 1.5°C looks more and more like a fiction, how should investors adapt?

Forcing through an energy transition would be hard enough, anyway—growing demand from data centers in developed economies and rising standards of living in emerging economies already made that a tall order. The problem is that other forces are playing out in parallel:

- A decrease in the working-age population of many developed economies and China implies that, other things equal, growth rates will fall.
- A tipping of the balance from globalization to deglobalization implies inflationary forces and possibly a further constraint on growth.
- Government indebtedness: There is a high degree of fiscal largesse in the US that is set to continue in the near term, but for G7 countries *en masse*, the last 40 years have seen a backdrop of growing government debt. There is no hard theoretical limit to the debt burden, but it brings uncertainty to the ability to continually provide a fiscal backstop.
- A period of relative peace is transitioning to one that features both ongoing “hot” wars and an emerging cold war between the US and China.

All these forces imply higher inflation and/or lower real growth as well as constraints on the growth of standards of living. There are possible positive forces, but we don’t think they can be relied upon for forecasting. For example, AI could boost aggregate productivity, but it’s not clear that it has ever been possible to forecast changes in productivity, not to mention the possible negative implications of AI. Our assumption is that for AI to achieve enough productivity growth to offset these downward forces on growth, it would have to increase aggregate productivity by an amount equal to the historical maximum trough-to-peak change in productivity. That is not something that we would be willing to assume as our base case[4].

From a blunt economic perspective, increased immigration into advanced economies could generate growth and defuse inflationary pressures, but that path is politically toxic. The bottom line is that, in democracies, it seems hard to imagine a set of circumstances that would allow an energy transition to take place within the timeframe required for a 1.5°C or even 2°C temperature increase.

This challenge is reflected in growing evidence that, faced with constraints on standards of living, governments are in fact slowing instead of hastening such commitments. There are numerous examples of countries finding it too hard politically to adhere to such targets; they have relaxed the targets instead. For example, in 2023, the previous UK administration under Sunak pushed back the date for banning the sale of new petrol or diesel cars from 2030 to 2035.[5] Earlier in 2024, the Scottish government abandoned a targeted 75% reduction in carbon emissions by 2030. Admittedly, Scotland is a small economy in the global context, but this example is notable because the administration had previously made energy transition a core differentiating aim.[6]

In Germany, the law to replace fossil-fuel-powered heating systems with more efficient alternatives powered by renewable energy had to be watered down after widespread opposition. Germany also argued for a loophole in the European Union (EU) law that would allow the sale of combustion engine cars beyond the 2035 deadline if they run on synthetic fuels. The reason was fear of the impact of employment in the auto sector, combined with the parallel shock of no longer being able to rely on strong exports to China in a deglobalized world. These countries are already small in terms of total emissions, in part as they are already fairly energy efficient, and their commitments to the Paris Agreement have not wavered, but it is the specific enactment of this in regulation that has proved difficult.

The deployment of renewable energy sources is also progressing very slowly in some Eastern European countries such as The Czech Republic, Poland, Hungary and Bulgaria, and is significantly below the EU average. Meanwhile, despite the pledges of US president Joe Biden's administration to take on climate change, US oil and natural gas production levels hit an all-time high in 2024.

Given the scale of the adjustment needed—specifically the difficulty in electrifying industry and transport and the slow development of carbon sequestration—some have called for a more radical agenda. The "de-growth" proposal of Hickel[7] amounts to a manifesto holding that the only way to avoid a profoundly negative impact on the climate and the planet in general is to actually de-grow: to set negative targets for growth rates in gross domestic product (GDP). Aside from the proponents asserting that this is the only way to avoid an unacceptable rise in temperature, they also present it as a way to avoid broader anthropogenic impact on the planet, such as via biodiversity. This issue is even harder to model and beset by both irreversible processes and potential nonlinearities, thus it is a more difficult process to determine its impact on society, and macroeconomic variables. Hickel claims that the energy transition itself requires massive mineral extraction, so a shift to clean energy is not sufficient. He concludes that politicians are not really to blame; capitalism itself is at fault.

In a similar vein, Jonathan Crary delivers an incredibly bleak account of the impact of capitalism on nature in *Scorched Earth*.[8] He echoes Hickel in the view that renewable energy misses the point and that the only way forward is to reduce usage. The conclusion: advanced economies must drastically reduce energy use. For Crary, this point is inseparable from a broader point about how the intertwined relationship of the internet's evolution and contemporary capitalism has remolded social and interpersonal relations. His contention is that if there is to be a future, it has to be offline and with a very different kind of capitalism.

There has been strong criticism of the de-growth view. Indeed, the strongest form of rejection holds that it is not just an issue of de-growth being a tough sell to an electorate, but also that the de-growth agenda is not morally acceptable. Morality is at stake

[4] Productivity, Democracy, Power and Truth: The Influence of AI on Markets and Investing

[5] https://www.bbc.co.uk/news/live/uk-66863110

[6] https://www.politico.eu/article/scottish-government-abandons-flagship-climate-goal-mari-mcallan-says/

[7] Hickel (2020) : Less is More: How de-growth will save the world, Penguin

[8] Crary (2022) Scorched Earth: Beyond the digital age to a post-capitalist world, Verso

because de-growth requires imposing a decline in global standards of living.[9] In practice, de-growth would mean slashing the standard of living in advanced economies and denying an increase in the standard of living to people living in extreme poverty. The other moral strand here is the observation that it is the very poorest people globally who are set to lose the most by unabated climate change and thus paths to de-carbonizing the economy via an energy transition rather than de-growth try to (or should try to) address this.

Aside from the moral dilemma, there is a more practical aspect—in democratic systems, it is not possible to introduce a policy that requires votes to accept a lower standard of living. Techno-determinists have asserted that they can provide an answer here. In their view, de-growth is not necessary to achieve an outcome in which standards of living can continue to rise, gross carbon emissions could remain high and net zero could still be achieved. This path would require huge investment in carbon sequestration, not to mention technical advances. As we discussed earlier, it is not at all obvious either from a scientific or an infrastructure perspective that such an outcome is achievable.

The debate about the nature of capitalism and the morality, or otherwise de-growth, might seem to be overly philosophical for some. However, the reason for bringing it up is that, just as outright de-growth is arguably not compatible with democracy, the evidence is mounting that a rapid energy transition is not compatible either. If the benefits of globalization, unprecedented financialization and modest productivity improvements over the last 30 years had been shared more broadly, it may have been possible to sell such an agenda to voters. But that ship has sailed.

And yet, we see elements of this low-demand and low-growth narrative being used in financial literature. To take one example, the latest NGFS scenario[10] proclaims that "limiting the temperature increase to 1.5°C above pre-industrial levels in an orderly fashion is within reach." But then, as one of the possible routes to this goal, the NGFS cites that "the new low demand scenario shows that it will require even greater ambition in the future, with significant reduction in energy demand and changes in consumption patterns."

To be completely clear, de-growth is definitively not the only way to achieve an energy transition. As we discussed earlier in this note, some combination of de-carbonizing, change of behaviors and carbon sequestration can achieve that, and presumably is ultimately the way forward, albeit over an extended time frame. We just think that any assumption of net lower energy demand is very hard to achieve.

There are, however, planetary boundaries. If the target of more growth (or, more specifically, growth in the real standard of living) is too hard to change, then maybe it is the nature and structure of capitalism that should be the target instead? The more radical manifestos from the contemporary left call for a rejection of capitalism; the whole capitalist edifice is seen as inevitably injurious to the planet. There are, however, a number of alternative suggestions that very much work within the current capitalist system and are alive to the moral and electoral constraints of permanent negative economic growth.

Susskind has suggested[11] that, given planetary constraints, policymakers should not fixate on the quantum of growth; instead, they should more openly discuss the trade-offs and distribution of who benefits. For most of humanity, growth measured by GDP has, along with increased longevity, been one of the huge positive forces of recent decades, and policymakers would reject any idea of wanting less growth. The GDP metric has been useful in helping focus stakeholders on a drive for prosperity, but it does have shortcomings, and its impact on the climate is an important one. Susskind points out that, while many today take it as a metric of almost God-given authority, GDP is in fact a relatively new metric anyway, having been invented in the 1940s. The author makes the case for reconsidering the definition of growth, including which components are included in the calculation of GDP. The conclusion is that we cannot abandon growth but can redirect the pursuit of it.

There have been other attempts to rebalance notions of growth and its broader impact at an aggregate level. For example, Pope Francis comes at this from a necessarily very different angle in his Encyclical on Climate Change and Inequality.[12] He makes the

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9 See, for example, Wolf (2024) The Crisis of Democratic Capitalism, Penguin London

10 https://www.ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_for_central_banks_and_supervisors_phase_iv.pdf

11 Susskind (2024), Growth: A Reckoning

12 Francis (2015): Encyclical on Climate Change and Inequality, Laudato si', Melville House

case that profit is only ethical if the full social cost is considered. The encyclical takes the position that any impact on the climate is inseparable from the concept of inequality and, hence, a new concept of progress is needed.

Our assumption is that politicians have not done nearly enough to educate populations about the expenditure trade-offs required now versus the benefits to come far in the future. Part of the problem is the scale of uncertainties about climate forecasts and the impact these uncertainties may or may not have on standards of living. They pose a substantial problem for people making doom prophecies about the climate. What makes this even harder is that other forces unrelated to the energy transition also challenge the rate of real growth: shrinking working-age populations, deglobalization and already-high public debt. One has to add to this the blunt observation that median real standards of living in developed economies have stagnated despite a long run of high aggregate growth and despite (or maybe because of) the financialization of recent decades. Taken together, these imply limited openness to any near-term imperilment of standards of living. We show later in this note that a delayed energy transition probably leads to ultimately worse outcomes for the median standard of living, but that point is not likely enough to change behavior now.

We conclude Part I of this note by considering what all this means for the likely path of temperature, and then we tackle how to think about the implications for macroeconomic variables and ultimately asset allocation.

What prognosis does delayed decarbonization imply for temperature and climate?

Given the discussion above, and the IPCC's attempt to link carbon emissions with temperature that we outlined at the beginning of this note, it seems more likely than not that temperatures will rise by more than 2°C. For example, Lawson[13] surveys a broad range of assumed climate outcomes from the IPCC, IEA and NGFS, outlining a case that the transition to a lower-carbon global economy is highly likely to continue, but that the world is unlikely to converge on a Paris-aligned trajectory. The conclusion in the work of Lawson is that the probability-weighted mean scenario points to a 2.3°C warming by 2100 (*Display 14*).

DISPLAY 14: CHANGE IN BEHAVIOR AND CONSUMPTION REQUIRED FOR GIVEN TEMPERATURE OUTCOMES

	Mean Expected Outcome (Lawson et al 2023)	Baseline Assumed by Market	Required for Paris-Aligned Outcome	If Current Policies Continue
Temperature change 2100, compared to pre-industrial levels	2.3°C	2.7	1.8	3.2
Share of non-fossil power generation in 2050	82%	59%	97%	79%
Coal demand (annual growth 2020-2050)	-2.65%	-1.95%	-5.85%	0.82%
Oil demand (annual growth 2020-2050)	-0.97%	-0.08%	-2.03%	-0.98%
Gas demand (annual growth 2020-2050)	0.52%	1.98%	-1.43%	0.77%
Electricity demand (annual growth 2020-2050)	2.66%	2.38%	3%	2%
EV share of new vehicle sales in 2050	86%	80%	96%	73%

Paris outcome requires much more aggressive cuts

Current analysis and forecasts do not guarantee future results.

As of February 28, 2023

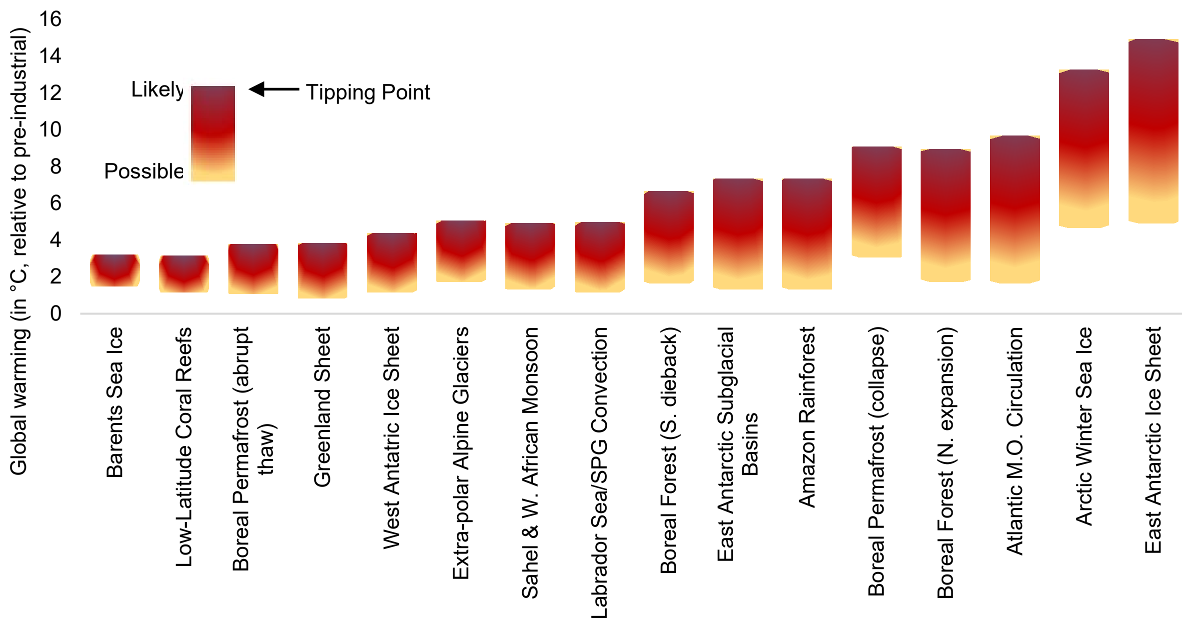
Source: Lawson, J, A Moss, A Popa, E Cairns and C Mackenzie (2023), 'DP17944 A Bespoke, probabilistic approach to climate scenario analysis', CEPR Discussion Paper No. 17944. CEPR Press, Paris & London. https://cepr.org/publications/dp17944 and AB

[13] Lawson, J, A Moss, A Popa, E Cairns and C Mackenzie (2023), 'DP17944 A Bespoke, probabilistic approach to climate scenario analysis', CEPR Discussion Paper No. 17944. CEPR Press, Paris & London. https://cepr.org/publications/dp17944

One specific aspect of the temperature forecast that is relevant when we consider the distribution of future outcomes for macro variables is the risk of nonlinear outcomes. It is hard enough to attempt to link climate to macroeconomic outcomes; it would be even harder if the process is likely to be highly nonlinear.

The problem is that as temperature rises, the risk of passing key tipping points increases. In *Display 15*, we show data from the Institute of Actuaries[14] on the risk of various tipping points and how they increase with temperature. The implication is that passing the point of a 2°C increase in temperature could make several of these tipping points much more likely: for example, a thaw in Boreal Permafrost (the risk of methane emissions) and the Greenland ice sheet (higher sea level). When it comes to the economics of all this, the nonlinear nature of these outcomes significantly increases the uncertainties about potential future paths.

DISPLAY 15: RISK OF TIPPING POINTS AND NONLINEAR OUTCOMES RISES WITH TEMPERATURE



Current analysis and forecasts do not guarantee future results.

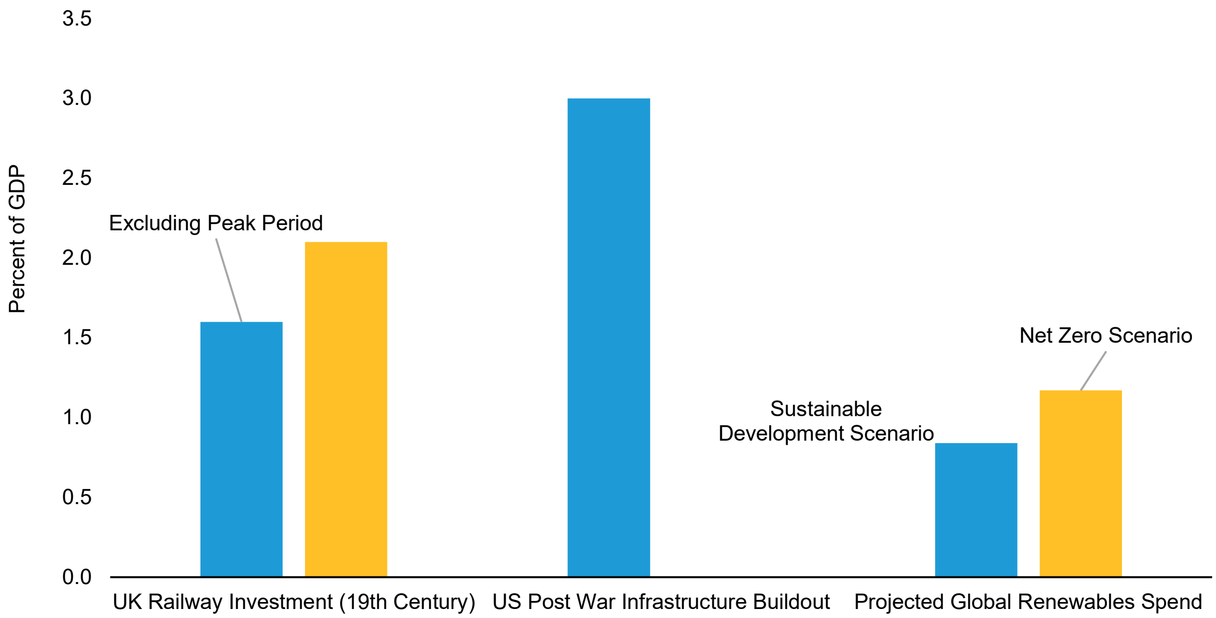
As of July 4, 2023

Source: McKay et al, Exceeding 1.5OC global warming could trigger multiple climate tipping points, 2022, Trust et al (2023): The Emperor's New Climate Scenarios, Institute and Faculty of Actuaries the-emperor-s-new-climate-scenarios.pdf (actuaries.org.uk) and AB

We do not wish to be entirely depressing about the prospects, so we point out a potential expansion in the scale of capital devoted to the technology and infrastructure needs of the energy transition. In *Display 16*, we compare the amount of spending required for global renewables to prior large waves of infrastructure spending—the UK investment in railways in the mid-nineteenth century and the US buildout of the interstate highway network in the 1950s. Those prior episodes consumed a much higher share of GDP, suggesting that the allocation of capital could grow significantly from current numbers.

[14] Trust et al (2023): The Emperor's New Climate Scenarios, Institute and Faculty of Actuaries the-emperor-s-new-climate-scenarios.pdf (actuaries.org.uk)

DISPLAY 16: PROJECTED SPENDING ON ENERGY TRANSISTION IS STILL LESS THAN NINETEENTH-CENTURY SPENDING ON RAILWAYS AND POST-WWII INFRASTRUCTURE



Current analysis and forecasts do not guarantee future results.

As of April 24, 2024

Source: IEA, World Bank and AB

Part II: What does exceeding a 2°C temperature rise mean for growth and the economy?

So our working assumption is that the planet sails through a 2°C increase in temperature. What does it mean if we apply this assumption to the macroeconomic variables that are the basis for forming investment views?

The majority of pension plans assume a minimal impact of climate on GDP. Can this be right? Is it a sign of complacency? It has been suggested that this apparent lack of impact might be because finance papers tend to be peer-reviewed by economists rather than climate scientists. We will discuss this in more detail later in the report.

Our view is that any net impact of climate on growth and inflation needs to be put into context alongside other forces unfolding at the same time. In particular, we point to demographic changes (much more certain than climate forecasts), the likelihood that deglobalization as a force is here to stay and the role of AI. We have already seen that AI usage implies a significant increase in power demand, though it also might raise productivity. That's what the techno-determinists hope for, anyway.

We divide the impact of climate on macro variables into direct and indirect. The latter are often ignored, but could be larger.

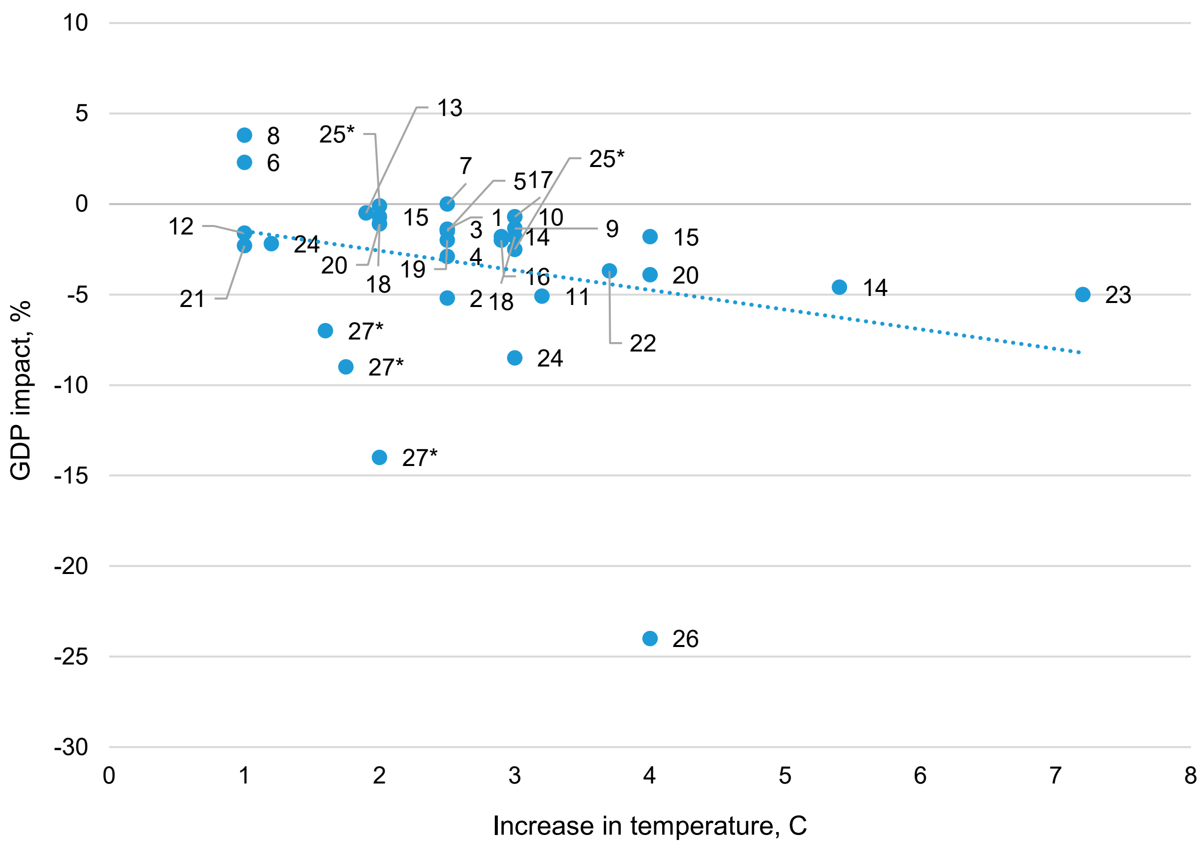
While there are huge error bars around the future path of average temperatures, the error bars around the impact of a given temperature on economic growth are even larger. Thus, one is piling uncertainties upon uncertainties. When we discuss the consequences of all this for asset allocation, we distinguish between the various mega forces defining the investment environment. For example, demographics, while slow, is (more or less) predictable and linear versus climate, which is highly uncertain and nonlinear.

In *Display 17*, we summarize the range of possible impacts on GDP growth for a range of possible temperatures across some of the most cited academic papers that have attempted to quantify this link. This illustration shows the range of possible temperatures assumed in such analysis and how different methodologies have arrived at a disparate range of estimated growth rates. Part of the reason for the range of assumed impacts is that some studies focus on temperature alone, some assess the impact on a broader range of routes for impact (such as precipitation), and others include indirect effects.

The key point to note about this work is the range and what it implies for needed diversification. One conclusion would be that exceeding a 2°C temperature increase and reaching, say, a 2.2°C increase would imply that global GDP would decline by 2.8%. Assuming that this temperature rise occurs by 2050, the implied decrease in global GDP is 0.11% annualized. We note that the NGFS forecasts (average of Current Policies and Delayed Transition scenarios) imply a worse outcome, with a 1.9°C increase in temperature that implies a 0.44% decrease in annualized GDP by 2050.

We have included a line of best fit in this chart. It is not intended to indicate a trend for the progression of growth if temperature rises; instead, it is intended simply as a way to find the least mean squares average across a broad range of modeled outcomes.

DISPLAY 17: UNCERTAINTIES UPON UNCERTAINTIES: 27 ACADEMIC STUDIES OF THE IMPACT OF CLIMATE CHANGE ON GDP GROWTH



Current analysis and forecasts do not guarantee future results.

1: Fankhauser (1995) 2: Schauer (1995) 3: Nordhaus and Yang (1996) 4: Plambeck and Hope (1996) 5: Nordhaus and Boyer (2000) 6: Tol (2002) 7: Maddison (2003) 8: Horowitz (2009) 9: Eboli et al. (2010) 10: Hope (2011) 11: Maddison and Rehdanz (2011) 12: Ng and Zhao (2011) 13: Bosello et al. (2012) 14: Roson and van der Mensbrugghe (2012) 14: Roson and van der Mensbrugghe (2012) 15: McCallum et al. (2013) 15: McCallum et al. (2013) 16: Nordhaus (2013) 17: Sartori and Roson (2016) 18: Kompas et al. (2018) 18: Kompas et al. (2018) 19: Dellink et al. (2019) 20: Takakura et al. (2019) 20: Takakura et al. (2019) 21: Kalkuhl and Wenz (2020) 22: Conte et al. (2021) 23: Cruz and Rossi-Hansberg (2021) 24: Howard and Sylvan (2021) 24: Howard and Sylvan (2021) 25*: Kahn et al. (2021)* 25*: Kahn et al. (2021)* 26: Burke et al. (2015) 27*: NGFS (2023)* 27*: NGFS (2023)* 27*: NGFS (2023)*

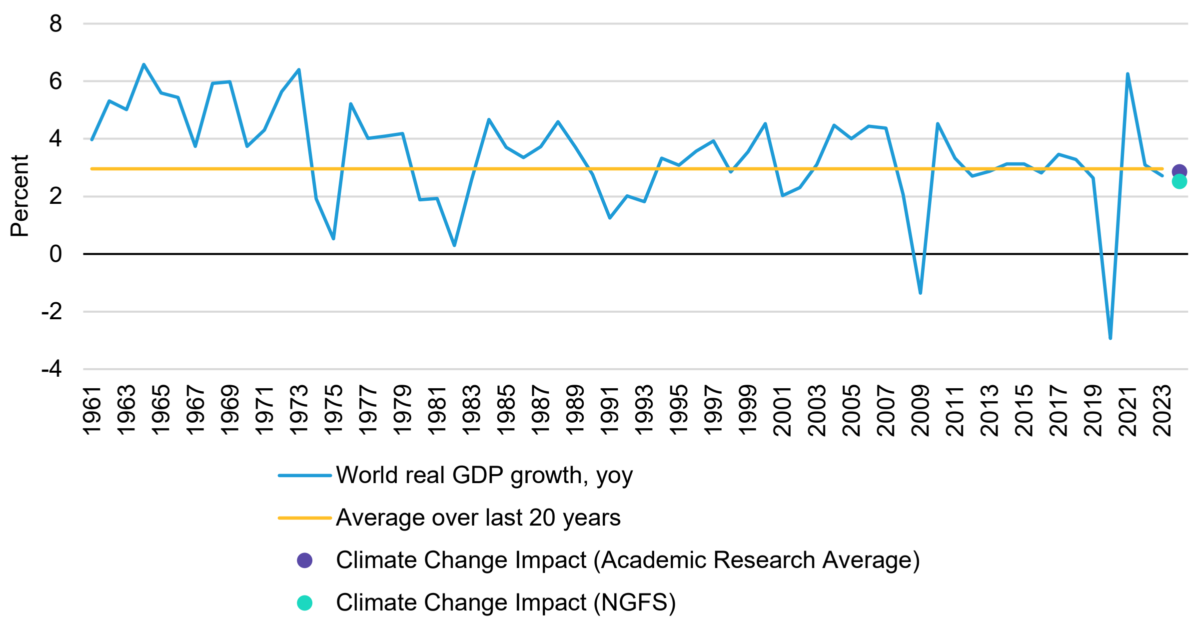
Note: The chart shows a summary of academic research conclusions estimating the impact of temperature change by year 2100. or similar. on Global GDP. Asterisk denotes the studies where scenarios consider the impact by year 2050. GDP impact is cumulative change.

As of November 2023

Source: As referenced above and AB

Display 18 puts the impact of the best-fit estimate, from the academic studies above, and the NGFS scenario impact into the context of global GDP growth. The dots reflect the estimated impact to average global GDP growth over the last 20 years. We provide more context on the impact to annual growth in the following section that discusses the impact on equity returns. We stress however, that this growth impact is not happening in isolation, so when we consider its impact on SAA, other factors come into play that depress growth and are, on balance, inflationary.

DISPLAY 18: RANGE OF GDP ESTIMATES IN PERSPECTIVE



Current analysis and forecasts do not guarantee future results.

Note: The research average climate change estimate is a summary of academic research conclusions estimating the impact of temperature change by year 2100 or similar on global GDP. It is adapted from Tol (2022) with extra estimates added from Kahn et al. (2021), Burke et al. (2015) and NGFS (2023). For multiple publications by the same author, we selected estimates only from the latest listed publication. For the GDP impact estimate we assume the forecast temperature change of 2.2°C occurs by 2050. The NGFS scenario is based on NGFS Scenarios for central banks and supervisors November 2023 presentation available at: https://www.ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_for_central_banks_and_supervisors_phase_iv.pdf. It is an average of Delayed Transition and Current Policies scenarios.

Source: NGFS, Thomson Reuters Datastream and AB

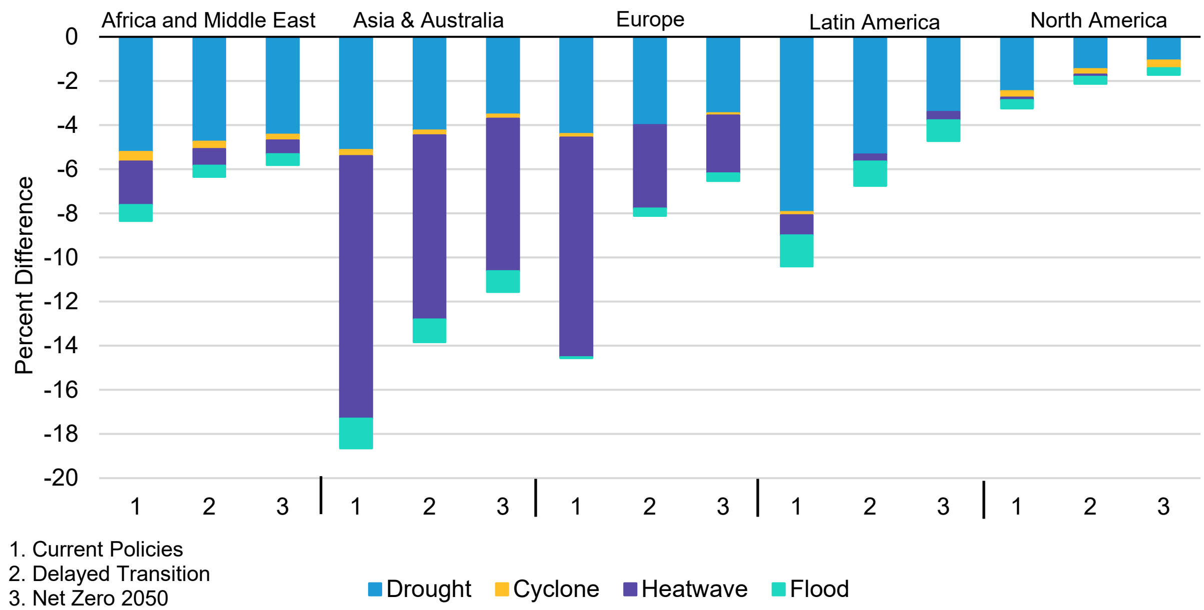
A common finding from academic studies is that the impact of climate change on economic growth is highly heterogeneous. The NGFS scenarios imply that North America will be relatively less affected, Asia and Australia face the most deleterious impact, and Europe falls in between (*Display 20*). The NGFS "delayed transition" scenario still assumes that the temperature increase is kept below 2°C, hence seemingly on the benign side of our central expectation. It suggests that the total cumulative hit to North American GDP is 3%, to Europe is 8% and to Asia and Australia 14.5% by 2050. Having said that, a smaller average impact on GDP for North America should not be conflated with little impact, because the potential impact on insurance costs are high, for example.

In a similar vein, the International Monetary Fund 2017 paper on this[15] studies the contemporaneous effect of temperature on growth, finding that advanced economies face, on average, a negligible contemporaneous impact from a temperature rise on

[15] IMF.2017. World Economic Outlook, October 2017, Seeking Sustainable Growth. Washington, DC: International Monetary Fund.

activity. However, for the median emerging economy, a 1°C increase in temperature depresses growth in that year by 0.9 percentage points, with the effect becoming stronger for hotter countries.

DISPLAY 19: REGIONAL ACUTE GDP IMPACT BY HAZARD AND SCENARIO (REGIONAL AVERAGES)



Current analysis and forecasts do not guarantee future results.

All values are differences from baseline (a hypothetical scenario with no transition nor physical risk). Simple averages across those countries available for a given region. Latin America is composed of Chile, Mexico, and Argentina, except for Floods, only available for Mexico. North America includes US and Canada, but only US for floods. Africa includes Egypt and South Africa (only South Africa for floods).

As of November 2023

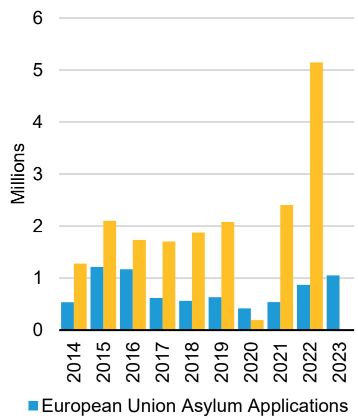
Source: NGFS (NGFS Climate Scenarios for central banks and supervisors phase _ iv.pdf) and AB

Indirect impact of climate change: migration pressures are only just beginning

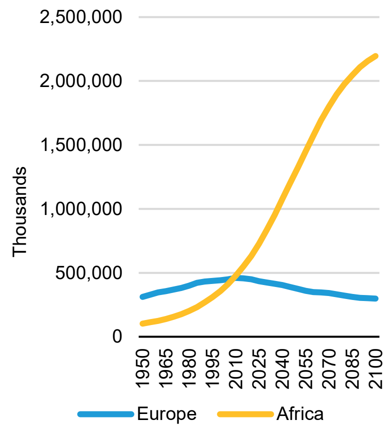
It is one thing to try and estimate the impact of climate change on economic activity but quite another to try to model the indirect effects on political systems across multiple election cycles. It is hardly possible to make such a forecast. However, we raise this as an issue because we think the indirect effects of a temperature increase greater than 2°C could, if anything, be larger than the direct effect. There are many possible indirect channels, such as geopolitical clashes over natural resources, but we highlight migration here because it is possible to make some quantitative statements about it.

The case rests on the juxtaposition of projected increases in temperature and projected population growth. Worse growth outcomes in hotter countries and faster population imply that migration pressure will remain. As examples, we think there will be increased pressure for migration from Latin America to the US and from Africa to Europe. While immigration from Latin America to the US is currently an issue of intense political debate, the total population of the US is expected to continue growing slightly, while Latin America's is expected to begin declining by 2050. The imbalance between the US and Latin America would then begin to narrow. However, when comparing Europe to Africa, the outlook is stark and diverging. The bottom line is that migration is set to remain a political issue far into the future.

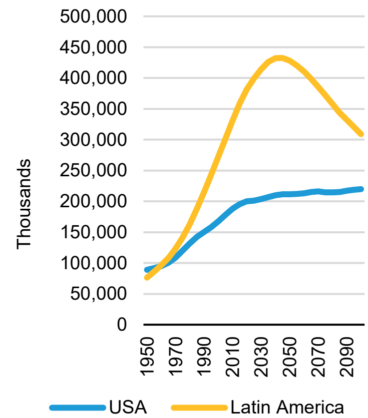
DISPLAY 20: EUROPEAN UNION ASYLUM APPLICATIONS AND IMMIGRANTS FROM NON-EU COUNTRIES



DISPLAY 21: UN POPULATION FORECASTS—EU VS SUB-SAHARAN AFRICA



DISPLAY 22: UN POPULATION FORECASTS—US VS LATIN AMERICA



Current analysis does not guarantee future results.

In addition to migration, there is a secondary labor market impact: the OECD finds that the central-transition scenario job destruction is largest for "blue collar and farm workers." https://one.oecd.org/document/ENV/EPOC/WPIEEP(2016)18/FINAL/En/pdf

As of March 10, 2023

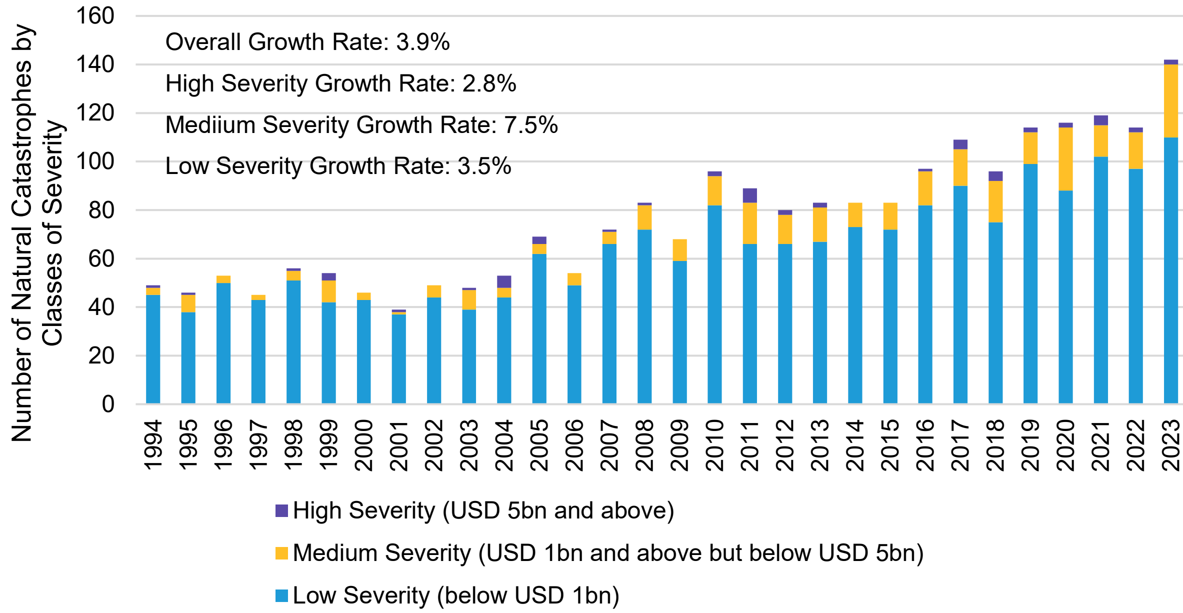
Source: UN and AB

Extreme weather on the rise

A specific route for a more detrimental version of climate change to impact the real economy and portfolios is more extreme weather. There are two aspects of particular interest: the impact of more extreme weather on insurance costs (relevant if the allocation advice from the broader narrative is to own more real assets) and its impact on inflation more generally, for example via the impact on supply chains, food and energy prices.

Evidence suggests that severe storms have become more frequent. For example, according to the Swiss Re institute, the total number of natural catastrophes has increased by 3.9% annualized since 1994. In particular, the frequency of mid-sized storms that cause damage of $1–5Bn (in constant dollars) has increased by 7.5% annualized since 1994 (*Display 23*).

DISPLAY 23: NUMBER OF NATURAL CATASTROPHES BY CLASS OF SEVERITY, 1994-2023



Current analysis and forecasts do not guarantee future results.

As of February 22, 2024

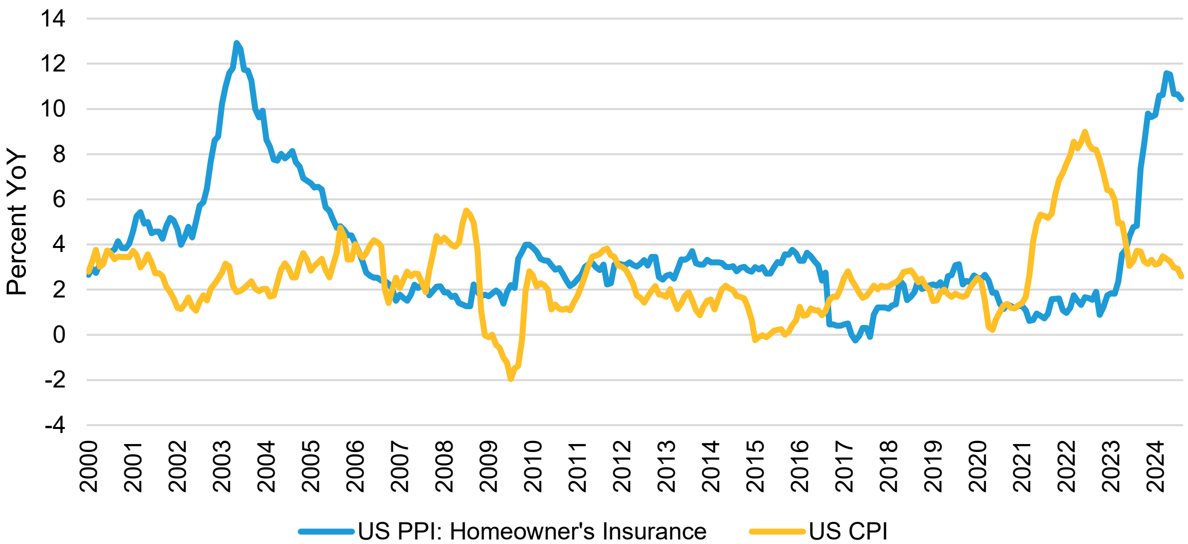
Source: https://www.swissre.com/dam/jcr:c9385357-6b86-486a-9ad8-78679037c10e/2024-03-sigma1-natural-catastrophes.pdf and AB

Overall, the number of billion-dollar disaster events in the US (on a constant dollar basis) has increased from an average run rate below 4 in the 1980s to over 16 each year during the 2020s (with 28 events in 2023).[16] This trend is already having a knock-on effect on insurance costs (*Display 24*). As an example, home-insurance premium inflation has risen significantly in recent years and shows no sign of abating, even as broader inflation has declined. No such display is the full picture, because in some cases assets may become uninsurable or terms may be rewritten so that extra insurance is needed (for example, the need for separate flood insurance). A recent study by Deloitte forecasted that commercial-building insurance costs are projected to double by 2030 in the most high-risk areas.[17]

[16] Swiss Re Institute. 2024-03-sigma1-natural-catastrophes.pdf (swissre.com)

[17] https://www2.deloitte.com/us/en/insights/industry/financial-services/financial-services-industry-predictions/2024/impact-of-climate-change-on-commercial-real-estate-insurance-costs.html

DISPLAY 24: US PRODUCER PRICE INDEX HOMEOWNERS-INSURANCE COMPONENT AND US CONSUMER PRICE INDEX



Current analysis and forecasts do not guarantee future results.

As of August 15, 2024

Source: Thompson Reuters Datastream and AB

Aggregating this at the economy-wide level, insurance costs have the potential to grow significantly as a share of GDP. Numbers for the EU suggest the potential for this to double by 2050 (*Display 25*). Note that these numbers are for impact of severe weather, and so differ from the aggregate impact of climate change discussed earlier in the note.

When it comes to asset allocation, this impact is significant. If the forces investors face imply an elevated level and volatility of inflation, then one implication is a need to hold more real assets. For the subset of real assets that are physical, this implies an extra level of insurance costs that eats into returns and possibly introduces common shocks.

DISPLAY 25: EXPECTED FUTURE ANNUAL DAMAGES FROM CLIMATE-RELATED CATASTROPHES AS A SHARE OF GDP WITHOUT ADAPTATION AND MITIGATION MEASURES

		2050			2100	
EU and UK (2015 Values)	**Baseline (1981-2010)**	1.5°C Moderate	2°C Severe	1.5°C	2°C Moderate	3°C Severe
Total (Windstorms, Droughts, River and Coastal Flood)	0.17%	0.21%	0.29%	0.19%	0.41%	0.76%

Current analysis and forecasts do not guarantee future results.

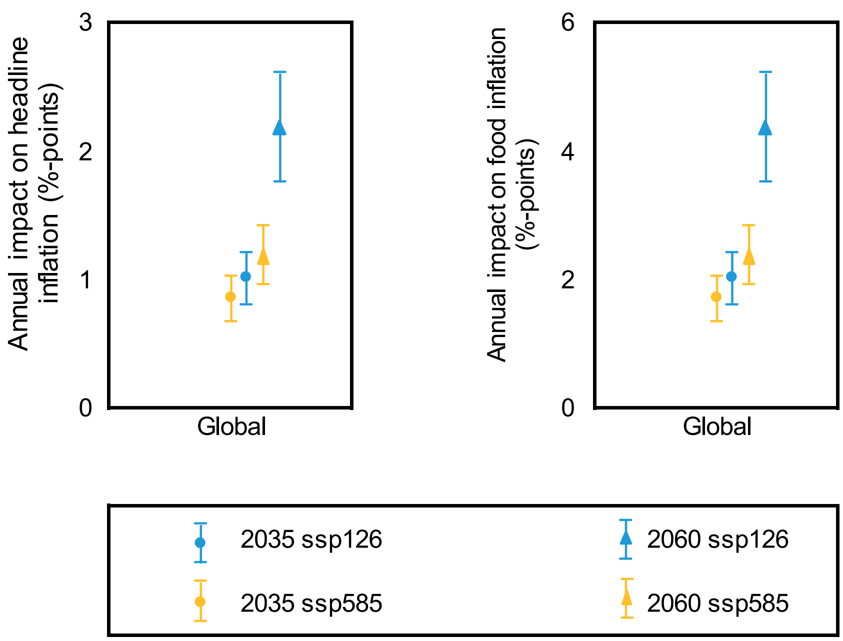
The GDP impact numbers refer to a percentage point per annum impact by the year 2050 and 2100.

As of July 2021

Source: Fache Rousová, L., Giuzio, M., Kapadia, S., Kumar H., Mazzotta, L., Parker, M., Zafeiris, D., (2021), "Climate Change, Catastrophes and the Macroeconomic Benefits of Insurance" BIS Working Paper No. 394, EIOPA Financial Stability Report and AB

There is a body of academic work on the link between climate change and inflation. For example, Kotz et al (2023) show that future warming is estimated to cause, on average, persistent increases in food inflation of 1.49±0.45 or 1.79±0.54 percentage-points per-year (p.p.p.y.), respectively, in an optimistic or pessimistic emission scenario. Impacts on headline inflation follow similar patterns and are approximately half as large, 0.76±0.23 or 0.91±0.28 p.p.p.y. under a best- or worst-case emission scenario (*Display 26*). In this case, persistent refers to changes in 30-year average equilibrium inflation.

DISPLAY 26: IMPACT OF CLIMATE CHANGE ON INFLATION



Current analysis and forecasts do not guarantee future results.

The annual impacts on inflation aggregated across world regions (population weighted), at different time periods (30-year averages centered on the point in question) and under both a low (SSP126) and high (SSP585) emission scenario for headline (a) and food (b) price aggregates. Point estimates show the average, and error bars the standard deviation, of impacts from the warming projected across the ensemble of 21 CMIP-6 climate models, in the absence of historically unprecedented adaptation.

SSP refers to Shared Socioeconomic Pathway scenarios. They are based on five narratives describing broad socioeconomic trends and are intended to incorporate a range of plausible future scenarios. SSP1 refers to a sustainability focused growth and equality scenario. SSP2 is a "middle of the road" scenario where trends are in line with historical patterns. SSP3 is a fragmented world and resurgent nationalism scenario. SSP4 is a world of ever increasing inequality and SSP5 is a world of rapid and unconstrained growth in economic output and energy use scenario. In addition these baseline SSP scenarios include different mitigation and adaptation targets which are expressed by the level of radiative forcings with different outcomes of 1.9, 2.6, 3.4, 6 and 8.5 watts per square meter. Thus a scenario SSP585 for example refers to the world of rapid and unconstrained growth with minimal mitigation efforts that results in additional radiative forcing of 8.5 watts per square meter.

As of May 24, 2023

Source: Kotz et al (2023) The Impact of Global Warming on Inflation: Averages, Seasonality and Extremes ECB Working Paper No. 2023/2821 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4457821 and AB

For SAA decisions, whether these are transient or persistent effects is a critical distinction. Other work points to a link between temperature and inflation, but of a more transitory nature. Mukherjee and Ouattara (2021) suggest that temperature shock leads to an inflation shock which, while persistent for several years, would see the main impact dissipate within a year. Faccia et al (2021) also show a significant link between temperature and inflation. They demonstrate that the short-term impact is most notable on food prices, but that there are also medium-term price developments from temperature shocks with nonlinear effects. A broader worry here is the impact on supply chains, especially in the context of deglobalization already having a potential negative impact by fragmenting supply chains. This leads to a questioning of the ability of supply chains to cushion price shocks in the future.

This literature suggests that two elements of the impact of severe weather on inflation need to be considered in portfolios. There is the risk of an upward shift in the background mean level of inflation but also—probably more importantly—the risk of an increase in inflation volatility.

Part III: What does all this mean for asset allocation and portfolios?

The ultimate aim of this note is to map this assessment back to actions that investors must take on their portfolios. Any change in the climate is not happening in isolation; other major forces, such as demographics and deglobalization, are happening in parallel. Compared with these other forces, any impact of climate on economic variables is much more uncertain. Thus, while we think it is important to try and quantify some likely impact of temperature change on expected returns, it is probably not the main mechanism by which climate change impacts on portfolios. Instead, much of the implications for investors come via the likelihood that the range of possible paths is much broader than we have seen before.

If the transition is likely to be delayed, is the industry underestimating the effect on returns?

A recent study by the Institute of Actuaries[18] concluded that there is a disconnect between the current state of climate science and the assumptions underpinning scenario modeling in financial services. The Institute noted the risk that as regulatory scenarios for climate's impact on GDP evolve, they are useful for introducing consistency but also may engender group-think. The paper goes on to analyze Task Force on Climate Related Financial Disclosures (TCFD) documents from major UK investors, showing that there is essentially no assumed difference in the expected impact on portfolios between an orderly transition to net zero and a "hot house" world of missing Paris targets. It seems odd that there is no assumed difference between these outcomes in the industry. But in the case we make below, even in the case of no impact on mean expected returns, the two scenarios do imply a very different distribution of outcomes.

In a similar vein, Keen (2023) analyzed disclosures from pension funds, showing that in many cases funds' investment models predict that global warming in excess of 2°C will have only a minimal impact on portfolios. The implication is that the models used by investment consultants are at odds with the scientific literature in terms of the impact of these levels of warming. Keen concludes that the weakness is that papers on the economics of climate damages tend to be refereed by economists rather than by climate scientists.

Growth

We apply the conclusion that we arrived at in part I: a rapid energy transition is too painful politically and hence not the most likely path, thus investors need to incorporate a forecast outcome that temperatures may well rise more than 2°C. We then use the academic work we outlined in part II that attempts to map temperature increases to an impact on GDP. In *Display 27* we show two interpretations of what this means for growth: 1) the average impact taken from a trend line across all studies (assuming the temperature rise occurs by 2050); 2) and the NGFS outlook average of delayed transition and current policies scenarios. Some of the attempts in academic literature to link temperature to growth imply an impact to aggregate growth, and hence equity valuations, that is small compared with other forces such as demographic change and any assumed mean-reversion in valuations. The NGFS forecasts imply a large hit to equity returns, though one that is still on the same scale as these other forces.

Part of the reason for the apparent relatively small impact on growth is that the biggest impact is often forecast to be in countries with a lower share of global GDP. Hence, the larger impact may be via indirect channels such as migration and its impact on politics.

[18] Trust et al (2023): The Emperor's New Climate Scenarios, Institute and Faculty of Actuaries the-emperor-s-new-climate-scenarios.pdf (actuaries.org.uk)

DISPLAY 27: IMPACT ON CENTRAL-FORECAST EQUITY RETURNS OF MEGA-FORCES—CHANGE IN FORECAST ANNUALIZED RETURN 2024-2050

US	Central Impact on Equity Returns	Uncertainty in the Impact on Equity Returns
Demographics	0.2	Low and Linear
Deglobalization	0.0	Medium and Linear
Climate Change (Academic Research Average)	-0.1	High and Non Linear
Climate Change (NGFS)	-0.4	High and Non Linear
Labor vs. Profit Share	-0.1	Medium and Linear
Valuation Mean Reversion	-0.5	High and Linear
World ex US		
Demographics	-0.8	Low and Linear
Deglobalization	-0.1	Medium and Linear
Climate Change (Academic Research Average)	-0.1	High and Non Linear
Climate Change (NGFS)	-0.4	High and Non Linear
Labor vs. Profit Share	0.0	Medium and Linear
Valuation Mean Reversion	0.0	High and Linear

Current analysis and forecasts do not guarantee future results.

Note: Demographic projections are based on United Nations estimates from 2025 to 2050. World ex US uses Developed World ex US region plus China. The research average climate change estimate is a summary of academic research conclusions estimating the impact of temperature change by year 2100 or similar on the Global GDP. It is adapted from Tol (2022) with extra estimates added from Kahn et al. (2021), Burke et al. (2015) and NGFS (2023). For multiple publications by the same author we selected estimates only from the latest listed publication. For the GDP impact estimate we assume the forecast temperature change of 2.2C occurs by 2050. The NGFS scenario is based on NGFS Scenarios for central banks and supervisors November 2023 presentation available at: https://www.ngfs.net/sites/default/files/medias/documents/ngfs_climate_scenarios_for_central_banks_and_supervisors_phase_iv.pdf. It is an average of Delayed Transition and Current Policies scenarios.

As of November 2023

Source: Tol (2022), Kahn et al. (2021), Burke et al. (2015), NGFS(2023) and AB

The impact of climate on portfolios must be seen in the context of other structural forces that will affect markets and hence portfolios contemporaneously. What sets climate apart from the other forces, with the possible exception of AI, is the degree of uncertainty. We started this note by making the case that a quick energy transition is politically and socially very costly, and therefore unlikely. Thus, the uncertainty around the prognosis for climate are very large, indeed. The uncertainty around the consequences for a given climate outcome on growth and inflation is also huge. Thus, from the perspective of portfolio design, the principal consequence of a slow energy transition is likely to be much greater path risk when trying to model possible economic scenarios further out. The other contemporaneous forces imply a higher equilibrium level of inflation (from deglobalization and demographic change). We believe that an energy transition can ultimately be disinflationary, but the view that we outline here is that completing such a switch will take longer. We have shown, however, a likelihood that climate increases inflation volatility. Likewise, the directional impact on growth seems likely to be downward, with a central projection that is possibly smaller than the impact of demographics.

Inflation

There are two distinct effects of the interaction of climate and the energy transition on inflation. There is the potential effect of extreme weather on short-term inflation shocks and the separate question of how an energy transition affects inflation. As for extreme weather, as average temperatures increase it seems likely that inflation volatility will also increase. The economic mechanism is mainly via food and energy prices, supply-chain disruption and higher insurance costs, which we discussed in the section on extreme weather. Our view is that higher temperature will lead to higher inflation volatility via extreme weather.

But what about the impact of the energy transition itself on inflation? Our prior starting point on this is that the process of energy transition raises prices over the course of the transition but then has the potential to be disinflationary longer term. The upward pressure of the transition on inflation can be thought of as a function of a few elements:

- The pass-through of any taxes or carbon taxes that make explicit any negative carbon externalities onto consumers
- The cost of installing new requisite infrastructure in terms of generating capacity, grid infrastructure and carbon sequestration assets
- The potential for misallocation of resources (which is usual in any large infrastructure/technology change), hence lower economic efficiency during a transition.

The promise of disinflationary forces later on comes from the downward adjustment in prices of new "green" energy as capital is invested in them. Also, there's the longer-term possibility that economies are de-linked from the vagaries of commodity prices. This would be a significant change, specifically compared to the last century, in which oil has been the primary source of energy. If this is the case, there is then the huge question of when a shift from net inflationary to disinflationary pressure could take place and how much it depends on the form the transition takes (ordered/disordered, late/early, via taxes or subsidies).

There is support from policy makers for this point of view. For example. Isabel Schnabel, a member of the Executive Board of the European Central Bank (ECB), suggested in a recent speech that we face a "prolonged period of upside pressure on inflation".[19] A World Bank report agreed that during the transition, demand for certain energy sources (such as gas) may grow significantly and that an increase in the price of minerals needed for green technologies would be inflationary.[20]

Taking a different approach, Ferrari and Landi (2022) show that an energy transition brought about by taxing "dirty" sectors exerts inflationary pressure, but that the expectation of further tax increase in the future depresses demand. The second effect is larger, but the result is that inflation rises at first and is deflationary later.

The pace of the energy transition and the degree to which it is orderly is important. The ECB has suggested that an orderly energy transition poses little threat to the ability of a central bank to maintain price stability. However, a disorderly transition—which we think now looks more likely—would present a much more difficult trade-off between growth and inflation, with headline inflation diverging from target for a prolonged period. Specifically, the ECB research suggests that a disorderly transition results in much higher energy-cost inflation. The central bank could choose to "look through" this effect and focus on core inflation, but that overall inflation would still be 0.5 percentage points higher up to 15 years later. The alternative would be to target headline inflation, but that would entail a much greater impact of GDP, again over a period longer than a decade.[21]

Recent work by the Federal Reserve has suggested that the energy inflation does not have to be inflationary per se, but may spur the central bank to think more explicitly about the trade-off between its employment and inflation objectives. This balance depends on whether climate policies are enacted as subsidies to "green" sectors or taxes on "dirty" sectors and the flexibility of prices within those sectors. However, the ability to use subsidies as the main mechanism for advancing a transition presumably has limits, given that the level of public debt/GDP across the G7 nations has reached the same level as at the end of WWII. While politicians in the US (of either party) seem unable to propose a way of reducing the current level of fiscal largesse, this debt burden would eventually limit the ability of a subsidy approach.

The Fed starts from the observation that policies to price "dirty" and "green" energy differently bring changes in relative prices, not absolute prices. So if prices for green energy fall quickly, this could be consistent with deflation. The research shows that the price "stickiness" in US sectors correlates with carbon emissions/value added for the sector. The more carbon-intensive sectors such as air transport, electricity and gas supply see price changes on a more frequent basis than the average economic

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[19] A new age of energy inflation: climateflation, fossilflation and greenflation (europa.eu)

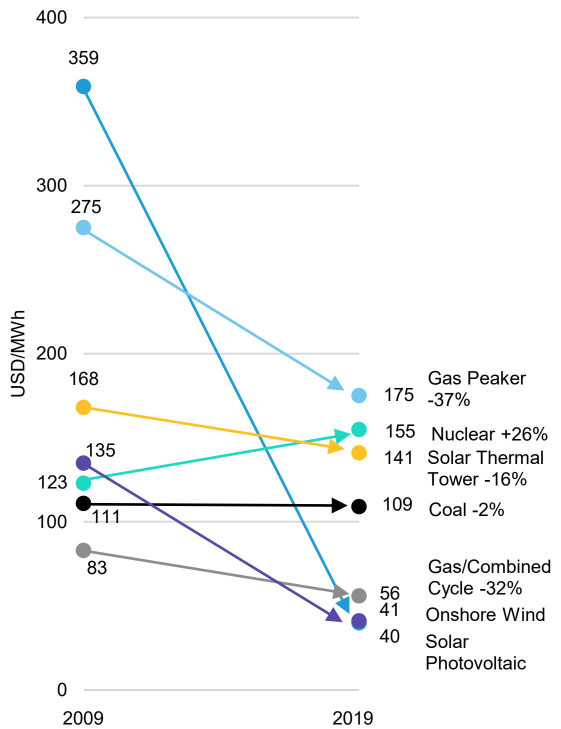
[20] World bank (2022): Inflation and the ecological transition: A European perspective Inflation and the ecological transition: A European perspective (worldbank.org)

[21] ECB (2021): Climate change and monetary policy in the euro area, ECB Occasional Paper Series, https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op271~36775d43c8.en.pdf

sector. Thus, for a central bank to achieve lower inflation overall—including in areas with more sticky prices—it has to aim for lower output and employment across the whole economy than it would otherwise target.[22] There is possible good news here. If the transition were brought about by subsidies rather than taxes on "dirty" sectors (which the Inflation Reduction Act has, in part, attempted to achieve), and if prices in green sectors are flexible, then they could adjust quickly. This could balance price pressures and even be disinflationary.

We do not have a long data set for price flexibility in the newly emerging sectors related to the transition. However, evidence from the prices of renewable-power generation and the price of Lithium ion batteries suggests that prices are indeed flexible and decreasing rapidly (*Display 28 and 29*). Moreover, rapidly evolving battery chemistry points to a range of more flexible options with less supply-chain risk.[23]

DISPLAY 28: PRICE OF ELECTRICITY FROM NEW POWER PLANTS

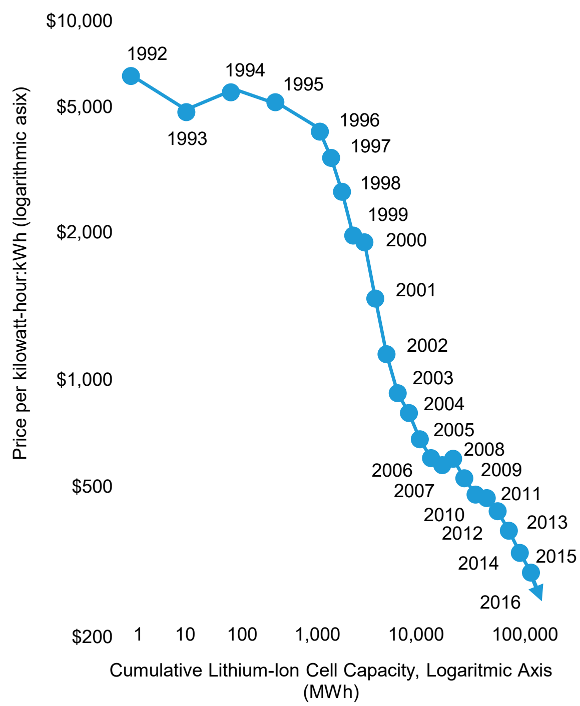


Historical analysis does not guarantee future results.

Through June 4, 2021

Source: Hannah Ritchie (2021) - "The price of batteries has declined by 97% in the last three decades" Published online at OurWorldinData.org. Retrieved from: https://ourworldindata.org/battery-price-decline and AB

DISPLAY 29: PRICE DECLINE VS. CAPACITY INCREASE IN LITHIUM-ION BATTERIES



Historical analysis does not guarantee future results.

As of June 4, 2021

Source: Hannah Ritchie (2021) - "The price of batteries has declined by 97% in the last three decades" Published online at OurWorldinData.org. Retrieved from: https://ourworldindata.org/battery-price-decline and AB

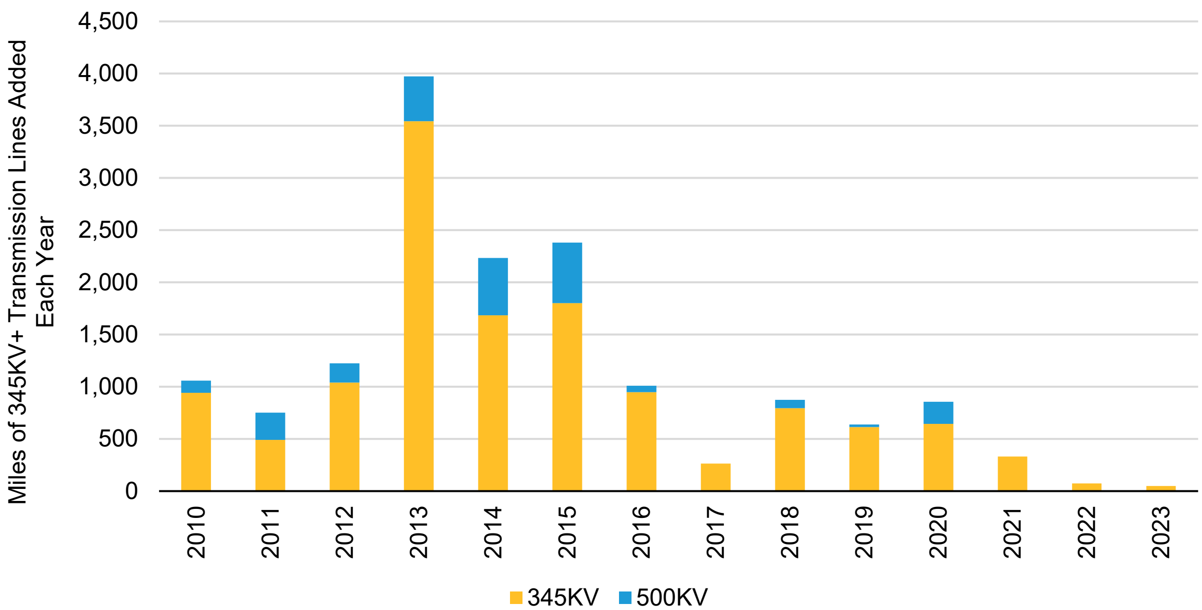
The speed of cost reductions is stark. Moreover, there is evidence that forecasters have persistently underestimated both the pace of cost reduction and speed of increase in installed capacity in recent years. However, generation and batteries are just two parts of the energy-transition process. Other elements that could still pose considerable costs are the need for a significant

[22] Del Negro, Marco, Julian di Giovanni and Keshav Dogra. *Is the Green Transition Inflationary?* Federal Reserve Bank of New York Staff Report Number 1053, 2023

[23] Yu, Xingwen and Arumugam Manthiram. *Sustainable Battery Materials for Next-Generation Electrical Energy Storage*, Advanced Energy and Sustainability Research, Wiley VCH GmbH, 2021

improvement in the grid, the buildout of carbon sequestration technology and the shift of the primary energy source for sectors not currently electrified (transport and industrial processes like cement). We covered carbon sequestration and primary-energy source changes earlier in this note; the grid-buildout process is still in its infancy. In the US, for example, the rate of new transmission-line building peaked in 2013, and in recent years has been growing at a small fraction of the rate of recent decades. A recent study on national transmission planning[24] suggested that the US transmission system must more than double in size by 2050 if there is a need to decarbonize while not limiting demand.

DISPLAY 30: INVESTMENT IN NEW HIGH-VOLTAGE LINES PEAKED IN 2013 AND HAS STEADILY FALLEN OVER THE LAST 10 YEARS



Current analysis and forecasts do not guarantee future results.

As of July 2024

Source: https://cleanenergygrid.org/wp-content/uploads/2024/07/GS_ACEG-Fewer-New-Miles-Report-July-2024.pdf and AB

Our strong conclusion is that inflation volatility is set to be higher, but the impact of the transition on equilibrium inflation is moot. We assume that the transition is initially inflationary but then disinflationary. The timing of that switch will be a function of how energy policy develops. More generally, this research suggests that the link between the energy transition and inflation, at the very least, likely creates trade-offs for central banks on the inflation versus growth/employment spectrum.

Asset allocation

The increased uncertainty of outcomes means that diversification becomes even more important across asset classes and regions. The tricky aspect is that new exogenous inflation sources that are not growth-linked imply that bonds will be less effective diversifiers, so diversification requires a broader array of return streams.

A risk of higher inflation volatility implies a greater need for real assets. However, in some cases physical real assets may also face greater costs of insurance and maintenance. Physical real assets are still needed, but their "inflation beta" may be less effective than before.

[24] https://www.energy.gov/sites/default/files/2024-10/NationalTransmissionPlanningStudy-ExecutiveSummary.pdf

A challenging aspect of this modeling is determining what happens to predicted variance and covariance. Our starting view is that these moments tend to be much more stable than those of returns, so setting them equal to long run averages is a good starting point. However, climate change is potentially unlike historical shifts in economic regimes, so it's not clear if such an approach should hold in this case.

There have been attempts to model the risk characteristics of asset classes in relation to temperature over and above standard macro variables. For example, Bertrand et al (2024) propose modeling equity variance and covariance as a linear function of variables such as changes in GDP, inflation and temperature, finding that an increase in temperature has a positive link to volatility.

Past changes in temperature have been in a very different range from that indicated by climate models of the future, so we like an approach to modeling future asset class correlation that depends on macroeconomic variables—not past temperature observations. The key aspect here is that the broader mega forces that we think define the investment environment imply somewhat greater inflationary pressure but lower real growth. This is very different from recent years, when growth and inflation tended to be positively linked. This shift implies a positive stock-bond correlation, not negative.[25]

For asset owners' positioning, the conclusion is that climate impact could be larger than currently assumed, and it is not something that can be resolved by buying a simple "ESG" fund that excludes sectors passively. There is a much broader allocation question around real assets that can help over a period when inflation could be higher and more volatile and when there's a diversification problem. Thus, responding to the likely path of climate change's impact on investment assets poses an asset-allocation problem that requires much more attention in the investment industry.

The need to find sources of return and diversification that may work across a much more broadly distributed set of possible outcomes is probably the key requirement for those tasked with devising SAA. In this light, the ultimate focus is on governance and those tasked with framing investment objectives. Less is said about this aspect than about asset allocation. There are many reasons for this, one being that such decisions are "above the pay grade" of many in the industry. Changes in governance structure should generally happen even more slowly than, and be approached even more humbly than, asset allocation. However, there is a good prima facie case to be made that climate change, especially "bad" outcomes, are not really diversifiable in a traditional sense (see Quigley (2020) for a discussion on this point). If that is the case, the response might have to be a different setting for risks and returns and also for the way policymakers set targets and constraints for the investment industry overall.

While a "bad" climate outcome might not really be diversifiable, allocators will need to respond working within the current framing of investment guidelines. The view that we have outlined—one of much greater uncertainty and path risk in the outlook for growth and inflation, with a bias towards higher inflation and lower growth—has implications for allocations. For most investors, the ultimate need is to protect purchasing power. We assume that need guides allocation decisions.

- Increased focus on diversification implies the need for a greater variety of return streams, therefore a more widely distributed spread of risk weights across public/private, regions, active, long-only and long-short, and asset classes.

- While our working assumption is that the US is relatively less adversely affected than other regions from some aspects of climate risk, analysis of asset class returns over very long horizons shows the dangers of regional concentration. Of the eight largest equity markets by market cap in 1900, six went to zero within the following 50 years. Regional diversification matters, especially given what are likely to be highly localized differences in climate outcomes. Thus there is a tricky trade-off to be made of North American exposure vs long run regional diversification.

- There is a need for greater exposure to real assets and we include equities as a real asset. The objective of preserving purchasing power when inflation volatility will likely rise and in the presence of greater inflation path risk implies that returns linked to the real economy matter. This means not only assets with high correlations to inflation, but also assets with a high probability of delivering a positive real return over extended periods of uncertain inflation. The caveat for real assets is the need to incorporate greater insurance costs that might haircut the "inflation beta" of such assets.

[25] A Preliminary Language for a Post-Global World

- There is ample capacity for capex on energy transition to increase further, based on a comparison to past infrastructure changes over the last 150 years, so renewable energy is an important investment theme. At the same time, fossil fuels are likely to be present for perhaps longer than currently anticipated. In the presence of attractive free-cash-flow yields and strong net buybacks, we also want exposure to the global energy sector. Commodities also have a role to play in inflation hedging, albeit the weight of specific commodities within that exposure is likely to change over strategic horizons.

- Prefer Treasury Inflation-Protected Securities (TIPS) over nominal bonds. Inflation volatility is set to rise and inflation-path uncertainty to be high, so if governments choose to continue issuing TIPS, then investors should favor them over nominal bonds. Greater inflation volatility is yet another reason to assume that bonds will not fulfil a role of effectively diversifying equity risk.

- Exposure to private assets should increase. Many areas within renewable assets don't find their way into public markets, but they do need considerable capital. This supports a further increase in the weight of private assets. Our view, which we've expressed in other research[26], is that the illiquidity premium on the overall private equity asset class is currently nil, which suggests favoring other types of private assets such as private debt, infrastructure and natural resources.

[26] The Role of Private Assets in Strategic Asset Allocation: a Macro Perspective

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