Climate scenarios

What they are, why they are important, and how they are applied to investment portfolios

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In brief

- Climate scenario modelling is becoming widely used. Given the multitude of climate scenarios that are available, it is crucial that investors understand how scenarios are constructed, the uncertainties that are inherent in climate model design, and the associated implications for the results of a climate scenario analysis.
- Deciding on the type of climate scenario analysis to perform and the metrics used to analyze the results will also depend on an investor's use case – whether the aim is to consider the impact of a low carbon transition or physical climate change on a portfolio, or whether it is to consider a portfolio's impact on climate change.
- To help investors navigate their own climate scenario journey, and ensure they are able to interpret and use the outputs of their scenario analysis, we look in depth at the current state of climate scenario modelling. We explore the details of commonly used scenarios, their key assumptions and limitations, and assess the scenario-based metrics and tools that can be applied to gain the most effective results.

How can investors use climate scenarios?

"Climate scenarios" is an umbrella term used to refer to various forward-looking analyses that explore possible climate futures. Climate scenario analysis is still in its infancy, but regulators are starting to require the reporting of some climate scenario metrics , and many financial institutions are also using these metrics for stress testing, risk management and decision making.[1]

Climate scenarios aim to answer two key questions: first, what might happen to global warming as a result of certain actions, such as policy measures or technological choices, or their absence; and second, what it could take to limit the global temperature rise to a specific goal.

As such, investors can look to apply climate scenarios to answer these two questions from the perspective of their portfolios. First, they can use climate scenarios to assess the range of climate-related risks and opportunities, and the underlying drivers, that may manifest in investment portfolios over time, under different potential climate futures. The metrics that are most appropriate for stress testing or risk management are **Climate Value at Risk (CVaR)** metrics, as these allow users to consider outputs across a variety of different scenarios and over different time periods.

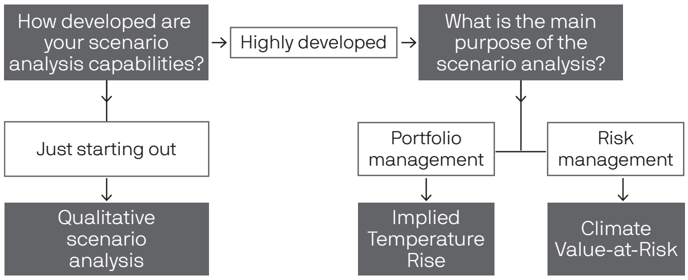
[1] The 2021 Task Force on Climate-Related Financial Disclosures (TCFD) status report notes that eight countries/jurisdictions have announced TCFD-aligned reporting requirements as well as "dozens of regulators and supervisors". https://www.fsb.org/wp-content/uploads/P141021-1.pdf

Second, investors can also use climate scenario analysis tools to quantify and track the alignment of their portfolios to a particular temperature target, such as 1.5°C of global warming compared to pre-industrial levels. These types of tools can help investors consider if a portfolio is "Paris aligned", or "net zero aligned", or how far away it is from this alignment. The metrics that are most appropriate for portfolio management are **Implied Temperature Rise** (ITR) metrics.

In both cases, the information provided can help investors minimize climate risks and harness climate opportunities in portfolios, understand the range of potential outcomes under different climate pathways, and obtain useful insights that can be used when engaging with investee companies on their need to set or strengthen climate-related targets.

Deciding on the "best" climate scenario metric to use will depend on the use case. This decision-making process is illustrated in **Exhibit 1**, although it is advisable to consider metrics across both categories to gain a more holistic understanding of potential climate-related impacts on a company or investment portfolio. In order to develop scenario analysis capabilities, users are recommended to start by considering the scenario impacts from a qualitative perspective and then, once comfortable with the scenarios and their output, move onto a quantitative perspective in which different climate scenario metrics are analyzed.

Exhibit 1: Which type of scenario analysis to perform will depend on user capabilities and the use case



Source: J.P. Morgan Asset Management. For illustrative purposes only.

Exhibit 2 outlines the main strengths and weaknesses of key climate-related metrics and their use cases. For the examples of how CVaR and ITR can be calculated, please refer to the relevant sections below.

Exhibit 2: Pros and cons of key climate-related metrics

Climate Value at Risk (CVaR) (% or $)			Use cases
Transition risks and opportunities	+	Considers company impact across several drivers e.g. potential changes in policy (e.g. carbon tax), consumer demand and technological shifts	Quantifying the impact on company/ portfolio financials as a result of the risks and opportunities from a low carbon transition
	+	Considers company data beyond emissions, such as revenue sources	
	-	Methodologies are often not transparent and company or portfolio outcomes may be difficult to explain	
	-	Calculations are complex and based on many assumptions within the scenarios, models and impact calculations	
Physical risks	+	Considers company impact across several different drivers e.g. business interruption and damage caused by the increased frequency and severity of climate change perils	Quantifying the impact on company/ portfolio financials as a result of the physical risks and opportunities of climate change
	+	This will be highly material for certain companies	
	-	Requires extensive company level data on asset locations	
	-	Difficult to capture full impact beyond the company itself i.e. impacts in the supply chain	
	-	Extensive and complex modelling required to capture impact of all perils in all regions	
Portfolio alignment (°C)			**Use cases**
Implied Temperature Rise (ITR)	+	Easy to interpret and tie back to specific alignment goals	Tracking the temperature alignment of a portfolio or company
	+	Typically relies on only a few commonly available data points per company (scope 1 and 2 (and 3) emissions)	
	-	Methodologies are not yet standardised and so lack comparability	
	-	Calculations are complex and require many assumptions	

Source: J.P. Morgan Asset Management. For illustrative purposes only.

Which climate scenarios are most popular among financial institutions?

A multitude of climate scenarios have been developed by different organizations over the years[2]. Among the most widely used by the financial sector are the climate scenarios published by the Network for Greening the Financial System (NGFS) and by the International Energy Agency (IEA).

NGFS scenarios are particularly popular with central banks and investment banks to stress test their portfolios. The NGFS has developed different groups of scenarios that describe a range of potential futures. For example, the NGFS orderly scenarios assume a timely and coordinated introduction of climate policies that consequently limit both climate-related physical risks and transition risks, such as the need for stringent climate policies and regulations later in the century. On the other hand, the NGFS disorderly scenarios assume that there is delayed or uncoordinated policy action across sectors and/or regions. For example, the delayed transition scenario considers the impact of waiting to implement policies required to mitigate climate change to well below 2°C until around 2030, resulting in overall higher stringency – for example, of carbon prices – over the following decades.

The IEA publishes several climate scenarios as part of its annual World Energy Outlook, which are widely used by both companies and investors. The IEA scenarios vary in their ambition and stringency, from business as usual under the current policy landscape in the Stated Policies Scenario (STEPS), to a net zero world under the Net Zero Emissions (NZE) scenario (see **Box A** for a discussion of the IEA scenarios).

The scenarios provided by the NGFS and IEA can be roughly mapped to one another, but investors undertaking climate scenario analysis will likely choose one scenario group over the other, based on the needs of their analysis. The IEA scenarios have been developed with qualitative storylines in mind, making it easier for investors to understand how and why changes occur, and to interpret the results. Many asset managers have used IEA scenarios for their own analysis, meaning that outputs may be more comparable among peers. The IEA scenarios are also regularly updated, which may be preferred by users interested in better understanding the changes in the implementation and ambition gap for current policy and technology rollouts.

On the other hand, NGFS scenarios cover GHG emissions from all sources, while most IEA scenarios currently consider only CO_2 emissions from energy systems, and so therefore exclude land use and other GHGs. There are also more scenarios and more models within the NGFS group, making them more useful for exploring uncertainty. Additionally, technical model documentation is freely available for the NGFS scenarios, and the models are mostly open source, allowing users to run them with bespoke inputs.

[2] The Intergovernmental Panel on Climate Change (IPCC), led by its Working Group III, has undertaken an extensive effort to review and compile a database of over 3,000 quantitative climate scenarios. AR6 Scenario Explorer and Scenarios Database hosted by IIASA, accessible here: https://data.ene.iiasa.ac.at/ar6

Box A: International Energy Agency scenarios for different temperature pathways

The IEA has two sets of widely used scenarios: normative scenarios and exploratory scenarios.

The IEA's normative scenarios, such as the Stated Policies Scenario (STEPS) and the Announced Policies Scenario (APS), analyse what temperature outcome the existing or envisaged policies might lead to. The aim of these scenarios is to show the distance of announced commitments to 1.5°C. The APS includes government climate commitments in Nationally Determined Contributions* and long-term net zero targets, assuming that all commitments are met in full.

On the other hand, STEPS reflects currently implemented policy and announced commitments that have sufficient policies in place to be realised. The APS could result in end of century warming of 1.8°C, when taking into account recent commitments such as those announced at COP26, while STEPS results in end of century warming of 2.6°C. The difference in the temperature outcomes between STEPS and APS is the implementation gap.

The IEA's exploratory scenarios, such as the Net Zero Emissions (NZE) scenario and Sustainable Development Scenario (SDS), analyse what it might take to limit global warming to a certain level. The NZE represents a tight, yet plausible, pathway to 1.5°C given its assumptions. The difference in emissions between APS and NZE is the ambition gap, as the latter would require more stringent policies than those currently announced and reflected in the APS.

The SDS aims to show the feasibility of reaching a "well below 2°C" goal, while also achieving by 2030critical development priorities, such as universal affordable energy access and modern energy services. In the SDS, advanced economies could reach net zero by 2050, with China and the rest of the world taking until around 2060 and 2070, respectively. Without net negative emissions, the SDS overall could lead to 1.65°C warming.

*NDCs are countries' climate action plans that governments every five years to the United Nations Framework Convention on Climate Change. NDCs lay out actions that each country is planning to take to reduce emissions., It also includes the description of adaptation efforts to address climate change impacts that have already been locked in.

Source: IEA, World Energy Model Documentation, October 2021; COP26 climate pledges could help limit global warming to 1.8 °C, but implementing them will be the key, https://www.iea.org/commentaries/cop26-climate-pledges-could-help-limit-global-warming-to-1-8-c-but-implementing-them-will-be-the-key

What are the key challenges for investors looking to use climate scenarios?

Because climate scenario models were originally designed with the policy and planning communities in mind, the scenarios require adjustments to serve the needs of business use cases[3]. One of the key challenges is the fact that policy makers and the private sector operate at different temporal horizons. While climate scenario models project temperature trajectories decades into the future, investment cycles are significantly shorter.

The "off-the-shelf" climate scenarios might also not always offer the granularity needed for investment decisions (for example, at the sector, market or issuer level). Improved detail is often needed both for scenario assumptions as well as their outputs. There is often additional work involved for climate scenario users to refine the assumptions made by the readily available scenarios and to break down the scenario outputs to a level required for decision making.

Company-level input data is also essential for deriving these metrics. While the reporting of company data has improved in quality, quantity and granularity over recent years, the majority of companies still do not report sufficient data. As a result, most of the analysis will rely on estimated data for key inputs, such as emissions and revenue segmentation.

[3] The Task Force on Climate-Related Financial Disclosures (TCFD) outlines the journey of developing scenario analysis capabilities: https://www.tcfdhub.org/scenario-analysis/

Furthermore, since climate scenario analysis aims to be forward looking, many metrics are now incorporating projections about the potential future emissions of companies based on the emissions reduction targets of the companies themselves. While caution is urged when considering outputs based on these projections, as the credibility of company targets is not typically considered, the forward-looking view given by the metrics does provide a useful insight into the extent to which climate-related risks may be reduced if targets are achieved.

Data providers have stepped in to try to fill this gap, by developing their own methodologies to translate climate scenarios into relevant metrics and provide estimates for company-level data. While these metrics can be useful, the proprietary methodologies used can lack transparency and flexibility. However, by developing a good understanding of the assumptions, limitations and uncertainties of the underlying scenarios, and the metric and data estimation methodologies applied, users can be better equipped to understand, interpret and use the outputs.

How are climate scenarios structured?

Climate scenarios are typically developed using a variety of specialized models, representing different elements of social, economic and natural systems. These models can be combined into integrated assessment models (IAMs) that analyze how different socioeconomic trends may interact with climate factors over time.

While IAMs may vary in their exact design, they tend to consist of two common components: Shared Socioeconomic Pathways and Representative Concentration Pathways.

Shared Socioeconomic Pathways (SSPs) describe the future in terms of broad economic, demographic and policy trends to enable easy comparison[4] . In total, there are five commonly used SSPs, with the sustainable and inclusive pathway (SSP1) and fossil-fuel development pathway (SSP5) as two extremes (**Exhibit 3**). In addition, climate scenarios may also include more granular assumptions about how the future might evolve, including assumptions about specific policy changes, such as carbon pricing levels, and technological developments, such as the cost decline in battery storage and uptake of non-hydro renewable energy.

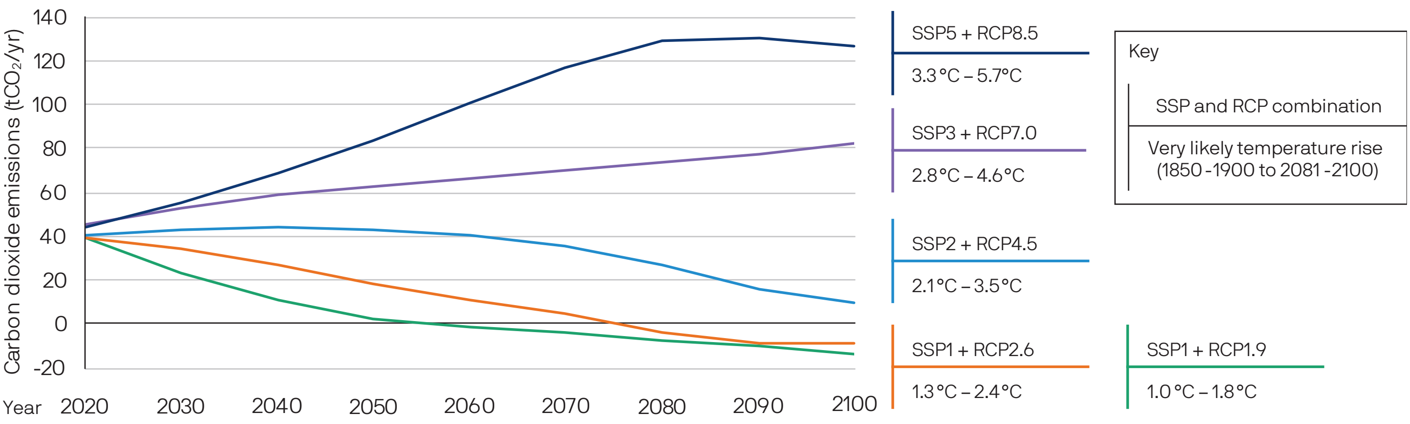
Representative Concentration Pathways (RCPs), on the other hand, help model the emissions associated with different socioeconomic and policy trends. RCPs, which represent possible greenhouse gas (GHG) concentration trajectories given different volumes of GHG emissions over the course of the 21st century, help to translate SSPs into expected global temperature changes (**Exhibit 3**).

[4] Riahi et al., The Shared Socioeconomic Pathways and Their Energy, Land Use, and Greenhouse Gas Emissions Implications: An Overview, Global Environmental Change, 42, pp. 153-168, 2017.

Exhibit 3: Summary of SSP storylines, RCP emissions trends and temperature outcomes[5,6,7,8]

	Name	Description
SSP1	Sustainable pathway	A gradual transition to an environmentally friendly future with an emphasis on inclusive development
SSP2	Middle of the Road	A continuation of current trends where environmental concerns are addressed at a slow pace and progress towards achieving wider Sustainable Development Goals is limited
SSP3	Regional rivalry	A world where both mitigation and adaptation challenges are high
SSP4	Inequality areas	A world with highly unequal investments and economic opportunity, with a focus on local issues in higher income
SSP5	Fossil Fuel Development	Continued use of fossil fuels and resource intensive lifestyles with a focus on the ability for competitive markets and innovation to address sustainable development

	Emissions trend
RCP1.9	Emissions decrease immediately and become negative by the middle of the century
RCP2.6	Emissions reduce from ~2020 and usually become negative after 2080
RCP4.5	Emissions start declining from the middle of the century and tend to stabilise from 2080
RCP8.5	Emissions increase rapidly until around 2080 when they level off



Source: J.P. Morgan Asset Management, IPCC.

Are climate scenarios forecasts?

While climate scenarios provide a view of possible futures, they are not forecasts. As can be seen by the breadth of existing climate scenarios, there is more than one way to achieve a specific temperature goal. For example, there are several net zero scenarios developed by different organizations that all present pathways to limit global warming to 1.5°C. The availability of a scenario is not an indication of its likelihood, while the multitude of existing scenarios does not necessarily mean that all possible futures have been modelled.

Nevertheless, users often raise questions about the likelihood that particular scenarios will play out in reality, and around the uncertainty in their outputs. For example, estimates for the share of wind and solar power in electricity generation by 2050 can range from 15% to 80%, depending on a specific scenario[9] .

Similarly, for solar panel capacity alone, a recent study found that projected generation ranges from zero to over 300 exojoules per year across a sample of 1,550 Intergovernmental Panel on Climate Change (IPCC),

5 IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, pp. 151.
6 van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. The Representative Concentration Pathways: An Overview. Climatic Change 109, 5 (2011). https://doi.org/10.1007/s10584-011-0148-z.
7 Lee, J.-Y et al. 2021: Future Global Climate: Scenario-Based Projections and Near-Term Information. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 553–672, doi:10.1017/9781009157896.006.
8 Data from IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.
9 IEA, Net Zero by 2050: A Roadmap for the Global Energy Sector, 2021.

non-IPCC peer-reviewed, and other scenarios[10]. The divergence of the results is particularly prominent for the near-term horizon of 2030.

Earlier climate scenarios have also been criticised for underestimating the remarkable fall in clean technology costs that has actually taken place. According to some estimates, the annual growth in solar panel system installation capacity averaged 38% between 1998 and 2015, compared to the projections by the IEA in the range of 16% and 30% for 1998 and 2010[11].

Such underestimation is not unique to the IEA with many historical scenarios facing a similar issue. The IAMs feeding into the 2014 IPCC fifth assessment report estimated the 2015 global solar panel deployment at just half of its actual level that year. This divergence from reality could be due to the underestimation of support policies and technological learning that have taken place, resulting in a decline in technology costs[12].

At the same time, while some trends might turn out to be steeper than modelled by the scenarios, the real world could also exhibit barriers unaccounted for in the scenario analyses. These barriers might include the lack of social acceptance of certain solutions, the lack of political and institutional buy-in, and the lack of global cooperation[13]. For example, the decrease in the costs and uptake of carbon capture and storage (CCS), or acceptance of nuclear power, seem to have been overestimated by earlier research.

What drives uncertainty in climate scenarios?

While differences in the results are expected, as climate scenarios do not necessarily aim to give an answer about the most likely future, understanding what drives their outputs could be helpful in forming an opinion, albeit subjective, on the possibility of different outcomes.

There are two key factors that can drive the divergence of climate scenario outputs: (1) the assumptions made in the scenario; and, to a lesser extent, (2) the climate scenario model type used.

1. The assumptions made in the climate scenario

As stylized versions of the future, climate scenarios make a number of assumptions about how the next few decades may play out, including around technology advancements and costs, and policy choices.

The realization that the assumptions underpinning climate scenarios can considerably affect their results is important for embracing the differences and uncertainty around the outputs these models generate. For example, scenarios might differ in the importance they attribute to specific technology solutions that are yet to be proven at scale, such as carbon capture and storage (CCS), and bioenergy with carbon capture and storage (BECCS). As a result, the climate scenarios that rely less on nascent technologies and more on the solutions that already exist could be considered by some users more likely.

Climate scenarios can also vary in their assumptions around the acceptability of a reliance on nuclear power or natural gas[14] – again, something that could be considered less or more probable by some users, given their beliefs about how the future might play out. As an illustration, the IEA's Net Zero Emissions Scenario differs from the scenarios included in the IPCC's Special Report, "Global Warming of 1.5°C", across multiple fronts, including, lower use of fossil fuels and limited reliance on CCS.

Furthermore, scenarios can vary substantially in their assumptions about the overall timing and ambition of a climate action, and the resulting peaks and reductions in emissions across geographies and sectors. Typically, the models that focus on a long-term end-century temperature and emissions target, without imposing a medium-term cap on emissions, see an emissions overshoot in the meantime, and therefore tend to rely more heavily on carbon dioxide removal solutions later in the century.[15] At the same time, the scenarios that include an explicit global warming cap throughout the century might be better at managing inter-generational trade-offs.

[10] Jaxa-Rozen, M. and Trutnevyte, E. Sources of Uncertainty in Long-Term Global Scenarios of Solar Photovoltaic Technology, Nature Climate Change, 11(3), pp. 266–273 (2021) doi: 10.1038/s41558-021-00998-8.
[11] Creutzig, F., Agoston, P., Goldschmidt, J. et al. The Underestimated Potential of Solar Energy to Mitigate Climate Change. Nat Energy 2, 17140 (2017). https://doi.org/10.1038/nenergy.2017.140
[12] Creutzig, F., Agoston, P., Goldschmidt, J. et al. The Underestimated Potential of Solar Energy to Mitigate Climate Change. Nat Energy 2, 17140 (2017). https://doi.org/10.1038/nenergy.2017.140
[13] Rogelj, J., Popp, A., et al. Scenarios Towards Limiting Global Mean Temperature Increase Below 1.5 °c, Nature Climate Change, 8(4), pp. 325–332 (2018) doi: 10.1038/s41558-018-0091-3.
[14] Weber, C. et al. Mitigation Scenarios Must Cater to New Users, Nature Climate Change, 8(10), pp. 845–848 (2018) doi: 1038/s41558-018-0293-8. Thimet, P. J. and Mavromatidis, G. Review of Model-Based Electricity System Transition Scenarios: An Analysis for Switzerland, Germany, France, and Italy, Renewable and Sustainable Energy Reviews, 159 (2022).
[15] Rogelj, J. et al. A New Scenario Logic for the Paris Agreement Long-Term Temperature Goal, Nature 573(7774), pp.357–363 (2019) doi: 10.1038/s41586-019-1541-4.

2. The climate scenario model type used

The other key factor that can affect the results of climate scenario outputs, even under similar assumptions, is the type of model used in the analysis (its structure and algorithm). Climate models also vary across a number of characteristics[16], ranging from optimization to simulation models, from myopic to perfect foresight models, and from general to partial equilibrium. **Box B** discusses the differences in the models used. That said, the differences stemming from the choice of a climate model could arguably be smaller compared to the impact of using divergent model assumptions.[17]

Box B: Climate models vary by their type

Climate models can differ across three key aspects*: whether they are simulation or optimization models; how they consider time in their analysis; and the extent to which they incorporate economic factors.

The first key difference is whether the climate models used are either simulation or optimization models. Simulations assess the outcomes under different alternative options, while optimization models seek to find a "least-cost" or "maximum welfare" solution to a problem.

The second key difference depends on how climate models consider time in their analysis. Perfect foresight models assume perfect information across their time horizons, in that decisions today and in the future are taken simultaneously, considering the same information. At the same time, recursive-dynamic models adopt a myopic perspective, which means that in each time period they provide a solution without considering the information from the future. There is also a middle way, where models assume adaptive expectations, in that decisions are taken based on the past and currently available information, combined with an imperfect view of the future.

Finally, the third key difference is the extent to which climate models cover the economy. There are partial equilibrium models that only include some sectors, while global equilibrium models aim to represent the whole economy and the interaction of different agents within it. These models might also differ in how they incorporate some of the factors into the analysis. For example, partial equilibrium models tend to treat economic growth exogenously, which means that they do not model growth explicitly within the analysis, but rather import growth assumptions from external models. As a result, partial equilibrium models are not able to capture how GDP might respond to different factors within the analysis, such as climate policies.

All of these differences in model type can impact the "choices" that a model makes. For example, a model with perfect foresight will be more likely to use low carbon technology sooner than a myopic model, as it is able to calculate that low carbon technology is a more cost optimal choice in the long term – considering future carbon prices – compared to only seeing the short-term impact of such a choice. On the other hand, a myopic model has similar information to what we might have in real-life, and so may provide a more realistic view of the choices that are made based on shorter-term thinking.

* IPCC Sixth Assessment Report, Mitigation of Climate Change, 2022

[16] IPCC Sixth Assessment Report, Mitigation of Climate Change, 2022.
[17] Pindyck, R. S. The Use and Misuse of Models for Climate Policy, Review of Environmental Economics and Policy, 11(1), pp. 100–114 (2017) doi: 10.1093/reep/rew012.

How are Climate Value at Risk metrics calculated, and what can the output tell investors?

Similar to financial scenario analysis, Climate Value at Risk (CVaR) metrics provide an estimate of how the value of a portfolio, and the companies within it, may change over time under a given climate scenario. The output from different scenarios can be compared to develop an understanding of how companies could fare under different assumptions. The output for a scenario may be provided relative to the present day or to a baseline where there are no further changes in climate-related policies or physical risk.

CVaR is a complex metric that combines IAMs and financial models, and thus incorporates all of the uncertainty and assumptions within them. It is most useful for risk analysis because users can consider a range of different scenarios and compare the outputs across them. Users often consider a set of scenarios that focus on high physical risk, high transition risk and what they deem to be the most likely scenario. This multi-scenario approach can help users to better understand the range in uncertainty within the models and the scenarios, as well as identify emerging trends in climate-related risks or opportunities.

While CVaR metrics are currently best suited to risk management, they could be useful for decision making in the future. However, at a minimum, improvements in data quality and better transparency over the assumptions used in the methodologies and CVaR models (and the limitations of these assumptions) would be required.

CVaR metrics are usually composed of two driver categories that account for transition-related and physical-related impacts, which themselves are composed of a number of drivers within their categories.

Complexity around transition-related CVaR

Transition-related CVaR takes into account how socioeconomic elements of the climate scenario impact the company, typically considering impacts such as an increasing price of carbon, changes in the cost of low-carbon technologies (such as renewable energy and electric vehicles) and shifts in consumer preferences towards lower-carbon products (for example, resulting from these products becoming relatively cheaper, including due to being subject to lower carbon pricing).

Given the uncertainty around exactly how these changes may play out, it is often most useful to consider the positioning of a company relative to its peers. For example, while two steel companies in the same region may be exposed to the same absolute carbon cost, if one has a lower emissions intensity compared to the other, it will incur relatively lower costs, so it can keep its prices lower, making it more attractive to the consumer. Similarly, as scenarios typically expect a growth in the demand for electric vehicles (EVs), automotive companies with a larger share of the EV market are considered more likely to benefit from increased revenues due to increased sales relative to peers with a smaller market share.

Some transition-related CVaR metrics also take into account company-level targets to reduce emissions intensity or increased sales of low carbon options, such as EVs. By considering cases when the target is and is not met, the output can be used to explore the relative difference in impact under each case, and to better understand if the target is sufficient to mitigate the climate-related risks considered in the analysis.

Underestimation of physical CVaR

Physical-related CVaR, on the other hand, considers how acute and chronic changes in climate are expected to impact a company or portfolio. Typically, the focus is on chronic changes, such as rising temperatures, increased drought and rising sea levels, but increasingly metrics are being developed to try to capture acute risks, such as tropical cyclones, wildfires and floods.

Acute risks are harder to capture in CVaR analysis as the models cannot predict the timing, location or magnitude of a specific event. As such, the analysis is often highly simplified, providing a view of background risk rather than considering the financial impact of an individual high-impact event, and would therefore likely underestimate the potential financial impact from the physical risk perspective. The user of this output must have a clear understanding of what is and is not being captured by the physical risk model and bear this in mind when interpreting the result.

Example CVaR output

As CVaR captures the change in a company's value, aggregating CVaR from the company to the portfolio level is typically a simple weighted sum. **Exhibit 4** shows an illustrative example for transition-based CVaR using a hypothetical equal-weighted portfolio that consists of 20 companies equally split across the automotive, oil & gas, technology and utilities sectors. Each of these sectors will face different challenges in the transition to net zero, as we can see from the range in CVaR values between and within sectors.

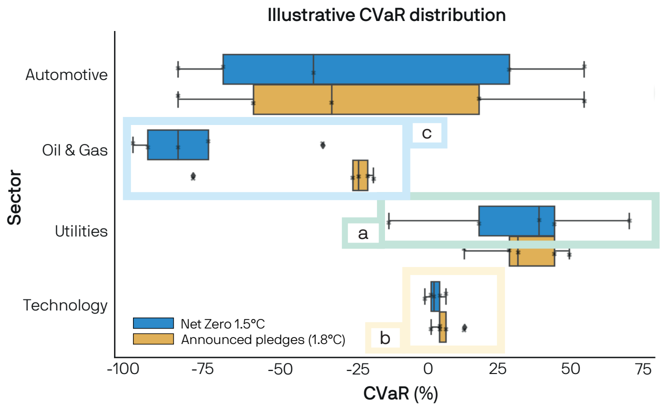
The range of values reflects the assumptions and drivers within the climate scenario models and the CVaR metrics, as well as the differences between companies in terms of their emissions and how well they are positioned to benefit from expected changes under a low carbon transition. By considering CVaR from these different perspectives, users can gain a better understanding of how climate-related risks and opportunities are distributed throughout a portfolio.

Exhibit 4: Illustrative example of how CVaR can be used in practice, using a hypothetical portfolio and CVaR values

Average sector and portfolio CVaR and inter-sector spread

	Mean CVaR 2050 (%)	
Sector	Net Zero 1.5°C	Announced policies
Automotive	-19.00	-7.35
Oil & Gas	c -73.40	-29.80
Technology	b 5.40	8.40
Utilities	a 33.00	34.60
Portfolio	-13.50	-1.84

Here the CVaR is expressed as the value at risk in the given year compared to a business as usual case.

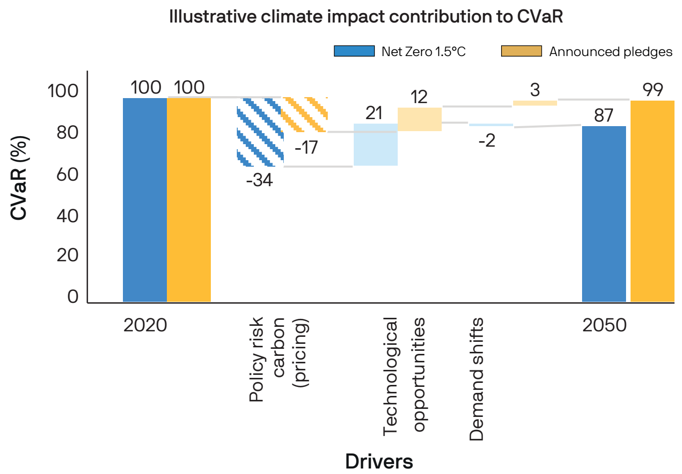


a While the table shows that average CVaR for the Utilities sector is +33%, we can see in the box plot that this ranges from -10% to +70% under a Net Zero scenario.

b On the other hand, the Technology sector is not expected to face significant risks under a transition scenario, and opportunities are likely to look similar to a business-as-usual case, hence mean CVaR and CVaR range between companies is small.

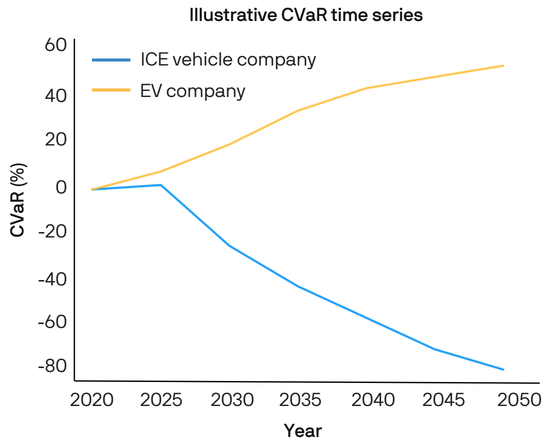
c Comparing CVaR values between scenarios provides you with insights into how differences in the underlying assumptions in each pathway can have an impact on your portfolio. Here we can see that oil and gas companies fare very differently under an ‘Announced Policies’ compared to a ‘Net Zero’ scenario. This will likely be driven by differences in policy assumptions (i.e. carbon pricing) under these two scenarios.

Drivers of CVaR across scenarios



By exploring the drivers of CVaR within each scenario, we can see how these assumptions play out differently in this portfolio. We can see that the value decrease in the Net Zero scenario is largely driven by policy risk. While there are more technological opportunities in this scenario too, which may be driven by increased investment in transitioning technologies, this is not sufficient to outweigh this risk.

CVaR changes over time for a sector



Here we consider CVaR changes over time for two companies in the Automotive sector. Looking at CVaR changes over time highlights key assumptions within the scenario being considered. Here we can see the impact of policies to limit sales of ICE vehicles over the next decade, as well as the consumer shift towards EVs that is already happening.

Source: J.P. Morgan Asset Management. For illustrative purposes only.

How are Implied Temperature Rise metrics calculated, and what can the output tell investors?

Implied Temperature Rise (ITR) metrics are a type of portfolio alignment tool that have recently grown in popularity due to the simplicity of interpreting the output and ease of comparing it to policy outcomes. In general, these metrics try to quantify the expected global temperature rise if the company or portfolio in question was representative of the economy as a whole, with the output being a degree alignment, for example, 1.5°C. These metrics can therefore help to answer questions on company and portfolio alignment, such as: "Is this portfolio Paris aligned?"; or "Is this company net zero aligned?".

A company-level ITR is typically calculated by considering how much the total emissions of a company overshoot or undershoot the total emissions that the company is allowed to emit under a particular scenario, such as a 1.5°C net zero pathway. This emissions allowance is usually referred to as the benchmark. Tools will often include company-level emissions reduction targets, and they will usually make the assumption that these targets are met. For companies without emissions reduction targets, methodologies tend to use either a default value based on an expectation of current policy outcomes (for example, 2.7°C) or an emissions projection based on historical trends.

Divergent ITR methodologies

Users of ITR metrics should be aware that methodologies are currently highly divergent[18] and that a given company can have a very different rating when different methods are used. Although recent efforts have been made to provide a set of guiding recommendations that outline best practice[19] in order to reduce this divergence, not all methodologies are currently provided with details on the extent to which this guidance has been followed and no methodologies currently follow the guidance in full.

Users should be aware of the assumptions being made in the ITR metric they are using when looking at the output and the consequences of its interpretation. For example, one of the recommendations is to calculate ITR metrics using a single scenario benchmark, rather than constructing a benchmark based on several scenarios (often referred to as a warming function). While this recommendation makes it easier to understand and compare the output, it also means that the output will inherit all of the assumptions made within the chosen scenario, and will therefore be highly dependent on those assumptions. Other key guidance covers the use of forward-looking emissions estimates, the metric used to measure company performance against the chosen benchmark, and the scope of emissions to include in the assessment.

Aggregation of ITR to portfolio level

Once a company level ITR has been calculated, there are several ways in which this metric can be aggregated to the portfolio level. The two most common approaches are the aggregate budget approach and the weighted average approach. The aggregate budget approach is the most scientifically robust method, but also the most complex to calculate. Aggregation works in a similar way to the company-level methodology in that it is based on how much the portfolio's emissions overshoot or undershoot a benchmark. The portfolio emissions are calculated by considering the amount of a company's emissions that are "owned" by the portfolio, and the benchmark is constructed using the same relative share of each company's emissions budget.

A simpler method is the weighted average approach, which most closely links with existing financial concepts, and is the best option for those wanting to optimise for capital allocation decisions. This aggregation works by apportioning the ITR of the company within the portfolio based on the company's weight in the portfolio. The weighted ITR values can then simply be summed to give the portfolio ITR.

18 Measuring Portfolio Alignment, Portfolio Alignment team: https://www.tcfdhub.org/wp-content/uploads/2020/10/PAT-Report-20201109-Final.pdf
19 Measuring Portfolio Alignment: Technical considerations, Portfolio Alignment Team: https://www.tcfdhub.org/wp-content/uploads/2021/10/PAT_Measuring_Portfolio_Alignment_Technical_Considerations.pdf

Example ITR output

Exhibit 5 provides an illustrative example of the ITR metric for a portfolio and its constituents. We consider a portfolio that is not net zero aligned, and which is made up of three companies that are representative of how companies are currently viewed by these types of tools. The impact of company targets and the different aggregation approaches can clearly be seen.

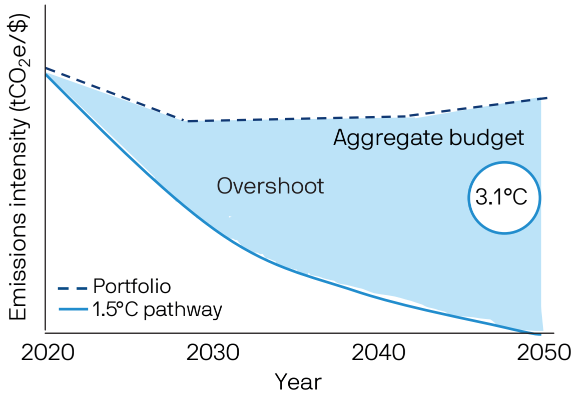
Exhibit 5: Illustrative example of an ITR estimate for a portfolio and three constituent companies

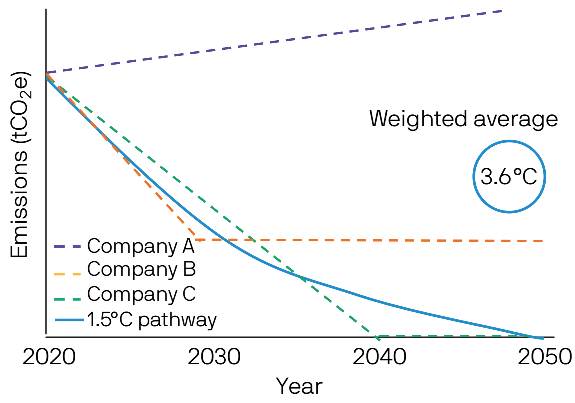
Not "Net Zero aligned"

This illustrative portfolio is comprised of three types of companies, detailed below:

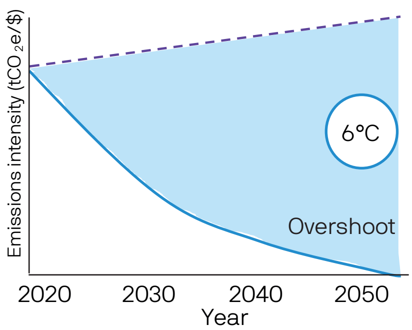
- Company A: No emissions reduction target, so historical emissions growth rates are assumed
- Company B: Short term emissions reduction target to 2030 only, and flat emissions assumed after this
- Company C: Net zero target for 2040

The portfolio is not Net Zero aligned when using either portfolio aggregation approach, as it overshoots the 1.5 °C pathway in all years due to a lack of long-term emission reduction targets.

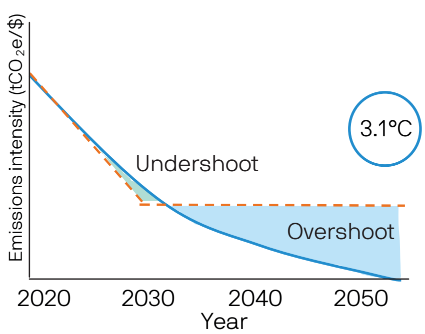




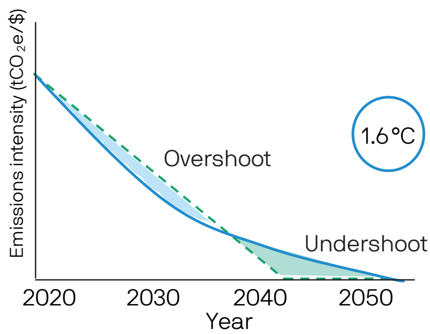
Company A



Company B



Company C



Not "Net Zero aligned"

Company A overshoots the 1.5 °C compatible emissions pathway in all years, and therefore also exceeds the emissions budget.

Not "Net Zero aligned"

Company B is in-line with the 1.5°C pathway until 2030, and even undershoots the pathway briefly. However, since it does not have a long-term emissions reduction target, it ends up overshooting the emissions budget when considering total expected emissions to 2050.

"Net Zero aligned"

Company C overshoots the 1.5 °C pathway in the early years, but undershoots from the mid 2030's. Despite slower initial emissions reductions than Company B, the long-term target results in almost no overshoot of the company's emissions budget.

Source: J.P. Morgan Asset Management. For illustrative purposes only.

Conclusion

Climate scenario analysis is becoming an increasingly important consideration for asset managers due to demand from regulators to better understand their exposure to climate-related risks and opportunities, and because of the need to take action towards achieving net zero targets.

A range of scenarios and tools have been developed for the specific purpose of better quantifying the interaction between climate change and companies. Having a good understanding of the assumptions used in climate models, including their limitations and uncertainties, is important when interpreting outputs from these types of analyses. Over time, the available tools and data are expected to increase in both quality and quantity. By starting to use the existing tools, users can be best positioned to enhance their capabilities and incorporate these new developments.

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