Integrating Climate Scenario Analysis into the Investment Process
Summary

Climate change poses significant risks to the global economy. However, it is inherently difficult to accurately predict how climate change could impact an investment portfolio for three primary reasons:

1. Investment horizons are typically much shorter than climate impact timescales
2. Climate impacts are highly uncertain and climate science is constantly evolving
3. It is difficult to relate non-financial factors such as greenhouse gas emissions directly to financial outcomes.

To address these challenges, investors are increasingly turning to quantitative climate scenario analysis, which can help explore the portfolio-level impacts of transition risks relating to decarbonization and physical risks such as hurricanes, extreme heat and wildfires.

In this report, the Institute for Sustainable Investing outlines how investors can integrate climate scenario analysis into the investment process, including key considerations, outputs and use cases. We also offer a case study leveraging Morgan Stanley’s in-house climate scenario analysis capabilities to explore the implications of two potential pathways for moving towards net-zero by 2050 with varying levels of available carbon capture and storage (CCS) technology.

SUMMARY

1. Understanding Climate Scenario Analysis for Investors
   - What is Climate Scenario Analysis?
   - Why Should Investors Consider Conducting Climate Scenario Analysis?
   - How Do Investors Conduct Climate Scenario Analysis?
   - Key Considerations for Effective Climate Scenario Analysis

2. A Case Study: Two Paths to a 2°C World

3. Appendix: Further Detail on Scenario Design and Integrated Assessment Models
Key Takeaways for Investors

There is demand for this innovative approach.
The Institute’s 2022 Sustainable Signals survey found that over half of asset owners wanted asset managers to conduct climate scenario analysis but less than one third could provide it. It is also increasingly viewed as best practice under disclosure frameworks like the Task Force on Climate-Related Financial Disclosures (TCFD) and by financial regulators.

Physical risks may be systematically underestimated.
As with other uses of scenario analysis, climate scenarios are helpful to explore questions rather than give definitive answers. Climate scientists increasingly emphasize that the physical impacts of climate change can be exponential and possibly irreversible if tipping points are reached in certain ecosystems. However, this is not well captured in existing models. As a result, investors should be mindful that physical risks may be systematically underestimated.¹

Quantitative climate scenario analysis brings important structure.
Climate change is inherently challenging for investors to analyze. Even with their limitations, quantitative climate scenarios that use computer models are the only methodical way to challenge preconceptions and explore connections between environmental factors (e.g., greenhouse gas emissions) and financial factors (e.g., GDP, carbon prices and energy prices). This quantitative approach can yield new insights and potentially turn risks into opportunities.

Potential uses for climate scenario analysis could include:
- **Adjusting company earnings projections**: Carbon prices could be applied to company or industry emissions to understand the potential impact to earnings
- **Sizing a market**: Running scenarios on a new technology could help to understand the potential addressable market
- **Informing macroeconomic views**: Energy prices could impact inflation or consumer spending assumptions in a macroeconomic model
- **Analyzing long-run demand sensitivity**: Energy demand and mix outputs could illustrate how long-run demand could play out for different energy sources
- **Exploring geographical differences or geopolitical issues**: Countries or regions over- or under-indexing to one type of energy generation could have different outcomes; trade tariffs and barriers between countries could inform views on currency or asset allocation

¹ A recent paper from the Institute and Faculty of Actuaries in the UK examined the use of climate change scenarios in financial services, and noted: “Current techniques exclude many of the most severe impacts we can expect from climate change, such as tipping points and second order impacts – they simply do not exist in the models.” “The Emperor’s New Climate Scenarios”, July 2023, by Sandy Trust, Sanjay Joshi, Tim Lenton and Jack Oliver the-emperor-s-new-climate-scenarios_ifoa_23.pdf (actuaries.org.uk)
Understanding Climate Scenario Analysis for Investors

Many institutional investors are likely already using some form of scenario analysis to understand portfolio exposure to certain market or macro risks. Considering system-wide impacts from climate change can help investors gain a more holistic understanding of their portfolio risks, especially investors with longer than average investment horizons, with exposure to a wide range of sector and asset classes or with a focus on high-emissions sectors.

What is Climate Scenario Analysis?

Climate scenario analysis is the process of using specialized computer models to explore a variety of plausible futures across climate impacts and time horizons to help understand a wide range of risks and opportunities (Figure 1). Climate scenario analysis does not assess the likelihood of future events happening.

Examples of climate futures include:

(1) A future in which we limit the rise in global temperatures to 1.5°C or well below 2°C above pre-industrial levels with greater transition risks expected;

(2) A future where we do not meet this target and temperatures increase by 3°C or more from preindustrial levels, resulting in more severe physical risks.

Each of these futures will have different political, economic, social, technological and environmental considerations. As a result, the global economy in each scenario is likely to look different in the future.

Climate scenario analysis can be useful for many financial market participants, including asset managers, asset owners, banks and corporates. While it is not a precise prediction for how the future will play out for the macro economy, investment portfolios or individual securities, it can be a useful quantitative approach for exploring the highly complex interactions between carbon emissions, populations, environmental factors and economies.

FIGURE 1

Climate Scenario Analysis


* Transition risks are those associated with businesses transition to a low-carbon economy. Transitioning requires policy and legal, technology and market changes to address the mitigation and adaptation requirements related to climate change, which could pose varying levels of financial and reputational risk to organizations.
Why Should Investors Consider Conducting Climate Scenario Analysis?

1. **Explore Key Variables Across a Range of Financial and Non-Financial Themes**

Understanding how climate change and the energy transition could affect companies, sectors and markets provides new insights for investors. Scenario analysis provides a quantitative way to consider how thousands of political, economic, social, technological and environmental variables could interact over time. Figure 2 shows an illustrative list of some commonly used variables across these areas.

2. **Meet Investor Demand**

A 2022 Institute survey of institutional investors found that over half of asset owners wanted asset managers to conduct climate scenario analysis, yet less than one third could provide it—one of the largest gaps between investor demand and manager capabilities in the survey (Figure 3). This suggests that providing climate scenario analysis results could be a differentiator for asset managers.

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**FIGURE 2**

**Commonly used scenario variables across a range of themes**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>POSSIBLE VARIABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy</td>
<td>- Net or gross CO₂ and sequestration split by industry sector, technology and/or geography&lt;br&gt;- Carbon pricing (market driven, government mandated or both)&lt;br&gt;- International trade tariffs</td>
</tr>
<tr>
<td>Economy</td>
<td>- GDP&lt;br&gt;- Investment in technologies and intellectual property&lt;br&gt;- Foreign direct investment&lt;br&gt;- Income elasticity for products such as fossil fuels&lt;br&gt;- Energy prices</td>
</tr>
<tr>
<td>Social</td>
<td>- Population, split by region, age, and urban/rural&lt;br&gt;- Energy demand&lt;br&gt;- Food and meat demand&lt;br&gt;- Land productivity for crops and livestock&lt;br&gt;- Social acceptance for fossil fuels</td>
</tr>
<tr>
<td>Technology</td>
<td>- Energy efficiency factor&lt;br&gt;- Carbon capture and storage availability&lt;br&gt;- Energy mix (fossil fuels vs. renewables)&lt;br&gt;- Technical change in fossil fuel extraction costs&lt;br&gt;- Cost of renewable generation</td>
</tr>
<tr>
<td>Environment</td>
<td>- Temperature change above pre-industrial levels&lt;br&gt;- Forest spread changes&lt;br&gt;- Negative emissions from bioenergy</td>
</tr>
</tbody>
</table>

Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023). The list of variables is not exhaustive.

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**FIGURE 3**

**Our Sustainable Signals survey found that more than half of asset owners want climate scenario analysis but less than one third of asset managers provide it**

![Climate Scenario Analysis Demand vs. Supply](chart.png)

- **Asset Owner Demand**: 51%
- **Asset Manager Provision**: 29%

Meet Current and Future Regulatory Requirements

Conducting climate scenario analysis is a recommendation of the Task Force on Climate-Related Financial Disclosures (TCFD) for both corporates and investors. TCFD “believes that scenario analysis is a useful and important tool for an organization to use both for assessing potential business-related implications of climate-related risks and opportunities, and for informing stakeholders about how the organization is positioning itself.”

Despite this, implementation of climate scenario analysis, as outlined in the “Resilience of Strategy” recommendations, has consistently been the lowest of all recommendations, with only 11% of corporates participating in 2022 (Figure 4). This could be due to the complexities involved. However, these rates are growing as more corporates adopt best practice and certain jurisdictions have or are considering implementation of mandatory TCFD-aligned reporting, including climate scenario analysis.

FIGURE 4

TCFD’s ‘Resilience of Strategy’ recommendations, which covers climate scenario analysis, has the lowest take-up rate among corporates

<table>
<thead>
<tr>
<th>TCFD RECOMMENDATION</th>
<th>RECOMMENDED DISCLOSURE</th>
<th>PERCENT OF COMPANIES DISCLOSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>a) Board Oversight</td>
<td>39% 64%</td>
</tr>
<tr>
<td></td>
<td>b) Management’s Role</td>
<td>23% 44%</td>
</tr>
<tr>
<td>Strategy</td>
<td>a) Risks and Opportunities</td>
<td>36% 62%</td>
</tr>
<tr>
<td></td>
<td>b) Impact on Organization</td>
<td>26% 43%</td>
</tr>
<tr>
<td></td>
<td>c) Resilience of Strategy</td>
<td>4% 11%</td>
</tr>
<tr>
<td>Risk Management</td>
<td>a) Risk ID and Assessment Processes</td>
<td>14% 36%</td>
</tr>
<tr>
<td></td>
<td>b) Risk Management Processes</td>
<td>19% 39%</td>
</tr>
<tr>
<td></td>
<td>c) Integration into Overall Risk Management</td>
<td>11% 25%</td>
</tr>
<tr>
<td>Metrics and Targets</td>
<td>a) Climate-Related Metrics</td>
<td>58% 66% 71%</td>
</tr>
<tr>
<td></td>
<td>b) Scope 1, 2, 3 GHG Emissions</td>
<td>50% 60% 66%</td>
</tr>
<tr>
<td></td>
<td>c) Climate-Related Targets</td>
<td>42% 59% 66%</td>
</tr>
</tbody>
</table>

Source: TCFD (Nov. 2023)

2 The Use of Scenario Analysis in Disclosure of Climate-related Risks and Opportunities – TCFD Knowledge Hub (tcfdhub.org)
3 Climate Scenarios: Understanding Use Cases, Limitations and Implications for Investors (sustainablefitch.com)
How Do Investors Conduct Climate Scenario Analysis?

There are many ways to analyze climate scenarios. At the simplest end of the spectrum, TCFD notes that most investors currently fulfilling this disclosure recommendation provide qualitative commentary on one or two broad scenarios. At the most complex, multiple computer models could be run together to generate a highly nuanced set of possible outcomes for quantitative analysis. In this section, we overview a process for investors seeking a more quantitative approach and highlight the important decisions investors will need to make in each step.

FIGURE 5

Key Stages in Climate Scenario Analysis

Set the Question
Select the relevant variables

Build the Scenarios
Decide between industry standard or custom scenarios

Conduct Analysis
Use Integrated Assessment Models (IAMs) to run the analysis

Use Outputs
Analyze outputs through a top-down portfolio analysis or a bottom-up company analysis


Task Force on Climate-related Financial Disclosures: 2022 Status Report
Set the Question

First, investors need to define what question they want to ask. This will inform how the scenarios are constructed, which variables need to be flexed or held constant, as well as the desired outputs.

For example, an investor might want to ask, “How could my portfolio react to a carbon tax?”

For this question, the key variable to flex would be government-mandated carbon pricing. Variables like population and GDP would be kept constant to allow the model to generate different outputs for energy demand and supply, energy mix and commodity prices.

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**FIGURE 6**

Key variables for considering how a carbon tax could impact a portfolio

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>VARIABLES* TO FLEX, KEEP CONSTANT, ALLOW MODEL TO CALCULATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy</td>
<td>• Carbon pricing (market driven, government mandated or both) &lt;br&gt;• International trade tariffs &lt;br&gt;• Net or gross CO₂ and sequestration split by industry sector, technology and/or geography</td>
</tr>
<tr>
<td>Economy</td>
<td>• GDP &lt;br&gt;• Investment in technologies and intellectual property &lt;br&gt;• Foreign direct investment &lt;br&gt;• Income elasticity for products such as fossil fuels &lt;br&gt;• Energy prices</td>
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<tr>
<td>Social</td>
<td>• Population, split by region, age, and urban/rural &lt;br&gt;• Energy demand &lt;br&gt;• Food and meat demand &lt;br&gt;• Land productivity for crops and livestock &lt;br&gt;• Social acceptance for fossil fuels</td>
</tr>
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<td>• Energy efficiency factor &lt;br&gt;• Carbon capture and storage availability &lt;br&gt;• Energy mix (fossil fuels vs. renewables) &lt;br&gt;• Technical change in fossil fuel extraction costs &lt;br&gt;• Cost of renewable generation</td>
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<td>Environment</td>
<td>• Temperature change above pre-industrial levels &lt;br&gt;• Forest spread changes &lt;br&gt;• Negative emissions from bioenergy</td>
</tr>
</tbody>
</table>

*KEY VARIABLES: ● FLEX ● KEEP CONSTANT ● ALLOW MODEL TO CALCULATE


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5 Carbon prices can be used to model different carbon policies and market mechanisms, enabling the model to encompass both regulatory and voluntary carbon markets.
Investors can either choose pre-defined scenarios—industry standard scenarios—provided by organizations such as the Network for Greening the Financial System (NGFS) and the International Energy Agency (IEA) or build their own custom scenarios. This decision will depend on the question, the variables needed and the resources available. Exhibit A in the Appendix covers the differences between industry standard and custom scenarios in more detail, while Figure 9 covers key considerations when deciding between the two options.

The example question of “How could my portfolio react to a carbon tax?” would likely require a custom scenario to allow ‘carbon tax’ to be an input assumption. Most industry standard options calculate the carbon price as an output adjusted to a climate goal.

There are many ways investors could approach scenario building for this question. One option could be comparing the three following scenarios:

1. A control scenario with no carbon tax
2. A carbon tax of $50/ton of CO₂, beginning in 2025 and increasing at a rate of 3% per year. This mimics the application in countries with an existing carbon price
3. A carbon tax of $150/ton of CO₂, beginning in 2030 and staying constant for 20 years. Two scenarios might be sufficient, but adding a third option could give additional insight into how sensitive outputs are to timing and the absolute tax level

Addressing this question would also need to consider whether to assume a global carbon tax (unrealistic, but relatively simple) or different regional approaches (more realistic, but more complex as this would also require assumptions for global tariffs and trade flows).
3 Conduct Analysis

Once the scenarios are built, the relevant inputs are then run through one or more mathematical computer models—usually Integrated Assessment Models (IAMs). IAMs model the relationship between greenhouse gas emissions and social and economic factors. Several different IAMs are available, all of which can materially differ in their underlying assumptions. See Exhibit B in the Appendix for more information on IAMs.

- For industry standard scenarios, the analysis step has been completed already by the scenario provider. It is helpful for investors to identify and understand which assumptions have been applied and which IAMs have been used because these can have a significant effect on the results.

- If using custom scenarios, investors would then need to run their own analysis with input from experts who understand how IAMs work. These are highly complex models with different starting points and markedly different in-built assumptions, such as global energy mix.

When considering the “How could my portfolio react to a carbon tax?” question, the analysis could benefit from using more than one IAM to give a broader spread of outcomes assuming this is within the investor’s capabilities and budget. Otherwise, investors should note that using a single IAM effectively builds in an element of model risk. As a result, some caution should be exercised if using absolute numbers for the outputs rather than only comparing the relative differences.

![Figure 7: Using industry standard scenarios or building custom ones](source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).)
Considering the “How could my portfolio react to a carbon tax?” question, investors could:

- **Adjust company earnings:** Carbon prices could be used to estimate earnings impact, relative to company or industry emissions

- **Analyze long-run demand sensitivity:** Energy demand and mix outputs could illustrate how long-run demand could play out for different energy sources

- **Inform macroeconomic views on consumer spending or debt service:** Energy prices could be applied to household budgets to understand a knock-on effect on consumer discretionary spending or ability to service debt

- **Estimate broad inflationary or deflationary factors:** Energy prices could be used in a macroeconomic model as a broad inflationary or deflationary factor

### FIGURE 8

**Potential scenario outputs include prices, supply/demand volumes and trade flows**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>POSSIBLE IAM OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices</td>
<td>Energy prices by region and by fuel type&lt;br&gt;Carbon price&lt;br&gt;Food prices&lt;br&gt;Water price&lt;br&gt;Agriculture and forestry commodity prices</td>
</tr>
<tr>
<td>Trade</td>
<td>Energy imports/exports&lt;br&gt;Water imports/exports&lt;br&gt;Agriculture and forestry imports/exports</td>
</tr>
<tr>
<td>Emissions</td>
<td>CO₂/GH emissions by end-use energy sectors&lt;br&gt;CO₂/GH emissions by fuel type&lt;br&gt;Non GHG emissions&lt;br&gt;Land use change emissions</td>
</tr>
<tr>
<td>Quantity</td>
<td>Energy demand/supply/production/consumption&lt;br&gt;Water demand/supply/production/consumption&lt;br&gt;Agricultural demand/supply/production/consumption&lt;br&gt;Carbon capture and storage (CCS) volumes&lt;br&gt;Investment funds</td>
</tr>
<tr>
<td>Land</td>
<td>Land use by sector&lt;br&gt;Water withdrawals&lt;br&gt;Land cover&lt;br&gt;Carbon fluxes (change in above/below ground)</td>
</tr>
</tbody>
</table>

Key Considerations for Effective Climate Scenario Analysis

In the previous section, we highlighted that the nature of the question is important because it informs the decisions made in the following stages of the scenario design and analysis process. Below, we outline what we see as the primary trade-offs that investors may also need to navigate throughout this process.

**FIGURE 9**

**Considerations for scenario selection or design**

The primary consideration for investors to balance is between limited resources and the granularity they might want in the climate scenario analysis process. Many of the other trade-offs we highlight below could probably be best resolved by adding more options, including adding custom scenarios to industry standard ones or using more than one IAM. However, these solutions require more resources, particularly as deep expertise in climate science could be outside the scope of many investors.

Climate scientists increasingly emphasize that the physical risks of climate change are not linear. If rising temperatures drive a particular ecosystem to a tipping point, the rate of climate change and associated physical risks could accelerate rapidly. However, tipping points are a comparatively new idea in climate science and may be systematically underestimated in many of the models available today.

Industry standard scenarios can be used with fewer resources and are widely recognized by various market players. However, they offer less flexibility in scenario design and less transparency in terms of the underlying assumptions. See Exhibit A for more detail.

Lower temperature outcome scenarios focus more on transition risks, while higher temperature outcome scenarios focus more on physical risks. In existing models, physical risks are more pronounced after 2050, a challenge for 30-year projections. As noted above, existing models may systematically understate the physical impacts of climate change. Even if the primary focus is on transition risks, TCFD recommends that investors also include a higher temperature outcome scenario as best practice.

Some scenarios focus on one or very few variables to understand sensitivities to those variables, such as exploring the impacts of various carbon prices. Other scenarios focus on global system-wide impacts and require modelling of multi-variable impacts.

Some scenarios are better suited for certain sector analysis. For example, IEA scenarios focus more on energy-specific drivers, while other scenarios may put more emphasis on socioeconomic factors or policy.

A short-term scope may enable the use of assumptions that are more accurate or based on historical patterns, especially for transition risks. A longer-term scope is useful when considering physical risks since the impacts are generally expected to manifest over many years.

Although scenario analysis is not forecasting, it is possible to create more likely scenarios using underlying assumptions that could be more realistic. Scenario analysis is also useful in exploring futures that are difficult to project today, similar to the COVID-19 pandemic, so using scenarios to explore tail risks is also a useful exercise.

Up front shocks and non-benign impacts may be more relevant if risk management is the primary consideration, while mid-term opportunities could drive strategy decisions.
A Case Study: Two Paths to a 2°C World

At Morgan Stanley, we have developed our own in-house climate scenario capabilities to extend analyses beyond standard IAMs and include more granularity for macroeconomic, sectoral and portfolio-level insights. In this case study, we show how this enables us to explore the implications of different pathways leading to the same outcome based on carbon capture and storage (CCS) availability.

Exploring High and Low Carbon Capture and Storage (CCS) Availability

We chose to explore two scenarios with the same temperature outcome (a 2°C increase in global temperatures vs. pre-industrial levels by 2100) but with different pathways for the adoption of carbon capture and storage (CCS).6 In this example, we hold other variables constant, notably the overall temperature outcome, as well as population, GDP, net emissions caps and energy intensity. It would be possible to add more scenario drivers for a more detailed picture, if desired.

THREE WAYS THAT AN INVESTOR COULD USE THIS SCENARIO IN PRACTICE

1. Explore potential ranges of demand for CCS to value possible investments exposed to these markets
2. Consider how electricity prices could impact household spending, with broad macroeconomic implications
3. Use the carbon price outputs to adjust company or sector earnings depending on emissions intensity

6 Carbon Capture and Storage (CCS) technologies are used to remove CO2 before, during or after combustion of fossil fuels or biomass at power plants, refineries and other industrial facilities.
In the **High CCS Scenario**, the lower cost of onshore storage and higher availability of offshore storage beginning in 2020 enables CCS to deliver 23 Gt CO₂ of sequestration by 2050. The **Low CCS Scenario** sees higher costs and lower storage potential, enabling only 15 Gt in 2050—around one third lower. The key difference is the amount of CCS used in electricity generation, with other energy and industrial sources mostly similar. Both Scenarios assume relatively high 2050 CCS rates above some commonly used net-zero scenarios such as those from NGFS, but not outside the high end of the range of assumptions in academic literature.

Putting these numbers in context, in 2022, CCS sequestrated just 45 Mt of CO₂ globally (0.2% of our 2050 High CCS Scenario figure). The International Energy Agency (IEA) notes that announced projects could increase sequestrated amounts to 383 Mt per year by 2030.\(^7\) While this implies rapid growth, it is still off track for the required sequestration needed to reach many net-zero scenario assumptions.

Both Scenarios assume as close to net-zero carbon emissions as possible by 2050, with policy inputs like regulatory caps on emissions held constant between the two Scenarios. As a result, the outputs explore market-driven impacts on other factors such as electricity prices. Exhibit C in the Appendix has additional technical detail on inputs and scenario design.

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**FIGURE 10**

**Differences in storage availability and cost drive a ~30% delta between 2050 CCS rates, excluding bioenergy**

<table>
<thead>
<tr>
<th>Carbon Capture and Storage, Mt CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
</tr>
<tr>
<td>Low CCS Scenario</td>
</tr>
<tr>
<td>High CCS Scenario</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>-5,000</td>
</tr>
<tr>
<td>-10,000</td>
</tr>
<tr>
<td>-15,000</td>
</tr>
<tr>
<td>-20,000</td>
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<td>-25,000</td>
</tr>
<tr>
<td>-30,000</td>
</tr>
<tr>
<td>-35,000</td>
</tr>
<tr>
<td>-40,000</td>
</tr>
</tbody>
</table>


\(^*\) Carbon capture and storage amounts are plotted as negative to contrast with positive emissions. This does not suggest direct reduction of existing CO₂ in the atmosphere.

\(^7\) *Carbon Capture, Utilisation and Storage – Analysis – IEA.* Also note that there can be confusion in the unit of measurement for carbon capture, as some sources show the weight in C (carbon), and others in CO₂ (carbon dioxide). We use CO₂ throughout, which can be converted to C by multiplying by 0.27.
Key Global Results

HIGHER CCS AVAILABILITY SEES HIGHER TOTAL EMISSIONS BUT SIMILAR NET EMISSIONS

Net emissions in both Scenarios are around 4Gt in 2050, consistent with the same 2°C temperature outcome (our scenario design required this of the model). However, total emissions are higher in the High CCS Scenario, at 27Gt compared to 20Gt in the Low CCS Scenario. This represents around a 40% difference.

Compared to the model’s 2020 figures, total emissions fall by one third in the High CCS Scenario and by half in the Low CCS Scenario. The rest of the decline in net emissions is driven by CCS.

CHEAPER CCS DRIVES A LOWER CARBON PRICE

The High CCS Scenario results in a 2050 carbon price of ~$750/tCO₂, while the Low CCS Scenario carbon price is sharply higher at ~$1,100/tCO₂. This reflects our scenario design that the High CCS Scenario saw higher CCS storage availability and cheaper costs.

In both Scenarios, the carbon price rises steadily between 2025 and 2040 as the cheaper options for CCS are utilized first. This peaks sharply in 2050/2055 (reflecting the use of more expensive CCS methods), before stabilizing from 2065 onwards. The High CCS Scenario carbon price is around 30% lower than the Low CCS Scenario.

FILE FIGURE 11

Higher CCS availability saw c.40% more total emissions

FILE FIGURE 12

Both Scenarios generate high carbon prices, peaking mid-century and then stabilizing. More expensive CCS in the Low CCS Scenario drive a higher carbon price.⁸


* The net negative contribution from bioenergy is reflected in the net emissions line. The difference between Total and Net CO₂ emissions for each Scenario is composed of the CCS amount and additional negative emissions from growing biomass for bioenergy.

⁸ Carbon prices in GCM represent the societal carbon price (see Exhibit B in the Appendix) and can be used to model different carbon policies and market mechanisms, enabling the model to encompass both regulatory and voluntary carbon markets. For example, the carbon price variable has been used to implement policies or market mechanisms such as cap-and-trade, CO₂ and non-CO₂ linked market, land carbon offsets, etc. In this model design, we applied an emission constraint and the model solved for the carbon price that satisfies the constraint, simulating market forces. Note that land use carbon prices are not presented here and are different from those shown in Figure 12.

⁹ Both scenarios result in carbon prices rising steeply between 2030 and 2050. Academic work conducted with similar parameters also results in very high carbon prices. See Exhibit C in the Appendix for detailed references.
INTEGRATING CLIMATE SCENARIO ANALYSIS INTO THE INVESTMENT PROCESS

What Are the Implications for U.S. Energy Companies?

The electricity price outputs are similar in both scenarios despite differences in demand, cost and mix of generation sources. Higher CCS availability could enable some types of fossil fuels to make a higher contribution to the primary energy mix for longer, as CCS means that the increased emissions from doing so can be partly offset.

U.S.-SPECIFIC OUTPUTS SHOW:

- **High CCS results in greater use of coal for power generation.** Coal makes up 9% of the primary energy mix in 2050 in the High CCS Scenario, but only 4% with Low CCS (both down on around 15% in 2020). Wind makes up most of the difference.

- **Demand for total energy falls further with lower CCS.** Total energy consumption falls compared with 2020 levels in both Scenarios, as they push to decarbonize by reducing demand more than what offsets the increased energy needed to power CCS. This is more pronounced with lower CCS (primary energy consumption down -12% vs. 2020 levels in the Low CCS Scenario, compared with -6% for High CCS).

- **Shifts in energy mix mean electricity prices are little changed overall, despite the increase in power production.** Although electricity generation from fossil fuels is relatively cheaper in the High CCS Scenario, both wind and solar are the cheapest in both Scenarios. The Low CCS Scenario has a higher use of renewable energy, offsetting the relatively higher cost of fossil fuel sources, while providing 5% higher electricity output. Overall, the High CCS Scenario put U.S. electricity prices at $54/GJ, with the Low CCS Scenario at $55/GJ.

Morgan Stanley’s climate Scenario capability includes linking the IAM with macro factors to analyze how IAM outputs impact the broader economy. For example, the 5% higher total electricity output in the Low CCS scenario leads to a ~3% increase in revenues for the U.S. utilities sector. This revenue increase is responsible for ~0.6% higher employment in this sector, which translates to ~0.03% higher total consumption and up to 0.04% increase in U.S. GDP. While these results may appear small and potentially immaterial, they can have material influence across the economy and in other sectors, especially manufacturing and mining.

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10 Primary energy refers to energy in the form it is first accounted for, before any transformation. In the example of coal used to generate electricity, coal would be primary energy and electricity secondary energy. Primary energy also includes petroleum and biofuel consumption, alongside a variety of electricity generation methods.
FIGURE 13

Key Charts on U.S. Energy

U.S. Primary Energy Mix

Total U.S. Primary Energy Consumption, EJ

U.S. Electricity Generation Costs by Fuel Type, Current USD/GJ

Total U.S. Electricity Generation, EJ

Conclusion: How These Case Study Outputs Could Be Used Today

The outputs from this case study show how climate scenario analysis enables us to explore the implications of different pathways for moving towards net-zero by 2050 based on varying levels of carbon capture and storage (CCS) availability and the impact on variables such as total and net emissions, the global carbon price, electricity generation and primary energy mix. As a result, investors could leverage these outputs to:

1. **Evaluate long-term fossil fuel demand as CCS innovation progresses**
2. **Consider the impact of carbon prices in bottom-up company analysis**
3. **Understand the potential change in electricity prices**
4. **Inform macroeconomic views based on the inflationary/deflationary impacts of CCS**

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1. **Delivering insights** to inform and empower investors and corporates on sustainable finance trends and thematic issues such as climate change, nature and biodiversity, sustainable consumption and production and inclusive growth.
2. **Driving innovation** by leveraging the Firm’s experience and market perspective to advance the field of sustainable investing, including our Sustainable Solutions Collaborative and annual Sustainable Finance Summit.
3. **Developing the next generation of sustainable investing leaders** through strategic partnerships and programs, such as the Sustainable Investing Fellowship and Kellogg-Morgan Stanley Sustainable Investing Challenge.

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Appendix: Further Detail on Scenario Design and Integrated Assessment Models

Exhibit A: Industry Standard Scenarios vs. Custom Scenarios

<table>
<thead>
<tr>
<th></th>
<th>BENEFITS</th>
<th>LIMITATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INDUSTRY STANDARD SCENARIOS</strong></td>
<td>Does not usually require deep expertise in climate science and therefore may be more suitable to investors with limited technical resources</td>
<td>May not provide all relevant output variables or the ability to customize the scenario or assumptions in line with investor views</td>
</tr>
<tr>
<td></td>
<td>Widely used, so may already be well understood by corporates or other stakeholders</td>
<td>Data like energy mix or energy prices may not be fully up to date. Due to differences in construction, it may not be possible to do a direct comparison between two industry standard scenarios from different providers</td>
</tr>
<tr>
<td><strong>CUSTOM SCENARIOS</strong></td>
<td>More control over scenario design, including determining the underlying assumptions. It is also possible to have scenarios that better account for recent events, such as capturing the sharp increase in energy prices since mid-2021</td>
<td>Requires specialized input with experience using IAMs, either in-house or from a third party, to generate robust scenarios and conduct the IAM work</td>
</tr>
<tr>
<td></td>
<td>Geographical differences can be captured, generally not offered by industry standard</td>
<td></td>
</tr>
</tbody>
</table>
Figure 14 provides an overview of industry standard scenario options. As these were developed by different organizations, there are natural variations in the assumptions and inputs, as well as in the underlying climate or economic models used. According to a 2021-2022 survey conducted by the UK Financial Conduct Authority, the NGFS scenarios and the IPCC scenarios were the most widely used by financial firms at around one third each.

**FIGURE 14**

**Key Industry Standard Scenarios**

<table>
<thead>
<tr>
<th>PROVIDER</th>
<th>MAIN SCENARIOS</th>
<th>TEMPERATURE OUTCOME</th>
<th>KEY CONSIDERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intergovernmental Panel on Climate Change (IPCC)</strong></td>
<td>SSP 1-1.9</td>
<td>1.6°C</td>
<td>• Combines Shared Socio-economic Pathways (SSPs) with climate outcomes</td>
</tr>
<tr>
<td></td>
<td>SSP 1-2.6</td>
<td>1.7°C</td>
<td>• Highly complex data, updated infrequently</td>
</tr>
<tr>
<td></td>
<td>SSP 2-4.5</td>
<td>2.0°C</td>
<td>• Most focus on higher temperature outcomes</td>
</tr>
<tr>
<td></td>
<td>SSP 3-7.0</td>
<td>2.1°C</td>
<td>• IPCC primarily a climate-focused organization, independent of financial services ties</td>
</tr>
<tr>
<td></td>
<td>SSP 5-8.5</td>
<td>2.4°C</td>
<td></td>
</tr>
<tr>
<td><strong>International Energy Agency (IEA)</strong></td>
<td>Net Zero Emissions by 2050 (NZE)</td>
<td>1.5°C</td>
<td>• Primarily energy focused, considering both existing policies and policy aspirations</td>
</tr>
<tr>
<td></td>
<td>Sustainable Development</td>
<td>1.5°C / 1.8°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Announced Pledges</td>
<td>1.7°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stated Policies</td>
<td>Around 2.5°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delayed Recovery</td>
<td>&lt; 2.7°C</td>
<td></td>
</tr>
<tr>
<td><strong>Network for Greening the Financial System (NGFS)</strong></td>
<td>Net Zero 2050</td>
<td>1.4°C</td>
<td>• Used by central banks</td>
</tr>
<tr>
<td></td>
<td>Low Demand</td>
<td>1.4°C</td>
<td>• Frequently updated</td>
</tr>
<tr>
<td></td>
<td>Below 2°C</td>
<td>1.6°C</td>
<td>• Higher temperature outcomes included, although physical risks may be structurally understated by all methods and providers</td>
</tr>
<tr>
<td></td>
<td>Delayed Transition</td>
<td>1.6°C</td>
<td>• Scenarios are run through three different IAMs, adding complexity but allowing users to isolate model effects from IAMs</td>
</tr>
<tr>
<td></td>
<td>Nationally Determined Contributions</td>
<td>2.6°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Current Policies</td>
<td>3.0°C+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fragmented World</td>
<td>2.3°C</td>
<td></td>
</tr>
<tr>
<td><strong>UNPRI Inevitable Policy Response (IPR)</strong></td>
<td>Scenario</td>
<td>1.8°C</td>
<td>• Includes some “just transition” and nature-related drivers</td>
</tr>
<tr>
<td></td>
<td>Forecast Policy Scenario + Nature</td>
<td>N/A</td>
<td>• Only low temperature outcome scenarios available</td>
</tr>
<tr>
<td></td>
<td>Required Policy Scenario</td>
<td>1.5°C</td>
<td></td>
</tr>
<tr>
<td><strong>One Earth Climate Model (OECD)</strong></td>
<td>1.5° Trajectory for All Sectors</td>
<td>1.5°C</td>
<td>• Builds on IPCC’s SSP 1 scenario</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Defines Scope 3 emissions across several industry sectors and considers the required path for net-zero</td>
</tr>
</tbody>
</table>

Source: Sustainable Fitch, UNEP FI 2023 Climate Risk Landscape (Nov. 2023).

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Exhibit B: Integrated Assessment Models (IAMs)

**What are IAMs?**
IAMs are sophisticated computer models developed at various academic institutions that aim to link the interactions between social, economic and environmental factors over time. Notable IAMs used in climate scenario analysis for financial actors include GCAM, REMIND-MAgPIE, and MESSAGEix-GLOBIOM. While investors using industry standard scenarios do not need to run these models themselves, they should still be aware of some of the differences between them as this can impact the ultimate outputs.

**What are the limitations of IAMs?**
Given the complexity of IAMs, it is important that they are regularly updated based on prevailing political, economic, technical, social and environmental realities so that they do not become outdated. This can be difficult to achieve with industry standard scenarios. Additionally, there is academic criticism that some existing IAMs rely too much on technological solutions that have not yet been fully proven, such as carbon capture and storage, while also failing to consider potential shifts in human behavior or sentiment (e.g., economic degrowth or significant lifestyle changes). Other criticisms are common to the wide application of theoretical economic models to the real world, such as the assumption that actors will always seek the lowest cost solution, which may not reflect real consumer adoption rates of new technologies.

**Do all IAMs make the same assumptions?**
Structural differences between IAMs can lead to sharply different outcomes even under the same climate scenario. Firstly, there are differences in how IAMs are structured: some require GDP as an input while others can have it as an output; some models assume that actors have perfect foresight while others allow actors to consider only past and present information at each decision point. Secondly, IAMs may use different assumptions around issues like energy mix or carbon capture.

As an example, Figure 15 shows outputs for annual CO₂ in 2050 removal using three different IAMs for the NGFS Net Zero 2050 Scenario, one of the industry standard scenarios. Because of different assumptions used in each of the IAMs, such as absolute levels of removal and the source of removal, the same scenario assumptions could lead to wide variations in CCS demand outputs. Investors should be aware that a scenario using only one IAM includes an element of model risk. If absolute numbers on outputs are important rather than comparing only the differences between the scenarios, then using more than one IAM may be preferable if resources allow.

![FIGURE 15](image)

Even using the same climate scenario, different IAMs can give a wide range of outputs


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13 Transformative pathways – Using integrated assessment models more effectively to open up plausible and desirable low-carbon futures - ScienceDirect. Braunreiter et al, 2021
14 NGFS Technical Documentation.
### SCENARIO DESIGN

Key assumptions are laid out below. Inputs such as GDP, population and price elasticity are primarily based on the “middle-of-the-road” shared socioeconomic pathways (SSP2) scenario from the Intergovernmental Panel on Climate Change’s (IPCC) framework, which assumes a continuation of historical demographic patterns.

---

#### FIGURE 16

**Key Assumptions for Case Study Inputs**

<table>
<thead>
<tr>
<th>EXAMPLES OF KEY ASSUMPTIONS</th>
<th>HIGH CCS</th>
<th>LOW CCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Population</td>
<td>Global population continues to increase, peaking around 9.4 billion in the 2070s and declining to 9 billion by 2100.</td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>GDP sees moderate growth, following regional and historical trends to reach $229.7 trillion in 2050 and $537.3 trillion by end of century.</td>
<td></td>
</tr>
<tr>
<td>2050 Net CO₂ Emissions</td>
<td>Cap on CO₂ emissions are put in place by various governments and net emissions fall to 4Gt/qa by 2050, consistent with a 2°C temperature outcome.</td>
<td>Most developed countries reach net-zero by 2050.</td>
</tr>
<tr>
<td>Income Elasticity of Demand</td>
<td>Income elasticity for each industrial sector, such as iron and steel, cement, aluminum, chemicals, etc.</td>
<td></td>
</tr>
<tr>
<td>Energy Intensity</td>
<td>Energy intensity for energy-for-water processes (desalination, abstraction, treatment, distribution wastewater treatment), etc.</td>
<td></td>
</tr>
<tr>
<td>Extraction Cost</td>
<td>Storage on land ranges from $0.33 to $250/tCO₂ depending on the resource grades. Lower grade resources are cheaper to deploy.</td>
<td>Storage on land ranges from $4.2 to $3,120/tCO₂ depending on the resource grades. Lower grade resources are cheaper to deploy.</td>
</tr>
<tr>
<td>Availability of Offshore Carbon Storage</td>
<td>Offshore storage becomes available at a realistic cost.</td>
<td>Offshore storage is not available, which reduces supply of CCS substantially.</td>
</tr>
</tbody>
</table>


---

**MODELING**
We used the Global Change Analysis Model (GCAM) for our IAM and Oxford Economics Global Economic Model and Global Industry Model.

**KEY OUTPUTS**
Further discussion and charts in the main body of the document.

### FIGURE 17
Summary of Key Outputs

#### GLOBAL

<table>
<thead>
<tr>
<th>OUTPUT VARIABLE</th>
<th>HIGH CCS</th>
<th>LOW CCS</th>
<th>DETAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emissions</strong></td>
<td>Net emissions of 4Gt CO₂ by 2050, with total emissions of 27Gt partly offset by 23Gt sequestrated in CCS</td>
<td>Net emissions of 4Gt CO₂ by 2050, with total emissions of 20Gt partly offset by 15Gt sequestrated in CCS</td>
<td>Government caps drive similar decarbonization pathways. As a result, higher CCS results in higher total but similar net emissions</td>
</tr>
<tr>
<td><strong>Carbon Price</strong></td>
<td>Peak of $746/tCO₂ in 2050, stabilizing around $600 by 2065</td>
<td>Peak of $1086/tCO₂ in 2050, stabilizing around $800 by 2065</td>
<td>Lower costs of CCS drive lower carbon prices in the High CCS Scenario</td>
</tr>
</tbody>
</table>

#### U.S. ENERGY FOCUS

<table>
<thead>
<tr>
<th>OUTPUT VARIABLE</th>
<th>HIGH CCS</th>
<th>LOW CCS</th>
<th>DETAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Energy Demand</strong></td>
<td>87 EJ by 2050, down 6% on 2020 levels</td>
<td>81 EJ by 2050, down 12% on 2020 levels</td>
<td>Lower CCS availability shifts focus to other decarbonization efforts</td>
</tr>
<tr>
<td><strong>Electricity Price</strong></td>
<td>U.S. fossil fuel-based electricity generation is c.10% cheaper in 2050 vs. other scenario</td>
<td>Higher U.S. fossil fuel energy generation prices are offset by higher renewables mix</td>
<td>In a Low CCS Scenario, higher fossil fuel energy generation prices are passed on to higher electricity prices</td>
</tr>
<tr>
<td><strong>Fossil Fuel Use</strong></td>
<td>Coal remains 9% of U.S. primary energy mix by 2050, primary energy consumption of 8 EJ</td>
<td>Coal falls to 4% of U.S. primary energy mix by 2050, primary energy consumption of 4 EJ</td>
<td>High CCS Scenario sees less pressure to transition away from fossil fuels</td>
</tr>
<tr>
<td><strong>Renewables Use</strong></td>
<td>Wind provides 10% of U.S. primary energy by 2050</td>
<td>Wind rises to 13% of U.S. primary energy by 2050</td>
<td>Low CCS Scenario sees more pressure to transition toward renewables</td>
</tr>
</tbody>
</table>


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20 Both scenarios result in carbon prices rising steeply between 2030 and 2050. Academic work conducted with similar parameters also results in very high carbon prices:


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