Morgan Stanley

INSTITUTE FOR SUSTAINABLE INVESTING

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

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;

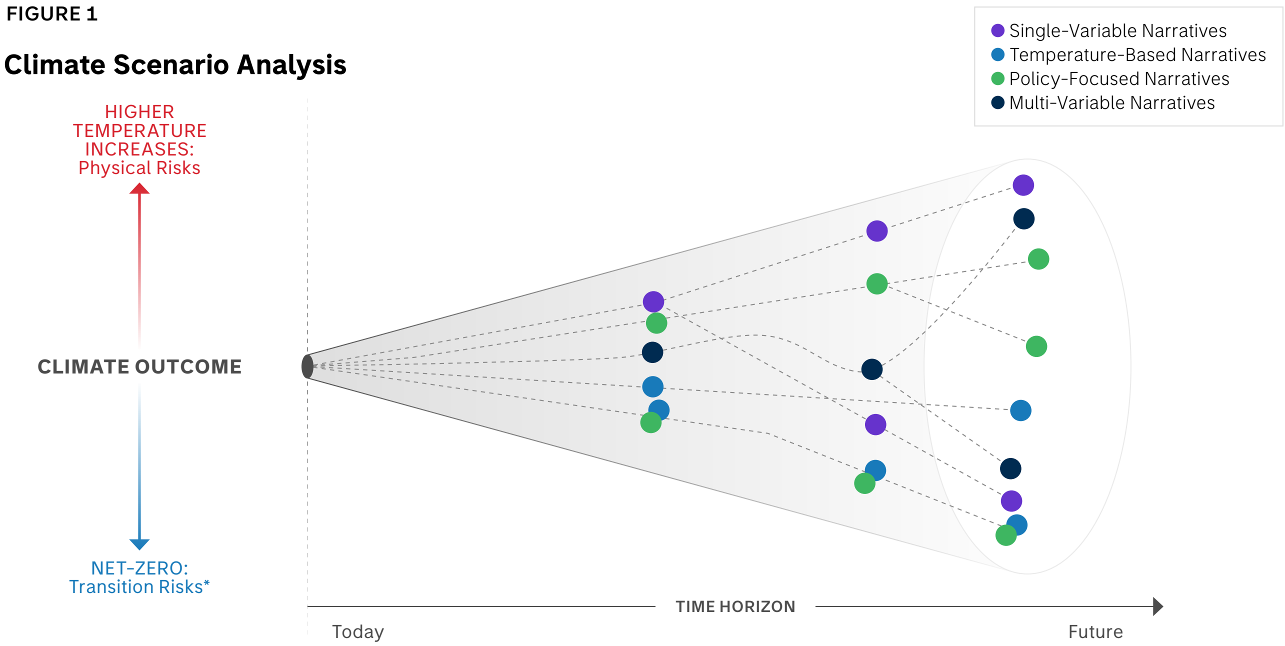
(2) A future where we do not meet this target and temperatures increase by 3°C or more from preindustrial levels, resulting in more severe physical risks.

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



Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

* 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.

FIGURE 2

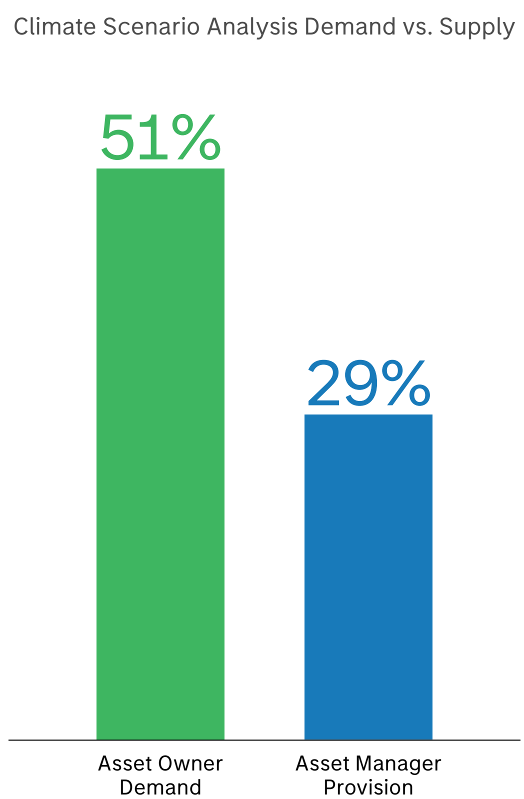
Commonly used scenario variables across a range of themes

CATEGORY	POSSIBLE VARIABLE
Policy	• Net or gross CO_2 and sequestration split by industry sector, technology and/or geography • Carbon pricing (market driven, government mandated or both) • International trade tariffs
Economy	• GDP • Investment in technologies and intellectual property • Foreign direct investment • Income elasticity for products such as fossil fuels • Energy prices
Social	• Population, split by region, age, and urban/rural • Energy demand • Food and meat demand • Land productivity for crops and livestock • Social acceptance for fossil fuels
Technology	• Energy efficiency factor • Carbon capture and storage availability • Energy mix (fossil fuels vs. renewables) • Technical change in fossil fuel extraction costs • Cost of renewable generation
Environment	• Temperature change above pre-industrial levels • Forest spread changes • Negative emissions from bioenergy

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

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



Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

3 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."[2]

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.[3]

FIGURE 4

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

TCFD RECOMMENDATION	RECOMMENDED DISCLOSURE	PERCENT OF COMPANIES DISCLOSING: 2020	2021	2022
Governance	a) Board Oversight	39%	56%	64%
	b) Management's Role	23%	37%	44%
Strategy	a) Risks and Opportunities	36%	55%	62%
	b) Impact on Organization	26%	37%	43%
	c) Resilience of Strategy	4%	9%	11%
Risk Management	a) Risk ID and Assessment Processes	14%	26%	36%
	b) Risk Management Processes	19%	33%	39%
	c) Integration into Overall Risk Managment	11%	21%	25%
Metrics and Targets	a) Climate-Related Metrics	58%	66%	71%
	b) Scope 1, 2, 3 GHG Emissions	50%	60%	66%
	c) Climate-Related Targets	42%	59%	66%

Source: TCFD (Nov. 2023)

[2] The Use of Scenario Analysis in Disclosure of Climate-related Risks and Opportunities - TCFD Knowledge Hub (tcfdhub.org)

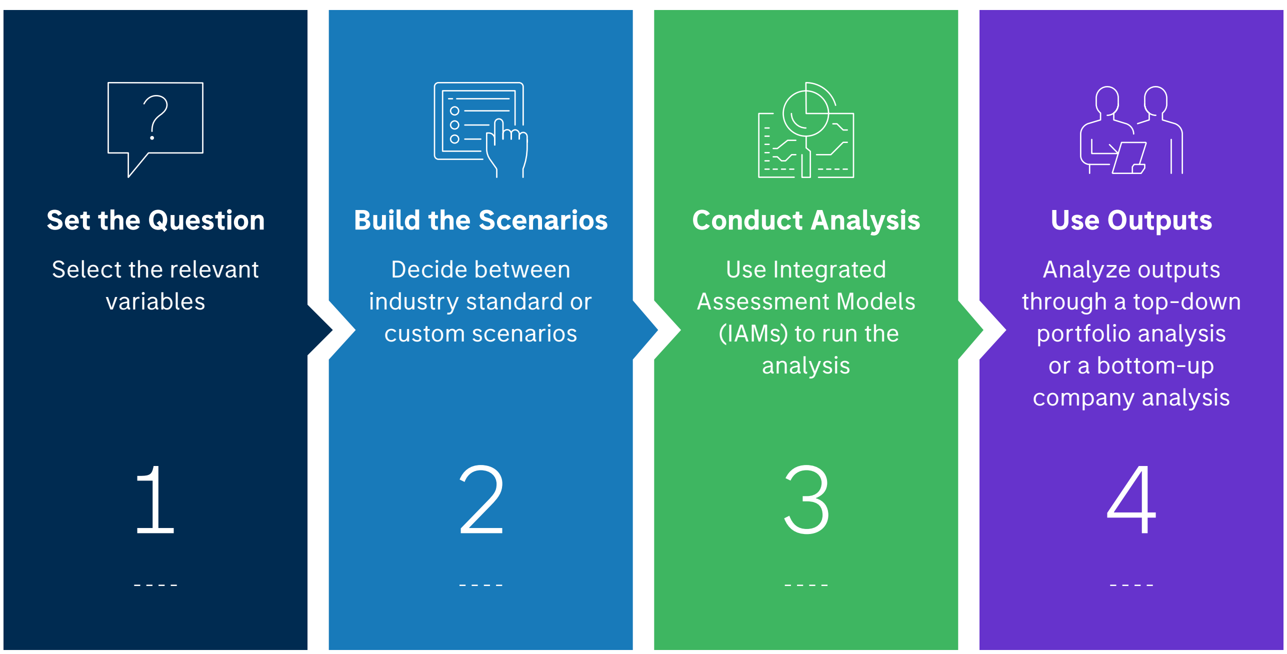
[3] Climate Scenarios: Understanding Use Cases, Limitations and Implications for Investors (sustainablefitch.com)

How Do Investors Conduct Climate Scenario Analysis?

There are many ways to analyze climate scenarios. At the simplest end of the spectrum, TCFD notes[4] 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



Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

[4] Task Force on Climate-related Financial Disclosures: 2022 Status Report

1 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.[5] 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.

FIGURE 6

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

CATEGORY	VARIABLES* TO FLEX, KEEP CONSTANT, ALLOW MODEL TO CALCULATE
Policy	• **Carbon pricing** (market driven, **government mandated** or both) • International trade tariffs • **Net or gross CO_2 and sequestration** split by industry sector, technology and/or geography
Economy	• GDP • Investment in technologies and intellectual property • Foreign direct investment • Income elasticity for products such as fossil fuels • **Energy prices**
Social	• Population, split by region, age, and urban/rural • **Energy demand** • Food and meat demand • Land productivity for crops and livestock • Social acceptance for fossil fuels
Technology	• Energy efficiency factor • Carbon capture and storage availability • **Energy mix** (fossil fuels vs. renewables) • Technical change in fossil fuel extraction costs • Cost of renewable generation
Environment	• **Temperature change above pre-industrial levels** • Forest spread changes • Negative emissions from bioenergy

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

Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

[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.

2 Build the Scenarios

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 CO_2, 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 CO_2, 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

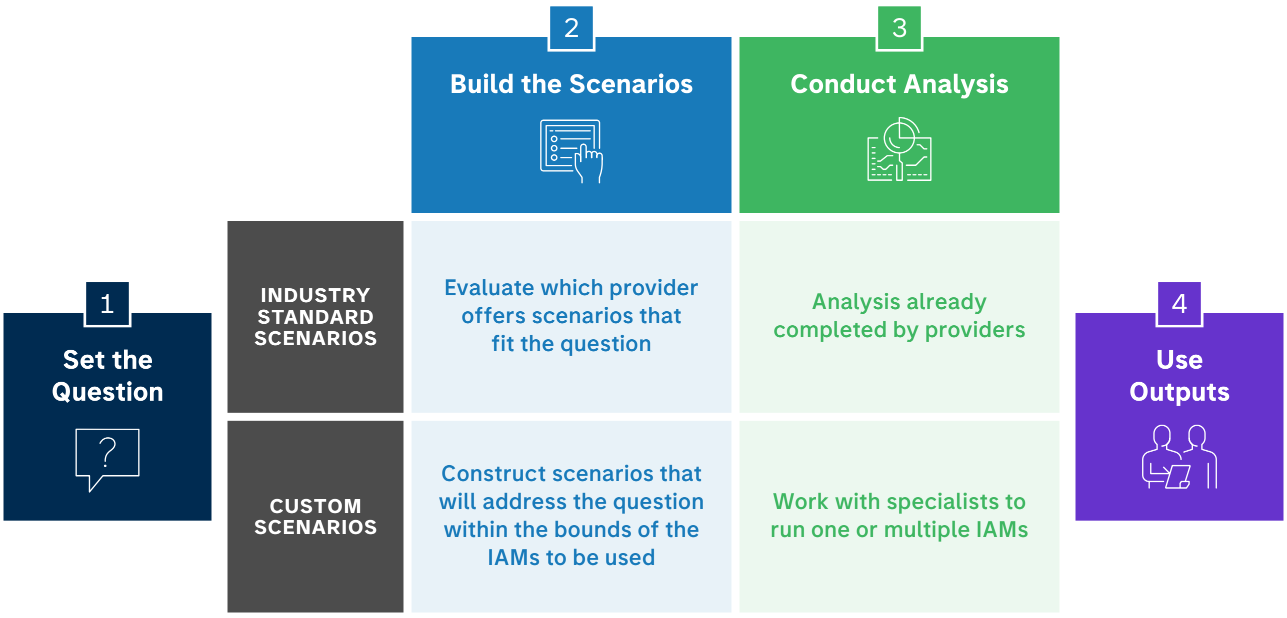
Once the scenarios are built, the relevant inputs are then run through one or more mathematical computer models—usually **Integrated Assessment Models (IAMs)**. IAMs model the relationship between greenhouse gas emissions and social and economic factors. Several different IAMs are available, all of which 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).

4 Use Outputs

Potential outputs from the 'Conduct Analysis' stage include prices for energy, carbon and a range of other commodities, as well as imports and exports, emissions, supply/demand volumes and land use. Depending on the scenario design, some inputs could also be held constant between scenarios to isolate the impact of particular factors. Figure 8 shows some commonly used outputs from IAMs.

Outputs from the IAMs can be used directly to inform portfolio risk analysis or bottom-up company analysis. For example, different carbon prices in each scenario could be applied to company earnings, or some investors might choose to run a macroeconomic model to generate outputs such as bond yields, inflation or index prices to link to top-down portfolio analysis.

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

CATEGORY	POSSIBLE IAM OUTPUT
Prices	Energy prices by region and by fuel type
	Carbon price
	Food prices
	Water price
	Agriculture and forestry commodity prices
Trade	Energy imports/exports
	Water imports/exports
	Agriculture and forestry imports/exports
Emissions	CO_2/GHG emissions by end-use energy sectors
	CO_2/GHG emissions by fuel type
	Non GHG emissions
	Land use change emissions
Quantity	Energy demand/supply/production/consumption
	Water demand/supply/production/consumption
	Agricultural demand/supply/production/consumption
	Carbon capture and storage (CCS) volumes
	Investment funds
Land	Land use by sector
	Water withdrawals
	Land cover
	Carbon fluxes (change in above/below ground)

Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

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

RESOURCES V **GRANULARITY**

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.

ANALYZING SCENARIOS NOW V **UNDERESTIMATING PHYSICAL RISKS**

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 V **CUSTOM SCENARIOS**

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.

TRANSITION RISKS V **PHYSICAL RISKS**

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.

SINGLE-VARIABLE ANALYSIS V **MULTI-VARIABLE ANALYSIS**

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.

SECTOR FOCUS V **HUMAN FACTORS FOCUS**

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.

SHORT-TERM V **LONG-TERM**

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.

MORE LIKELY V **EXCEPTIONAL BUT PLAUSIBLE**

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.

RISK MANAGEMENT V **STRATEGY**

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

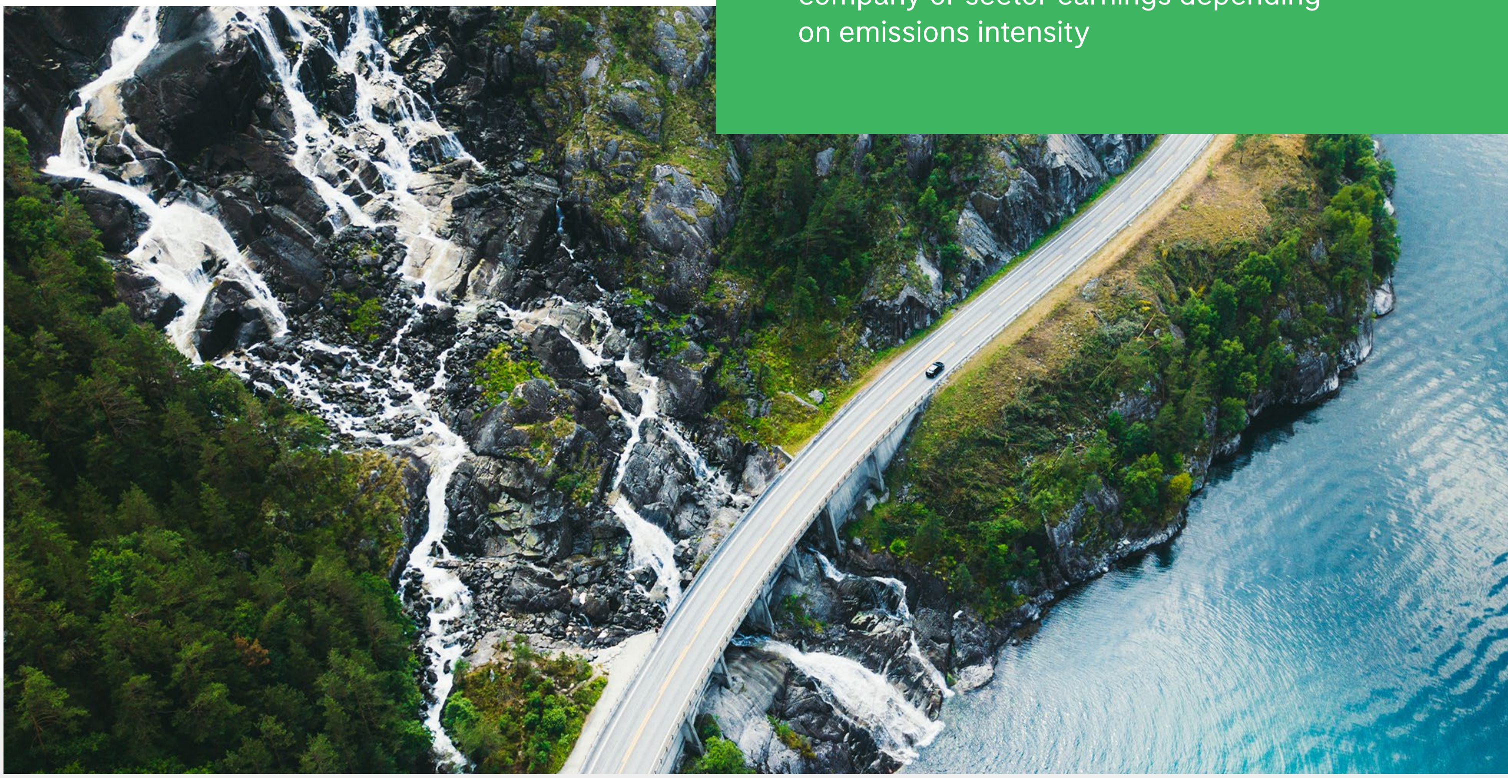
At Morgan Stanley, we have developed our own in-house climate scenario capabilities to extend analyses beyond standard IAMs and include more granularity for macroeconomic, sectoral and portfolio-level insights. In this case study, we show how this enables us to explore the implications of different pathways 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.

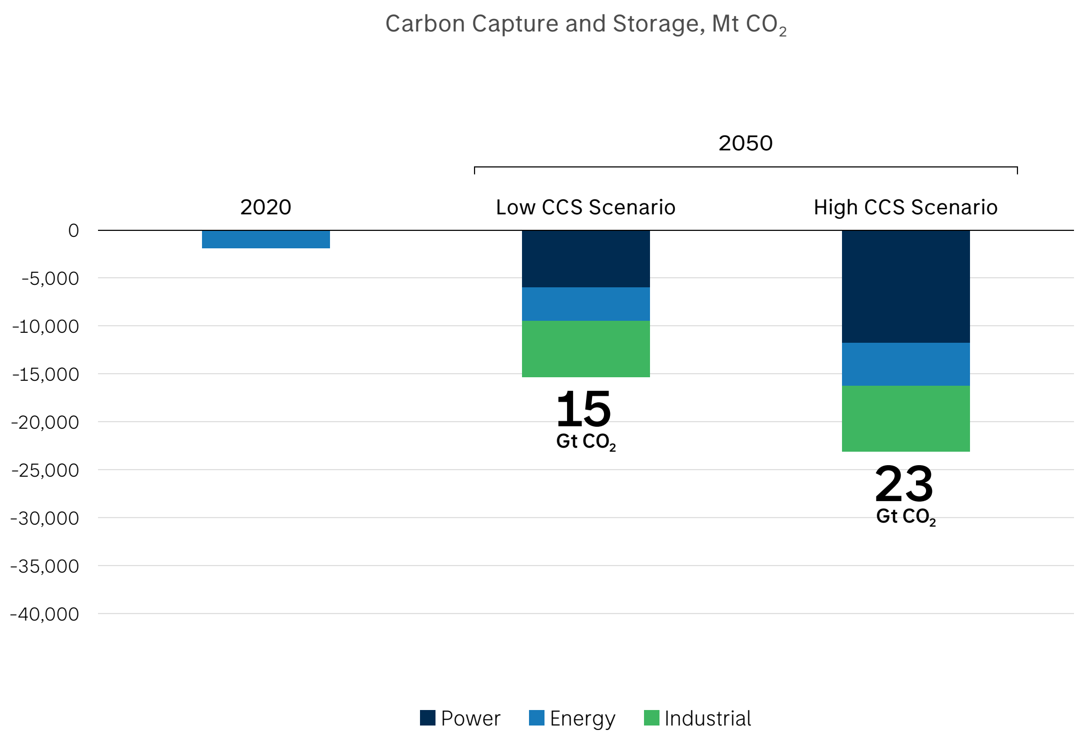
In the **High CCS Scenario**, the lower cost of onshore storage and higher availability of offshore storage beginning in 2020 enables CCS to deliver 23 Gt CO_2 of sequestration by 2050. The **Low CCS Scenario** sees higher costs and lower storage potential, enabling only 15 Gt in 2050—around one third 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 45Mt of CO_2 globally (0.2% of our 2050 High CCS Scenario figure). The International Energy Agency (IEA) notes that announced projects could increase sequestrated amounts to 383Mt 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.

FIGURE 10

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



Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

* Carbon capture and storage amounts are plotted as negative to contrast with positive emissions. This does not suggest direct reduction of existing CO_2 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 CO_2 (carbon dioxide). We use CO_2 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.

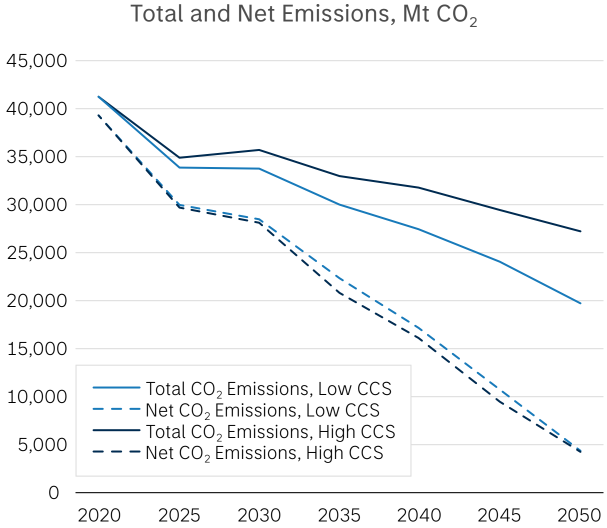
CHEAPER CCS DRIVES A LOWER CARBON PRICE[8]

The High CCS Scenario results in a 2050 carbon price of ~\$750/tCO_2, while the Low CCS Scenario carbon price is sharply higher at ~\$1,100/tCO_2. 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.

FIGURE 11

Higher CCS availability saw c.40% more total emissions

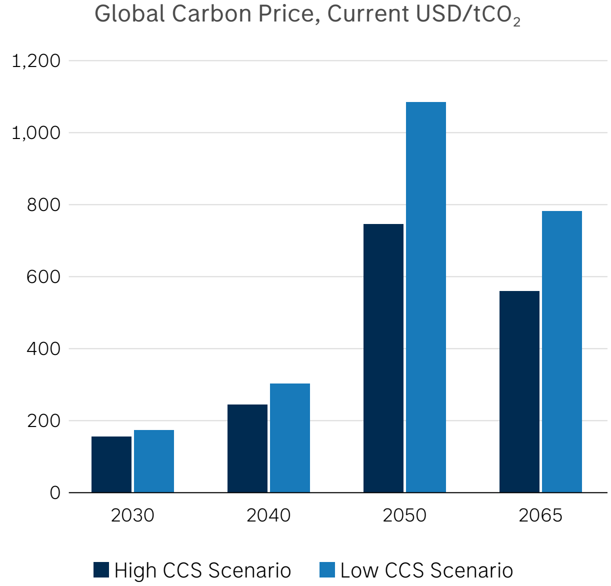


Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

* The net negative contribution from bioenergy is reflected in the net emissions line. The difference between Total and Net CO_2 emissions for each Scenario is composed of the CCS amount and additional negative emissions from growing biomass for bioenergy.

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.[9]



Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

[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, CO_2 and non-CO_2 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.

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:

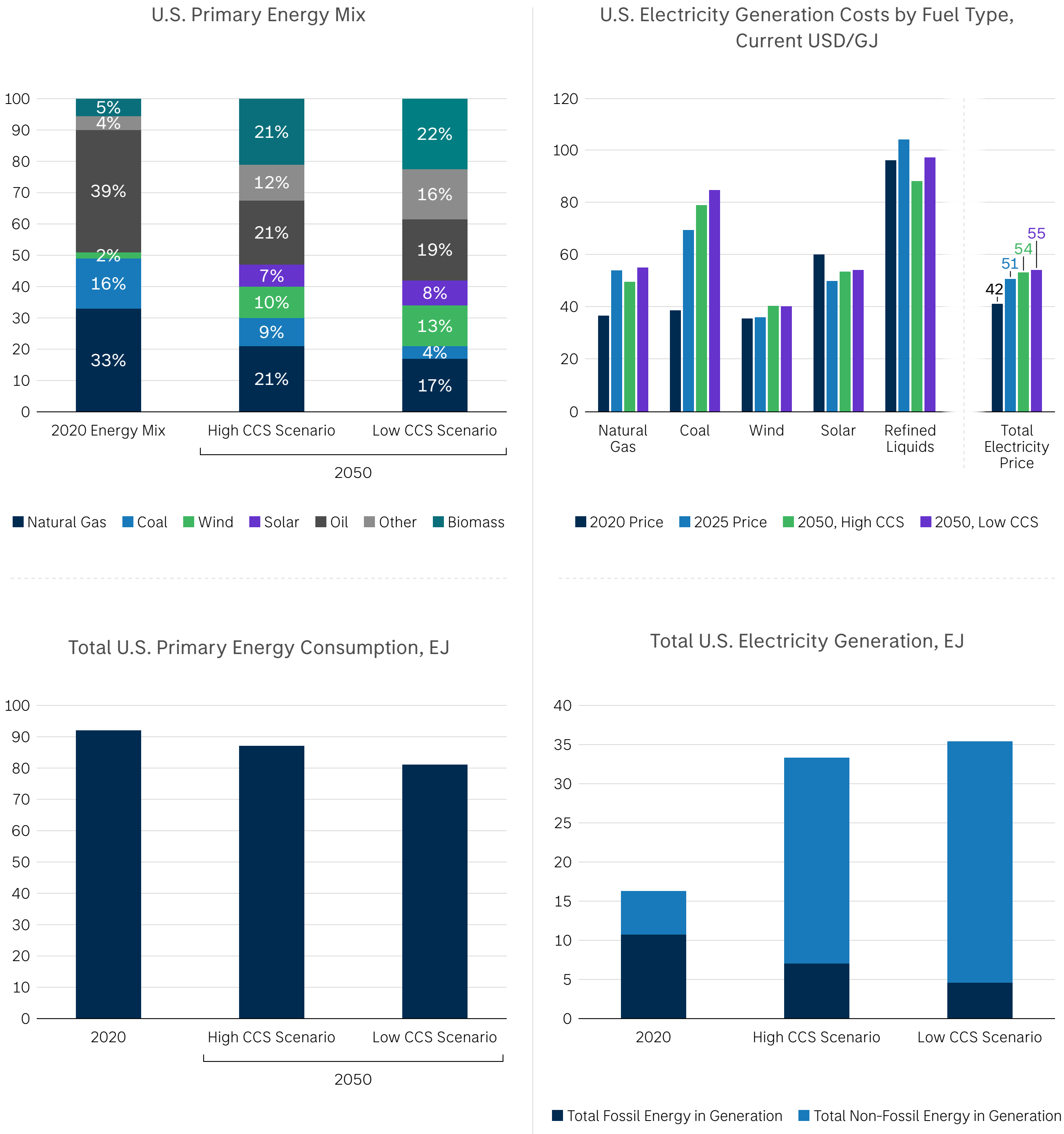
- **High CCS results in greater use of coal for power generation.** Coal makes up 9% of the primary energy[10] mix in 2050 in the High CCS Scenario, but only 4% with Low CCS (both down on around 15% in 2020). Wind makes up most of the difference.
- **Demand for total energy falls further with lower CCS.** 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.

[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



Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

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:

Evaluate long-term fossil fuel demand as CCS innovation progresses

Consider the impact of carbon prices in bottom-up company analysis

Understand the potential change in electricity prices

Inform macroeconomic views based on the inflationary/deflationary impacts of CCS

The Morgan Stanley Institute for Sustainable Investing

Established in 2013, the Morgan Stanley Institute for Sustainable Investing aims to accelerate sustainable finance by driving innovation, empowering investors with insights and supporting the development of the next generation of sustainable investing leaders. The Morgan Stanley Institute for Sustainable Investing is guided by an advisory board of prominent leaders from business, academia and nongovernmental organizations and is utilized to drive strategic internal sustainability-focused initiatives.

1

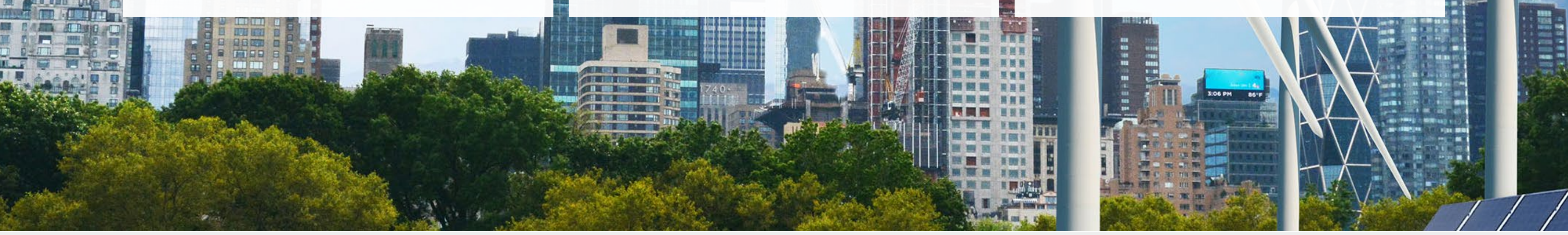
Delivering insights to inform and empower investors and corporates on sustainable finance trends and thematic issues such as climate change, nature and biodiversity, sustainable consumption and production and inclusive growth.

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.



For more information about the Morgan Stanley Institute for Sustainable Investing, visit morganstanley.com/sustainableinvesting.

For questions related to the content of this report, please reach out to globalsustainability@morganstanley.com.

Appendix: Further Detail on Scenario Design and Integrated Assessment Models

Exhibit A: Industry Standard Scenarios vs. Custom Scenarios

BENEFITS	LIMITATIONS
INDUSTRY STANDARD SCENARIOS	
Does not usually require deep expertise in climate science and therefore may be more suitable to investors with limited technical resources	May not provide all relevant output variables or the ability to customize the scenario or assumptions in line with investor views
Widely used, so may already be well understood by corporates or other stakeholders	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
CUSTOM SCENARIOS	
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	Requires specialized input with experience using IAMs, either in-house or from a third party, to generate robust scenarios and conduct the IAM work
Geographical differences can be captured, generally not offered by industry standard	

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,[11] 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

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

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

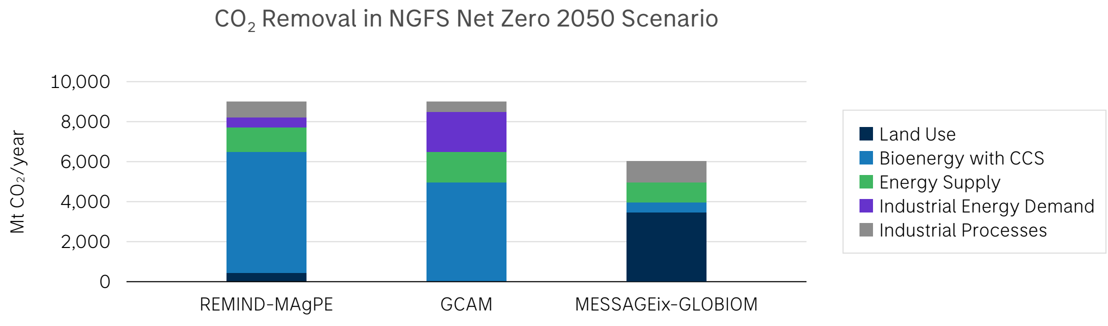
[11] Scenario Analysis in Financial Firms, Climate Financial Risk Forum, 2022.

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,[12] 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.[13]
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.[14] Secondly, IAMs may use different assumptions around issues like energy mix or carbon capture. As an example, Figure 15 shows outputs for annual CO_2 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

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



Source: NGFS, Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

[12] A Review of Criticisms of Integrated Assessment Models, Gambhir et al, 2019.

[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.

Exhibit C: Further Detail on Case Study Scenario Design and Outputs

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

EXAMPLES OF KEY ASSUMPTIONS	HIGH CCS	LOW CCS
Global Population	Global population continues to increase, peaking around 9.4 billion in the 2070s and declining to 9 billion by 2100.	
GDP	GDP sees moderate growth, following regional and historical trends to reach $229.7 trillion in 2050 and $537.3 trillion by end of century.	
2050 Net CO_2 Emissions	Cap on CO_2 emissions are put in place by various governments and net emissions fall to 4Gt/pa by 2050, consistent with a 2° temperature outcome.[15] Most developed countries reach net-zero by 2050.	
Income Elasticity of Demand	Income elasticity for each industrial sector, such as iron and steel, cement, aluminum, chemicals, etc.[16]	
Energy Intensity	Energy intensity for energy-for-water processes (desalination, abstraction, treatment, distribution wastewater treatment), etc.[17]	
Extraction Cost (Capital, operating and energy costs of removing carbon, separating CO_2, and transport)	Storage on land ranges from $0.33 to $250/t$CO_2$ depending on the resource grades. Lower grade resources are cheaper to deploy.[18]	Storage on land ranges from $4.2 to $3,120/t$CO_2$ depending on the resource grades. Lower grade resources are cheaper to deploy.[19]
Availability of Offshore Carbon Storage	Offshore storage becomes available at a realistic cost.	Offshore storage is not available, which reduces supply of CCS substantially.

Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

[15] A Ou, Y., Roney, C., Alsalam, J., Calvin, K., Creason, J., Edmonds, J., Fawcett, A.A., Kyle, P., Narayan, K., O'Rourke, P. and Patel, P., 2021. Deep mitigation of CO_2 and non-CO_2 greenhouse gases toward 1.5° C and 2° C futures. Nature Communications, 12(1), p.6245.

[16] GCAM, https://jgcri.github.io/gcam-doc/ssp.html

[17] Liu, Y., Hejazi, M., Kyle, P., Kim, S., Davies, E., Miralles, D., Teuling, A., He, Y., and Niyogi, D. 2016. Global and Regional Evaluation of Energy for Water. Environmental Science & Technology 50(17), 9736-9745

[18] GCAM, https://jgcri.github.io/gcam-doc/v3.2/The_Energy_System

[19] GCAM, https://jgcri.github.io/gcam-doc/v3.2/The_Energy_System

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

OUTPUT VARIABLE	HIGH CCS	LOW CCS	DETAIL
Emissions	Net emissions of 4Gt CO_2 by 2050, with total emissions of 27Gt partly offset by 23Gt sequestrated in CCS	Net emissions of 4Gt CO_2 by 2050, with total emissions of 20Gt partly offset by 15Gt sequestrated in CCS	Government caps drive similar decarbonization pathways. As a result, higher CCS results in higher total but similar net emissions
Carbon Price[20]	Peak of $746/t$CO_2$ in 2050, stabilizing around $600 by 2065	Peak of $1086/t$CO_2$ in 2050, stabilizing around $800 by 2065	Lower costs of CCS drive lower carbon prices in the High CCS Scenario

U.S. ENERGY FOCUS

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

Source: Morgan Stanley Institute for Sustainable Investing (Nov. 2023).

[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:

Ou, Y., Roney, C., Alsalam, J., Calvin, K., Creason, J., Edmonds, J., Fawcett, A.A., Kyle, P., Narayan, K., O'Rourke, P. and Patel, P., 2021. Deep mitigation of CO_2 and non-CO_2 greenhouse gases toward 1.5° C and 2° C futures. Nature Communications, 12(1), p.6245.

Riahi, K., Bertram, C., Huppmann, D. et al. Cost and attainability of meeting stringent climate targets without overshoot. Nat. Clim. Chang. 11, 1063–1069 (2021). https://doi.org/10.1038/s41558-021-01215-2

DISCLOSURES

This material was published in November 2023 and has been prepared for informational purposes only and is not a solicitation of any offer to buy or sell any security or other financial instrument or to participate in any trading strategy. This material was not prepared by the Morgan Stanley Research Department and is not a Research Report as defined under FINRA regulations. This material does not provide individually tailored investment advice. It has been prepared without regard to the individual financial circumstances and objectives of persons who receive it.

Morgan Stanley Smith Barney LLC and Morgan Stanley & Co. LLC (collectively, "Morgan Stanley"), Members SIPC, recommend that recipients should determine, in consultation with their own investment, legal, tax, regulatory and accounting advisors, the economic risks and merits, as well as the legal, tax, regulatory and accounting characteristics and consequences, of the transaction or strategy referenced in any materials. The appropriateness of a particular investment or strategy will depend on an investor's individual circumstances and objectives. Morgan Stanley, its affiliates, employees and Morgan Stanley Financial Advisors do not provide tax, accounting or legal advice. Individuals should consult their tax advisor for matters involving taxation and tax planning, and their attorney for matters involving legal matters.

Past performance is not a guarantee or indicative of future performance. Historical data shown represents past performance and does not guarantee comparable future results.

Certain statements herein may be "forward-looking statements" within the meaning of the safe harbor provisions of the Private Securities Litigation Reform Act of 1995. These statements are not historical facts or statements of current conditions, but instead are based on management's current expectations and are subject to uncertainty and changes in circumstances. These statements are not guarantees of future results or occurrences and involve certain known and unknown risks, uncertainties and assumptions that are difficult to predict and are often beyond our control. In addition, this report contains statements based on hypothetical scenarios and assumptions, which may not occur or differ significantly from actual events, and these statements should not necessarily be viewed as being representative of current or actual risk or forecasts of expected risk. Actual results and financial conditions may differ materially from those included in these statements due to a variety of factors.

Any forward-looking statements made by or on behalf of Morgan Stanley speak only as to the date they are made, and Morgan Stanley does not undertake to update forward-looking statements to reflect the impact of circumstances or events that arise after the date the forward-looking statements were made. Because of their narrow focus, sector investments tend to be more volatile than investments that diversify across many sectors and companies.

Certain portfolios may include investment holdings deemed Environmental, Social and Governance ("ESG") investments. For reference, environmental ("E") factors can include, but are not limited to, climate change, pollution, waste, and how an issuer protects and/or conserves natural resources. Social ("S") factors can include, but not are not limited to, how an issuer manages its relationships with individuals, such as its employees, shareholders, and customers as well as its community. Governance ("G") factors can include, but are not limited to, how an issuer operates, such as its leadership composition, pay and incentive structures, internal controls, and the rights of equity and debt holders. You should carefully review an investment product's prospectus or other offering documents, disclosures and/or marketing material to learn more about how it incorporates ESG factors into its investment strategy.

ESG investments may also be referred to as sustainable investments, impact aware investments, socially responsible investments or diversity, equity, and inclusion ("DEI") investments. It is important to understand there are inconsistent ESG definitions and criteria within the industry, as well as multiple ESG ratings providers that provide ESG ratings of the same subject companies and/or securities that vary among the providers. This is due to a current lack of consistent global reporting and auditing standards as well as differences in definitions, methodologies, processes, data sources and subjectivity among ESG rating providers when determining a rating. Certain issuers of investments including, but not limited to, separately managed accounts (SMAs), mutual funds and exchange traded-funds (ETFs) may have differing and inconsistent views concerning ESG criteria where the ESG claims made in offering documents or other literature may overstate ESG impact. Further, socially responsible norms vary by region, and an issuer's ESG practices or Morgan Stanley's assessment of an issuer's ESG practices can change over time.

Portfolios that include investment holdings deemed ESG investments or that employ ESG screening criteria as part of an overall strategy may experience performance that is lower or higher than a portfolio not employing such practices. Portfolios with ESG restrictions and strategies as well as ESG investments may not be able to take advantage of the same opportunities or market trends as portfolios where ESG criteria is not applied. There is no assurance that an ESG investing strategy or techniques employed will be successful. Past performance is not a guarantee or a dependable measure of future results. For risks related to a specific fund, please refer to the fund's prospectus or summary prospectus.

Investment managers can have different approaches to ESG and can offer strategies that differ from the strategies offered by other investment managers with respect to the same theme or topic. Additionally, when evaluating investments, an investment manager is dependent upon information and data that may be incomplete, inaccurate or unavailable, which could cause the manager to incorrectly assess an investment's ESG characteristics or performance. Such data or information may be obtained through voluntary or third-party reporting. Morgan Stanley does not verify that such information and data is accurate and makes no representation or warranty as to its accuracy, timeliness, or completeness when evaluating an issuer. This can cause Morgan Stanley to incorrectly assess an issuer's business practices with respect to its ESG practices. As a result, it is difficult to compare ESG investment products.

The appropriateness of a particular ESG investment or strategy will depend on an investor's individual circumstances and objectives. Principal value and return of an investment will fluctuate with changes in market conditions.

Investing in the market entails the risk of market volatility. The value of all types of investments, including stocks, mutual funds, exchange traded funds ("ETFs"), and alternative investments, may increase or decrease over varying time periods.

Because of their narrow focus, sector investments tend to be more No reports, documents or websites that are cited or referred to in this report shall be deemed to form part of this report. In addition, certain information contained in this report has been derived from publicly available information released by third-party sources, which Morgan Stanley believes to be reasonable, although Morgan Stanley has only been able to complete limited validation. Morgan Stanley makes no representation as to the accuracy or completeness of data from sources outside of Morgan Stanley. These and other factors could cause results to differ materially from those expressed in the estimates and beliefs made by third parties and by Morgan Stanley. References to third parties contained herein should not be considered a solicitation on behalf of or an endorsement of those entities by Morgan Stanley.

This material may provide the addresses of, or contain hyperlinks to, websites. Except to the extent to which the material refers to website material of Morgan Stanley Wealth Management, the firm has not reviewed the linked site. Equally, except to the extent to which the material refers to website material of Morgan Stanley Wealth Management, the firm takes no responsibility for, and makes no representations or warranties whatsoever as to, the data and information contained therein. Such address or hyperlink (including addresses or hyperlinks to website material of Morgan Stanley Wealth Management) is provided solely for your convenience and information and the content of the linked site does not in any way form part of this document. Accessing such website or following such link through the material or the website of the firm shall be at your own risk and we shall have no liability arising out of, or in connection with, any such referenced website. Morgan Stanley Wealth Management is a business of Morgan Stanley Smith Barney LLC.

For more information about the Morgan Stanley Institute for Sustainable Investing, visit **morganstanley.com/sustainableinvesting**.

CRC 6076015 11/2023