Preparing our Portfolio for the Future:
Integrating Climate Scenarios into Asset-Liability Management

An OPTrust Case Study

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OPTrust

With net assets of over $25 billion, OPTrust invests and manages one of Canada's largest pension funds and administers the OPSEU Pension Plan, a defined benefit plan with over 100,000 members. OPTrust is a global investor in a broad range of asset classes including Canadian and foreign equities, fixed income, real estate, infrastructure and private markets, and has a team of highly experienced investment professionals located in Toronto, London and Sydney.

Ortec Finance

Ortec Finance provides financial institutions globally with technology and solutions, using leading software models to enable people to manage the complexity of investment decision-making.

Executive Summary

As a pension plan, OPTrust's primary focus is to ensure the long-term health of our financial assets so we can pay pensions to our members both today and in the future. As the world prepares to decarbonize to limit global warming to 1.5°C in-line with the recommendations of the **Paris Agreement** – a treaty ratified by 193 countries – and as the costs of climate change manifest across a range of geographies and industries, it is critical we strengthen our understanding of climate change implications for OPTrust as stewards of our members' retirement income.

In 2018, we initiated a pilot project designed to illuminate the impact climate change could have on our pension plan's financial performance. Working with Ortec Finance, a provider of technology and solutions for risk and return management, we aimed to connect our understanding of various global warming scenarios described by scientists with both macroeconomic risk drivers such as inflation (i.e. CPI) and economic growth (i.e. GDP) and the asset-liability financial modelling that lies at the heart of pension investing. The pilot enabled OPTrust to see how structural impacts on the global economy, resulting from climate change, could affect our overall financial performance. Although this analysis was in its very early days, it nonetheless highlighted the importance of combining this type of top-down analysis with various bottom-up efforts in order to build climate-resilient portfolios.

Advancements in climate modelling and scenario design have been made since 2018 and, while this analysis is still not standard in the financial industry, it has become more popular among pension investors and regulatory bodies in North America and globally. As such, in 2021 OPTrust updated its 2018 climate scenario analysis (CSA) to gain new insights. This updated analysis confirmed that climate change is a material risk to our pension plan's long-term sustainability, increasing funding risk under all scenarios examined, with the magnitude varying by asset class, time horizon and the scenario considered. While the scenarios and macro-assumptions used in these models vary and translating the findings into actionable next steps is often challenging, our pilot proved to be a helpful start in positioning the risks of climate change to our financial purpose and paving the way for our **enhanced climate change strategy**, released in 2022.

OPTrust has tracked the evolution of climate scenario analysis over several years. We are often asked by peer plans to share our approach and learning. This paper is drafted in that spirit. We hope it serves as a resource to the industry as we all navigate the complexities and uncertainties of integrating climate considerations into our investment processes from top to bottom.

Although this paper cannot answer every question on the topic, it offers a good starting point for organizations unfamiliar with CSA who are interested in using it for asset-liability management (ALM). Following this executive summary, the paper is organized into five sections:

- Section 1 introduces CSA, potential use cases and CSA's growing popularity in the financial industry.
- Section 2 describes the model and its integration with OPTrust's ALM approach.
- Section 3 details the results of OPTrust's analysis on macroeconomic and capital market impacts, and the potential impact on total portfolio returns and funding risk.
- Sections 4 and 5 share reflections on limitations of this exercise and our current thinking on integrating the findings into our investment-planning processes. This is still an active area of research for us, and we **welcome your feedback**. We also commit to regularly updating the broader financial community as our understanding evolves through **OPTrust's website** and our *Taskforce on Climate-related Financial Disclosures*.

1 Introduction to climate scenario analysis

1.1 What is climate scenario analysis and why is it useful?

Climate change presents both risks and opportunities to investors worldwide. This includes pension funds such as OPTrust. As more countries and organizations ready themselves for a low-carbon future and global warming continues to cause shifts in global weather patterns, long-term impacts on the wider economy will affect nearly every sector in which we invest. This requires us to better understand climate-related risks and opportunities, their impact on investment portfolios, and how best to integrate them into asset class strategies and total portfolio construction.

Climate scenario analysis (CSA) is an analytical exercise that helps investors deepen their understanding of the potential economic and financial risks posed by climate change. It involves exploring risks and opportunities across a range of **hypothetical scenarios** that illustrate potential future climate pathways and policy and technology developments that may occur as the world adapts to climate change.[1] It is important to note that the scenarios used are not forecasts or predictions – rather, they are specifically designed to capture a range of potential outcomes, from scenarios where the world smoothly manages the transition to a low-carbon future to those where it doesn't, and to illustrate the kinds of stresses on the economy and financial system that could occur.

While CSA is still in its infancy, investors are increasingly using it to educate themselves more broadly on the financial impacts of climate change, including on asset class returns and, in the case of pension plans, on the funded status over various time horizons. It also helps investors understand their exposure to climate risks and prioritize certain organizational resources and activities to better prepare themselves for the anticipated impacts of climate change. Emerging applications include:

- **Risk management/sensitivity analysis:** Identifying the industries/geographies that are most impacted by climate change and the resulting investment implications.
- **Portfolio construction:** Understanding if the portfolio is resilient to a sudden realignment of the financial sector in accordance with the Paris Agreement or to plausible severe physical risks triggered by global warming.
- **Oversight and governance:** Enhancing an organization's knowledge of the potential impact of climate risks and enabling disclosure and communication to key stakeholders within and outside the organization.

1 Given their forward-looking nature, climate risks are hard to factor into traditional risk models. CSA offers a flexible what-if methodological framework better suited to exploring risks that could crystallize in different possible futures. (Source: Network for Greening the Financial System)

1.2 How do central banks and other financial institutions use climate scenario analysis?

In recent years, central banks and other financial regulators, as well as other financial industry participants have begun to experiment with climate scenario assessments to better understand the impact of climate change on their core purpose.

For central banks, CSA is used to better understand the financial system's vulnerability to climate change. This includes the near-term risks stemming from a rapid transition towards a low-carbon economy, as well as the more distant risks posed by heightened global warming in the absence of a timely transition. The Network for Greening the Financial System, which represents 114 central banks and financial supervisors around the world, developed a set of **climate scenarios in 2021** to provide a common reference point for understanding how global warming and climate policy and technology trends could evolve in different future states of the world. These scenarios are currently used by 31 members across six continents to stress test their financial systems. Results were forthcoming at the time of writing this report. Notable examples include:

- In 2018, De Nederlandsche Bank conducted an energy transition risk stress test for the financial system of the Netherlands. The **results** were a first to highlight that losses for financial institutions in the event of a disruptive energy transition could be sizeable but manageable.
- In 2019, the Bank of England was first to set an **expectation** that banks and insurers are to embed consideration of financial risks from climate change in their governance and use scenario analysis to inform strategy setting and risk assessment. The Bank of England then undertook a Climate Biennial Exploratory Scenario **exercise** to size the financial exposure, understand challenges to participants' business models and enhance management of climate-related financial risks.
- During 2020 and 2021, the Banque de France conducted a pilot **exercise** with banks and insurers that assessed physical and transition risks over a 30-year time horizon by economic sector, which revealed an overall moderate exposure to climate risks.
- In Canada, the Bank of Canada and the financial regulator, the Office of the Superintendent of Financial Institutions (OSFI), conducted a scenario analysis **pilot** focused on risks to financial institutions from the transition to a low-carbon economy in 2021. Two banks, two life insurers and two property and casualty insurers participated in the pilot project. The research highlighted potential material risks to the economy and the financial system. A second pilot is anticipated in late 2022 to include most major public pension plans. OSFI also created a Climate Risk Hub to deepen its expertise and more systematically incorporate the management of climate-related financial risks into its supervisory activities.

For pension plans, several research studies have illustrated the importance of CSA for investment planning and risk management. For example, in 2022, **research** from the Institute and Faculty of Actuaries and Ortec Finance illustrated that funding risks for a defined benefit pension scheme are greater under climate-informed pathways than under the climate-uninformed base scenario. While the researchers outlined uncertainties in the assumptions and model, the results show that the time taken to reach full funding increased from three to nine years, absent any changes to investment strategies or recovery plans. Similar **research** conducted on a hypothetical global 60 per cent equities/40 per cent bonds portfolio showed projected returns can still be positive in the long run with climate change, but they are meaningfully lower in climate-informed scenarios versus a baseline that assume further climate-related impacts beyond what has already occurred. For a long-term investor, the insights from CSA can help adjust expectations of performance and enable better management of the potential increase in market volatility as a result of sudden shifts in market sentiment that can create changes in asset prices.

In North America, pension funds are **similarly using CSA** to understand how their portfolios would fare under different global warming policy outcomes. In one American example, the Oregon state treasury conducted a climate scan report of the Oregon Public Employee Retirement Fund and noted lower return expectations across all assets due to negative climate impact over the next 20 years. In Canada, Caisse de dépôt et placement du Québec discussed in its ***2021 Sustainable Investing Report*** how CSA will shape its investment decision-making and portfolio engagement.

1.3 Climate scenario analysis at OPTrust

As a pension plan, OPTrust has a responsibility to consider all material factors that may impact our ability to fulfil our mission to pay pensions today and preserve pensions for tomorrow. We understand climate change represents a systemic risk and therefore needs to be analyzed alongside others typically considered in pension and asset management, such as interest rate, inflation and equity risks. We see CSA as one useful way to achieve this. From this analysis, we recognize that climate risks will affect the future value of both assets and liabilities, and that the impacts will be non-linear and will rapidly materialize over time.

In 2018, we initially partnered with Ortec Finance to conduct a **pilot project** on the impact of climate change on our portfolio. By illustrating how climate risk might impact our total portfolio and asset class specific returns, the pilot raised awareness of the importance of climate change integration in investment planning and strategy, and the need to include climate risk governance into our internal portfolio monitoring and management processes over time.

Since then, several improvements and additions were made to the model. This includes: the addition of pricing-in shocks[2] as markets begin to digest climate-related risks and opportunities; increased asset class coverage and breakdown of climate impacts into individual risk drivers, including the separation of physical and transition risks;[3] integration of the impact of the COVID-19 pandemic on the economy and global emissions; and the latest scientific thinking from the Intergovernmental Panel on Climate Change, a United Nations body that studies climate change.

In 2021, we collaborated with Ortec Finance again to fully integrate CSA with simulation-based asset-liability management analysis[4] to enhance our understanding of the impact of climate change on key macro-variables, asset class returns and subsequently, on our pension plan's funding risk. This top-down, total portfolio-based approach complements other work underway in the organization's climate change strategy that focuses more on the bottom-up, asset class-driven responses to climate change, including climate due diligence, stewardship plans for high-risk assets, climate-informed asset valuations and climate-related metrics and targets to guide our climate work going forward.

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2 Pricing-in refers to the change in assets' market prices due to the reflection of expected future risk or opportunities in valuations. In the context of climate change, pricing-in refers to the effect of expected future changes in revenue growth due to climate risks and opportunities, or reduced corporate revenues due to carbon taxes, which is taken into account in equity and bond prices.

3 Refer to Section 2.2 for more details.

4 Refer to Section 2.1 for more details.

2 How it Works

2.1 Asset-liability management at OPTrust

Asset-liability management (ALM) is at the heart of OPTrust's **Member-Driven Investing strategy**. In 2015–16, we began conducting ALM analysis internally to apply more rigor to our portfolio construction process and better understand the interaction of our assets (e.g. investment portfolios, member contributions) and liabilities (i.e. pension payments). OPTrust's ALM is based on a forward-looking simulation framework that fully integrates both assets and liabilities in a consistent manner under different economic regimes. This ensures that the valuation of pension liabilities, contribution rules and indexation are consistent with the returns and valuations on the asset side of the balance sheet.

The ALM analysis starts with model calibration to align with our capital market assumptions and discount rate/liability assumptions. After calibration, we run simulations on both asset returns and liability values over a 20-year horizon, which allows us to assess a range of asset mixes. A variety of asset and liability metrics are closely monitored and analyzed. From these, we select the one that meets our investment objective of delivering the required return over the long term at the lowest level of funding risk.

Collaboration with Ortec Finance allows us to integrate climate scenarios seamlessly with existing base-case ALM analysis[5] by overlaying climate impacts from three distinct climate change scenarios (outlined below). In doing so, we can expand our top-down perspective on the impact of climate change on our pension plan's funding risk and assess the resilience of our investments under those three climate scenarios.

2.2 Ortec Finance's climate scenarios (global warming pathways)

Ortec Finance's climate scenarios cover three different global warming pathways:

1. Paris Orderly Transition Pathway
2. Paris Disorderly Transition Pathway
3. Failed Transition Pathway

Figure 1 details three of the many possible transition scenarios that could lead to specified levels of warming. These what-if pathways are constructed to explore a range of plausible futures and each tests key elements of climate resilience (i.e. through heightened exposure to transition or physical risks).

5 We distinguish the base-case scenario from climate scenarios. The base-case scenario is a baseline for our regular ALM analysis and does not consider climate change risk and opportunities explicitly. All results in later sections are presented relative to the base case to highlight the impact of climate change.

Specifically, the pathways focus on two interdependent climate risk drivers:

1. **Transition risk**, which focuses on the impacts (opportunities/risks) of policies and technology uptake towards a low-carbon economy.
2. **Physical risk**, which focuses on changes in the natural system attributable to global warming, such as a reduction in agricultural and labour productivity, as well as increased frequency and severity of extreme weather events.

Figure 1: Global warming pathways modelled

Paris Orderly Transition	Paris Disorderly Transition	Failed Transition
• Paris Agreement goals are met • Avg. **global warming stabilizes at 1.5°C** • Large transition impact, but financial markets **respond smoothly and gradually to the transition steps taken** • Locked-in moderate physical impacts from existing level of warming	• Paris Agreement goals are met • Avg. **global warming stabilizes at 1.5°C** • Large transition impact, but financial markets **respond late and abruptly to the transition steps taken** • Locked-in moderate physical impacts from existing level of warming	• Paris Agreement goals are not met i.e. world maintains status quo • Avg. **global warming stabilizes at ~4°C** • Severe physical impacts from changing weather patterns

Source: Ortec Finance Climate MAPS (2020)

Failed Transition Pathway

In the climate scenario posited in the Failed Transition Pathway, no green recovery packages or additional climate policies are implemented after the COVID-19 crisis and the world returns to pre-COVID business-as-usual.[6] This scenario explores the risks of plausibly higher global warming, where the planet is around 1.9°C warmer than pre-industrial levels by 2050 and nearly 4°C warmer by 2100. Many countries suffer from extreme drought and water shortages. Productivity is reduced, affecting labour forces and crop yields. In addition, infrastructure damage from extreme weather events leads to direct costs and indirect effects on the economy through supply chain disruptions.

In this pathway, after several severe extreme weather event clusters hit the Western world, the market increasingly prices in lower expected performance due to these physical impacts, modelled as occurring between 2026 and 2030. The expected physical risks of the second half of the century are priced in between 2036 and 2040.

6 Global policies in the scenario are largely consistent with the IEA's World Energy Outlook Stated Policies Scenario (STEPS).

Paris Orderly and Disorderly Transition Pathways

On the other hand, the Paris Orderly and Disorderly Transition Pathways explore steep but realistic transition pathways. Global net-zero emissions are achieved before 2070, when global warming stabilizes at 1.6°C, but physical impacts continue to increase over the course of the century due to the locked-in effects of emissions from previous years. To construct the Paris Orderly and Disorderly Transition Pathways, a set of specific policies, which have been demonstrated to reduce emissions, are introduced. These include carbon pricing, coal phase-outs, and emission trading schemes and subsidies for renewable energy.

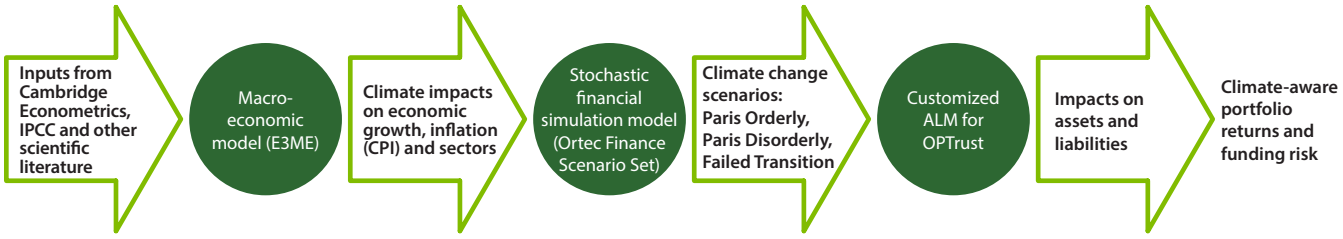
The Paris Orderly and Disorderly Transition Pathways follow the same emission and temperature trajectories and assume the same policy and technology changes take place. The only difference between the two is in the financial market consequences. In the Paris Orderly Transition Pathway, transition and physical risks are priced in over time, between 2021 and 2025. The Paris Disorderly Transition Pathway, however, sees climate risks priced in abruptly in 2025, which leads to a confidence shock to the financial system that year.

2.3 How does the tool work?

The global warming pathways are modelled using Cambridge Econometrics' **macro-econometric model** and incorporate inputs from the UN's Intergovernmental Panel on Climate Change (IPCC) and other literature. The expected impacts of climate change on inflation and economic growth and sector output of these scenarios are implemented as a shock to the stochastic Ortec Finance scenario set, from which we extract the median result.

This shifts the entire scenario distribution downwards, causing tail risks and downside probabilities to increase. The process is visualized in Figure 2. Based on these climate-informed scenario distributions, we can proceed with running the ALM analysis to evaluate our portfolios and assess the impact on funding risk.

Figure 2: From climate change to portfolio/funding risk analysis



Source: Ortec Finance, OPTrust

3 Summary of Results

3.1 Overall findings

Overall, OPTrust's climate scenario analysis (CSA) confirmed that climate change presents a material risk to the pension plan's sustainability, increasing long-term funding risk in all climate scenarios examined in the model portfolio[7]. While the anticipated impact of climate change will be pervasive, the magnitude of the impact varies by sector, geography, asset class, time horizon and the scenario considered. The specific impacts on our portfolio (which is not exactly the same as the one modelled) will also be influenced by the actions we take in our investment planning and asset management.

This section goes into greater detail on the modelled impact of climate change on the macroeconomy and capital markets, on the performance of our model portfolio, and a discussion of the impact of this analysis on one of the key metrics used at OPTrust to assess our funding risk and pension plan sustainability.

3.2 What are the macroeconomic impacts?

From an investor's perspective, the two most relevant variables to gauge the macroeconomy are gross domestic product (GDP) and inflation, measured as consumer price index (CPI). Figure 3 illustrates the climate impacts on these two variables, and this section further describes the impact on economic growth under different climate scenarios.

Overall, for the Paris Orderly and Disorderly Transition Pathways, global GDP impacts are limited. However, gradual physical and extreme weather risks will increase due to the already locked-in effects of current global warming and the 0.5°C extra warming in the years to come, adversely impacting economic growth over time.

In the Failed Transition Pathway, however, temperatures continue rising beyond 2100, resulting in increased physical risks and severe consequences for the global economy. As warming becomes irreversible, agriculture will be impossible in certain geographies, and the growing frequency and severity of extreme weather events will cause increasing damage. Overall, the world's ability to adapt is uncertain.

Of particular interest to OPTrust are the climate impacts for the Canadian and American economies. In the case of Canada, as compared with other countries, modelling suggests lower impact in a Failed Transition Pathway, at least until 2050. Even though Canada has warmed by a projected 1.7°C and will continue warming at a higher rate due to its high latitude, the country's current average temperatures are relatively low, limiting the impact of physical risk and extreme weather.

In the Paris Orderly and Disorderly Transition Pathways, however, the negative impact is larger than under the Failed Transition Pathway over the short-to-medium term. As a high-margin producer, Canada suffers the most from decreased global demand for oil and gas. By the 2040s, as oil and gas production approaches zero, investments in clean technologies lead to positive stimulus effects. At the same time, as in the Failed Transition Pathway, physical risks become more pronounced. GDP falls due to reduced revenues from fossil fuel exports and natural resource extraction, which leads to reduced government spending in other areas. This decreases employment, consumer spending and broader investment throughout the economy, putting additional downward pressure on GDP.

7 Refer to section 3.4 for more details.

By comparison, the United States (U.S.) experiences greater physical and extreme weather risks than Canada across all scenarios, and in the Failed Transition Pathway in particular. The risk is driven by increasing damage from hurricanes and particularly flooding, and by net negative impacts due to the policies pursued in the Paris Orderly and Disorderly Transition Pathways, although with less impact than in Canada. This is due to the U.S.' comparably lower-cost oil and gas and lower dependence on fossil fuel exports, which leaves the U.S. less vulnerable to a drop in fossil fuel demand. U.S.' GDP is also impacted by reductions in government spending as government revenues fall, which reduces employment, consumer spending and wider economic investment, placing additional downward pressure on GDP beyond the loss in export revenues.

Across both geographies, the results vary based on the climate scenario and time horizon. Figure 3 summarizes the annualized climate impacts on GDP and CPI, shown as differences compared to the base case, in Canada and the U.S. over three different horizons: five, 10 and 20 years.

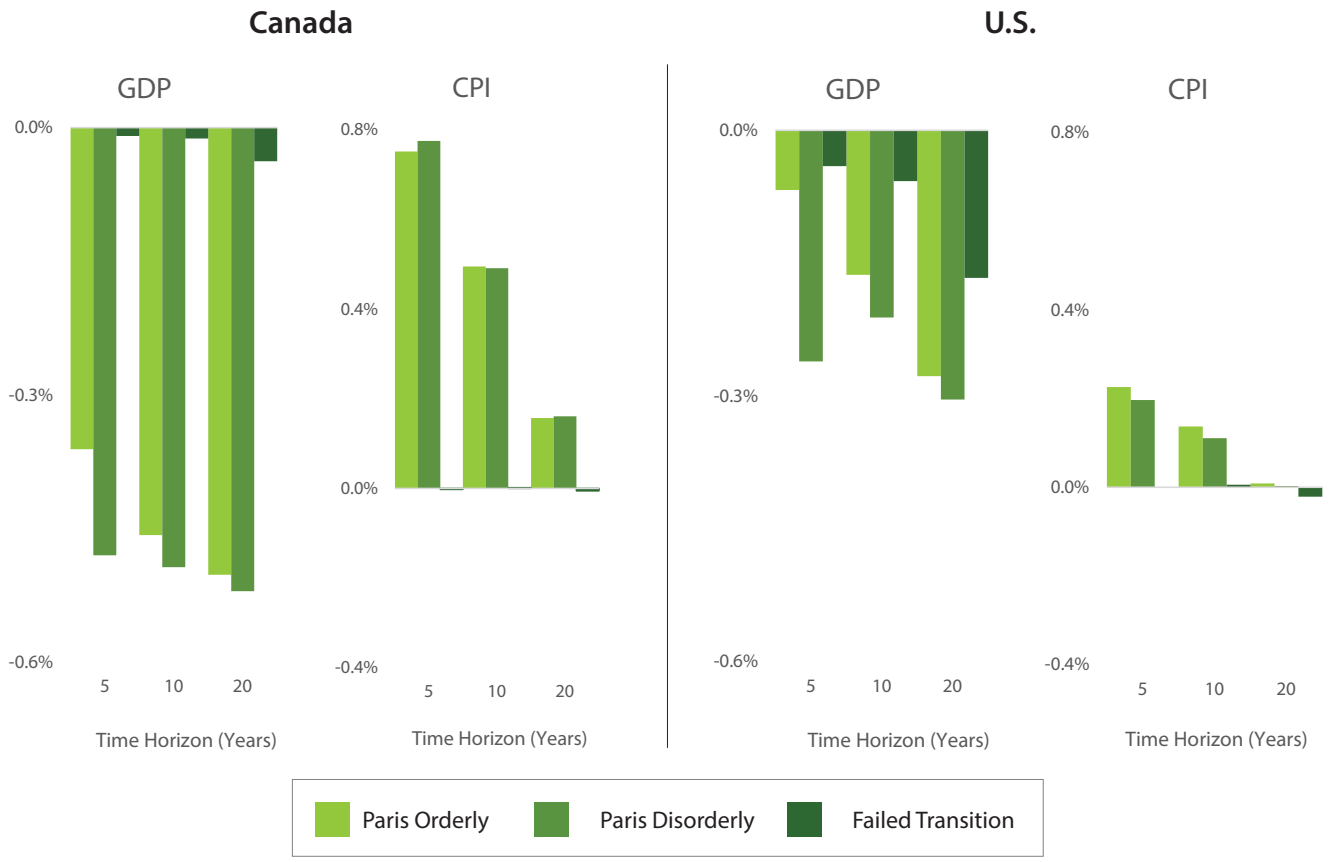
The cumulative impact on GDP over 20 years, relative to the base case, is more significant in Canada than in the U.S. under the Paris Orderly (-14.8 per cent drop in GDP in Canada versus -8.3 per cent in the U.S.) and the Paris Disorderly Transition (-15.3 per cent in Canada versus -9.1 per cent in the U.S.) Pathways. Under the Failed Transition Pathway, however, Canada will not be as hard hit (-1.2 per cent versus -5.0 per cent in the U.S.).

With respect to Canada and the U.S., climate change will increase inflation in both the Paris Orderly and Disorderly Transition Pathways, albeit at different magnitudes, and has only a marginal impact on inflation under the Failed Transition Pathway. Both countries require large amounts of investments to meet the Paris Agreement, which will increase price levels. The switch to cheaper renewables reduces inflation over time.

In the Paris Orderly and Disorderly Pathways, prices increase in the first few years. In Canada, this is driven by the stimulus effects of investments in low-carbon energy and infrastructure. As output catches up with demand, prices fall. In the U.S., ambitious carbon taxes drive price increases in fossil fuel and fossil-based electricity. As fossil fuels are phased out, high-carbon prices have a more moderate inflationary impact. The climate impact on Canadian inflation is larger than in the U.S. due to Canada's larger share of hydropower, a relatively expensive energy source compared with wind and solar.

Specifically, relative to the base case, the cumulative 20-year inflation impact in Canada is 4.3 per cent and 4.4 per cent under the Paris Orderly and Disorderly Transition Pathways, respectively, where in the U.S., inflation is only 0.2 per cent and 0.1 per cent higher.

Figure 3: Climate impact on Canadian and U.S. economies (annualized difference from base-case scenario)



Source: Ortec Finance Climate MAPS (2020), OPTrust Analysis

3.3 What are the capital market impacts?

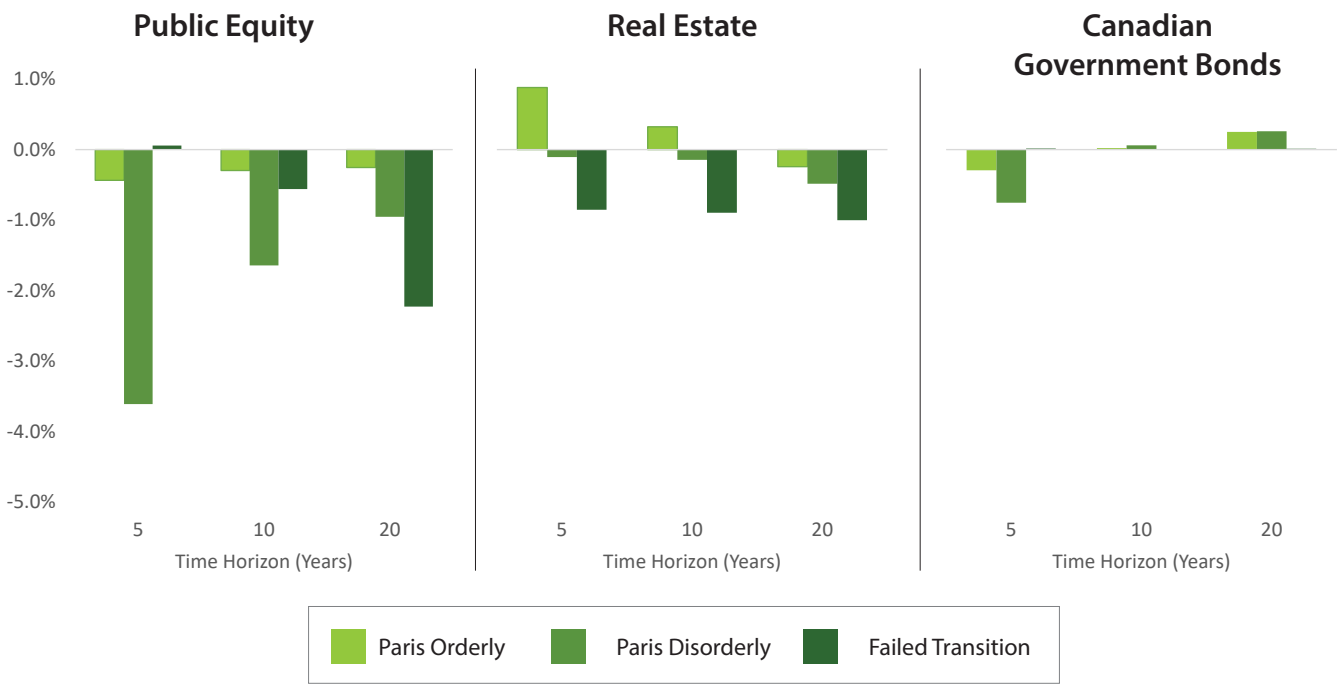
Consistent with its impact on the macroeconomy, climate change will also alter asset class performance. The anticipated impact will be pervasive and, as with the macroeconomic variables, the magnitude of the impact will vary by asset class, time horizon and the global warming pathway considered.

For illustration, Figure 4 presents the climate impact on returns of three selected asset classes: equities, bonds and real estate, on an annualized basis, over different time horizons. Key findings include:

- Equities are most adversely impacted, given their growth sensitivity. In the near term (i.e. five to 10 years), equity returns are significantly lowered under the Paris Disorderly Transition Pathway due to the abrupt pricing-in of climate risk. Over a longer horizon (i.e. more than 10 years), physical risk will materialize and more significantly affect equity returns, leading to a lower expected long-term equity return. This is more pronounced under the Failed Transition Pathway than under the other two.

- Real estate is also impacted, although to a lesser extent than equities. The expected lifetime of real estate is limited and finite when compared to equity, reducing the impact of a change in long-term expected growth. Rental incomes are frequently contracted for multi-year horizons and indexed to inflation. As a result, the impact is not felt until further in the future.
- The impact of climate risks on Canadian government bonds is generally immaterial as government bonds are typically less sensitive to wider market movements. Unlike most other countries, Canada's sovereign debt is more exposed to transition risks than to physical risks over a 20-year time horizon.

Figure 4: Climate impact on equity, bond and real estate returns over various horizons (annualized difference from base-case scenario)

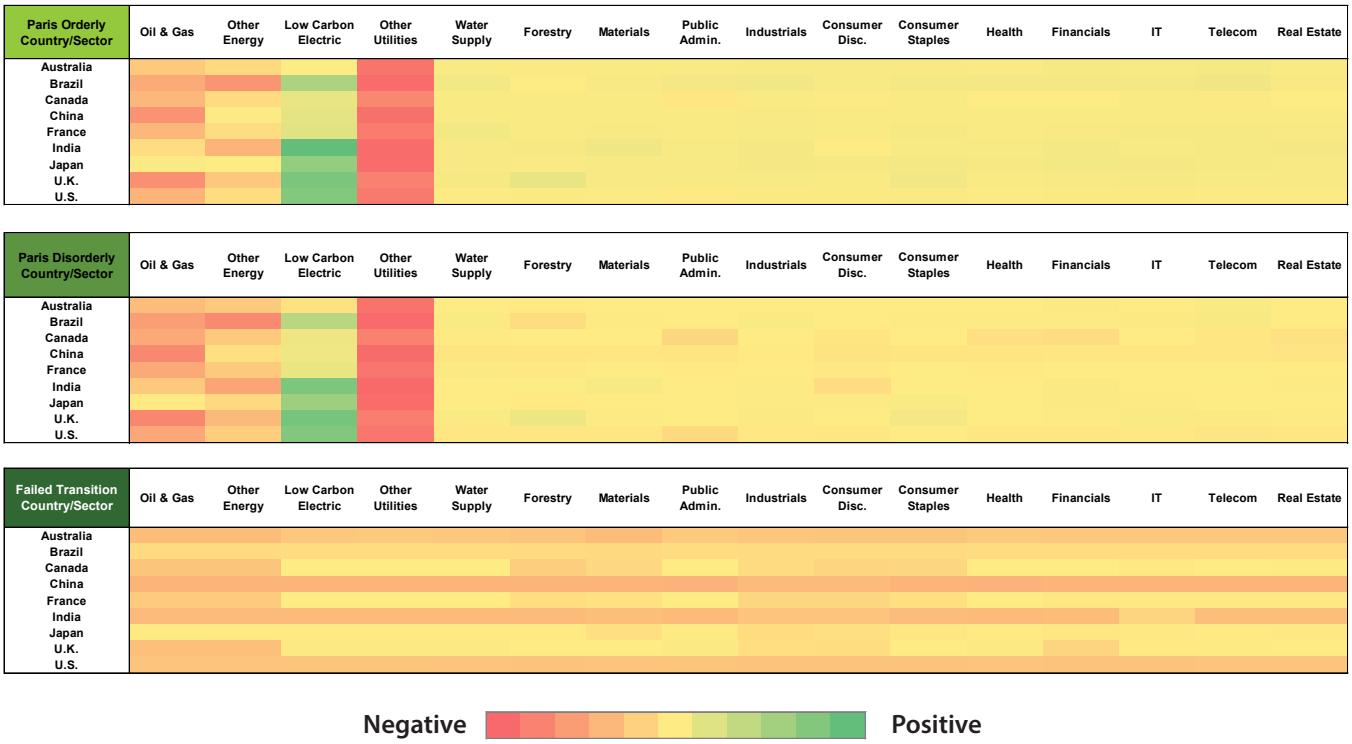


Source: Ortec Finance Climate MAPS (2020), OPTrust Analysis

Figure 5 looks more deeply at equity performance and illustrates the uneven impact of climate change across sectors and geographies, which presents both risks and opportunities. For example, the low-carbon electricity sector is expected to grow rapidly in the Paris Orderly and Disorderly Transition Pathways and therefore receives a positive price correction. On a global level, all other sector stocks show a negative price correction, with the high-carbon utility, oil and gas and other energy sectors most negatively impacted.

Climate pathways also influence equity performance. For example, price corrections are slightly larger in the Paris Disorderly Transition Pathway than in the Paris Orderly Transition Pathway because the price correction happens suddenly in 2025, whereas in the Paris Orderly Transition Pathway prices gradually adjust over the five years that follow. In the Failed Transition Pathway, there is no difference across sectors as this pathway assumes the entire economy will be hit by physical impacts and extreme weather events, affecting all sectors.[8]

Figure 5: Heatmap on climate impact on equity returns by sectors and countries[9] (20-year term)



Source: Ortec Finance Climate MAPS (2020), OPTrust Analysis

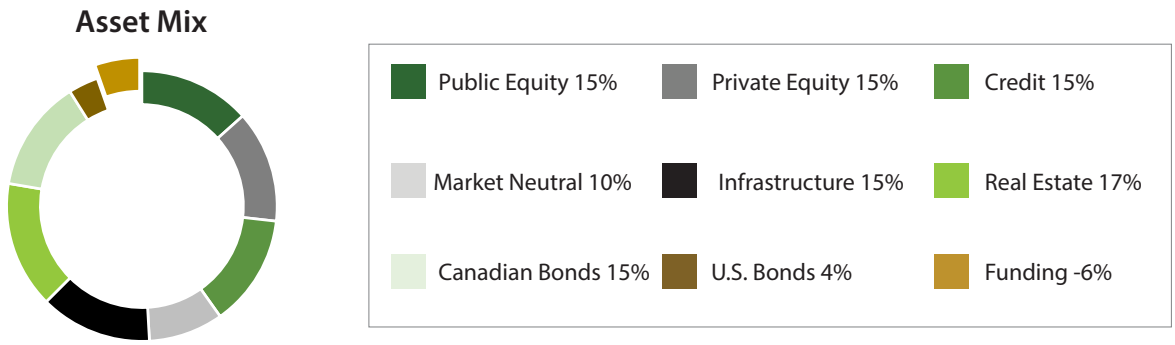
8 Sector-level physical risks are being addressed in ongoing research and development efforts.

9 Selected countries only.

3.4 What are the implications for our investment portfolio?

To understand the climate impact from the standpoint of OPTrust's total portfolio, we constructed a model portfolio with the asset mix shown in Figure 6 and assessed the portfolio's performance over time.

Figure 6: Model portfolio asset mix

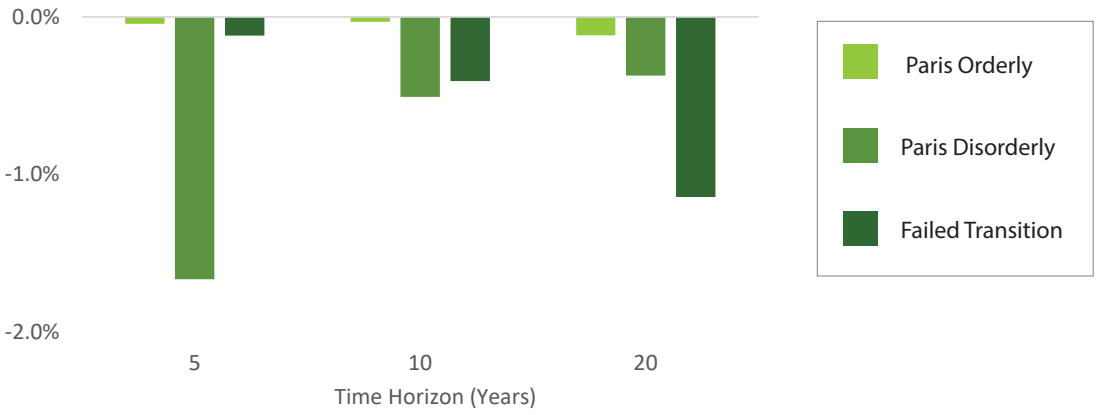


Source: OPTrust Analysis

Figure 7 illustrates the climate impact on the total portfolio returns on an annualized basis and key findings include:

- Overall, the least harmful pathway for a typical multi-asset portfolio is the Paris Orderly Transition Pathway. Under the other two pathways, the total portfolio return would be lowered by about one to two per cent on an annualized basis.
- Over a shorter horizon (i.e. five to 10 years), the portfolio performs worst under the Paris Disorderly Transition Pathway due to the abrupt pricing-in of climate risk in the year 2025.
- Over a longer horizon (i.e.10 to 20 years), however, the portfolio is most significantly impaired under the Failed Transition Pathway as physical risks materialize.

Figure 7: Climate impact on total portfolio returns (annualized difference from base-case scenario)



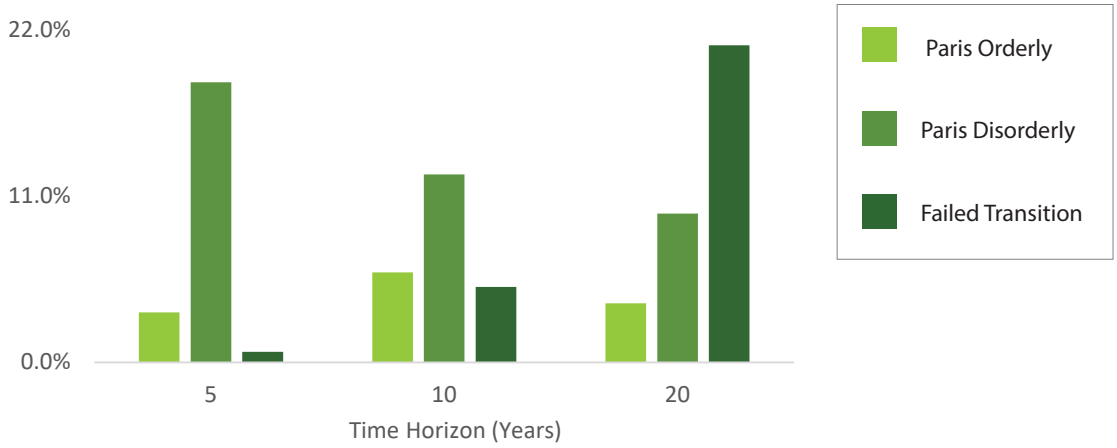
Source: Ortec Finance Climate MAPS (2020), OPTrust Analysis

3.5 How will this impact our pension plan's sustainability?

Levering up the integration of climate scenarios with ALM analysis, we took a step further to understand the climate impact on our pension plan's funded status. While OPTrust uses several metrics to assess the pension plan's funding risk holistically, this report will focus on just one: the probability of contribution rate change in excess of two per cent. This metric measures the likelihood that we would need to increase members' contribution rates by more than two per cent to bring the pension plan back to fully funded status (i.e. a funding ratio of 100 per cent). This probabilistic measure is a good quantification of the true risks faced by our pension plan members and a contribution rate increase of two per cent or more is deemed material.

Overall, the analysis confirms climate change is a material risk to our pension plan's sustainability, increasing funding risk in all climate scenarios under examination. As Figure 8 outlines, the Paris Disorderly and Failed Transition Pathways present the greatest risk to our funded status. The funding risk probability could increase by more than 10 per cent due to both deteriorating investment returns and changing liability valuation. In addition, the increase in funding risk is more acute in the near term under the Paris Disorderly Transition Pathway, while the Failed Transition Pathway makes it more difficult to keep our pension plan funded over the long term.

Figure 8: Climate impact on funding risk (difference from the base-case scenario at year-end)



Source: Ortec Finance Climate MAPS (2020), OPTrust Analysis

4 Limitations of climate scenario analysis and other considerations

Climate scenario analysis (CSA) is undoubtedly a useful tool to raise investors' awareness of climate change risk, to better understand its financial and economic implications and to facilitate communication with relevant stakeholders. That said, CSA has limitations in its current stage and they must be acknowledged. They include:

- Challenges with availability and quality of input data and the uncertainties associated with the use of climate models. For example, the slow onset of physical risks means not all these risks are explicitly captured and are instead modelled by proxies, based on the literature. The model also does not consider the economic impacts of land use change or climate adaptation, which will influence the economy's overall resilience to climate change.
- Reliance on simulation techniques that, while better than traditional econometric approaches that rely on historical inferences, can never perfectly project outcomes.[10]
- Complexities associated with modelling climate change impacts and linking them to the financial sector. For example, the financial modelling does not yet include impacts of climate-related physical risks on volatility,[11] climate tipping points (e.g. loss of Greenland permafrost), climate-related health implications, biodiversity loss, geopolitical conflict or migration. This suggests that impacts, especially those observed under a Failed Transition Pathway, are most likely still underestimated.

As any user of climate data will know, data are continually evolving and the model's improvements will strengthen the quality of analysis over time. Improvements made by Ortec in 2022 include:

- Updating the Paris Agreement pathway to a net zero by 2050 pathway.
- Increasing sector granularity.
- Capturing physical risk impacts on inflation.
- Refining the pricing-in of climate shocks.
- Enhancing the modelling of credit assets.
- Updating the model to reflect latest national policy commitments and progress in the uptake of new technologies.

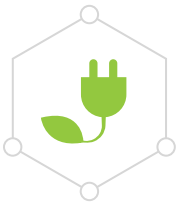
10 Cambridge Econometrics' E3ME model mitigates risks associated with traditional econometric approaches that rely on inferences based on historical relationships by using additional modules, including those that include technology investment decisions in response to the policy environment.

11 This is expected in Ortec Finance's 2023 model release.

In addition to the modelling limitations outlined above, investors should also be aware of other limits in interpreting the findings of any CSA exercise, including:

- Climate scenarios are hypothetical constructs, not forecasts or predictions, and should be used cautiously and with careful understanding of assumptions. Scenarios used here are only three among many possible pathways.
- Modelling is based on certain assumptions (e.g. proxy indices for certain asset classes) that may not be representative of actual portfolios.
- Capital market assumptions used today (base-case scenario) do not explicitly integrate climate considerations, nor do they address how these assumptions might change in the future if climate considerations become more material.
- Specific portfolios will be more resilient to climate change than the CSA suggests, based on bottom-up actions taken today and in the future.

The findings should be used as tools to prompt thinking and initiate conversation on how best to ensure climate-resilient portfolios, recognizing investors' approaches will inevitably evolve over time.



5 Takeaways and next steps

The full integration of climate scenario analysis (CSA) into our asset-liability management (ALM) framework, and the funded status results that followed, has facilitated communication and education on climate change. It helped bridge the gap between climate science and investments to help enhance our understanding of different climate risks and their impacts on our core purpose. While we are cautious not to interpret the findings with mathematical exactness, the analysis provides useful insights for the development of our climate change strategy and investment activities going forward.

Overall, the analysis confirms that climate change is a material risk to our pension plan's sustainability, increasing our funding risk in all climate scenarios under examination. The climate impact is most significant under the Paris Disorderly Pathway over the short term and under the Failed Transition Pathway over the long term. Transition risk is the key driver on the former while physical risk contributes most to the latter. As far as investment portfolios are concerned, while the anticipated impact of climate change will be pervasive, the magnitude of the impact varies by asset class, time horizon and the global warming pathway considered.

Looking ahead, we anticipate CSA will remain an indispensable tool as we continue our journey to net zero by 2050. Recognizing both the limitations of this approach and the uncertainties involved in understanding climate impacts over multiple geographies and industries, we have begun to build out the capabilities needed to help our teams explore and better understand the complexity of climate change and its implications on economies and financial markets.

From a top-down portfolio construction perspective, OPTrust has used CSA to complement the existing investment planning and total portfolio construction process in two major ways:

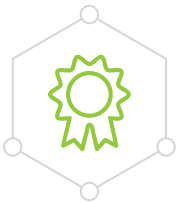
1. Although climate scenarios are hypothetical constructs, we consider CSA the same way we do what-if scenario analysis: it is used in parallel to the existing investment planning process to provide us with climate impact insights on our total portfolio and funded status of the pension plan in a way that was previously unavailable.

2. Recognizing there is still high uncertainty on the financial impact of climate change, we are also considering integrating those uncertainties into our ALM-based portfolio construction process. One possible approach would be to introduce a degree of uncertainty on capital market assumptions[12] into the ALM framework. This would build climate-awareness into the portfolio construction process in a natural way and enable us to incorporate climate risks directly into portfolio construction results. There may also be ways to better understand potential climate impacts on pension liabilities (e.g. mortality assumptions).

12 BlackRock shared a similar idea in 2021 on their **climate-aware capital market assumptions**.

Just as significantly, this analysis has underscored the importance of advancing other key bottom-up asset class-driven analyses, including:

- Using climate due diligence frameworks across all asset classes.
- Implementing stewardship plans to advance the transition of our high-risk assets.
- Collecting bottom-up baseline data on climate metrics for our portfolio and establishing a framework to set appropriate, relevant targets for OPTrust. Over time, we will move toward developing approaches to marry these bottom-up analyses with the top-down scenarios.
- Monitoring the climate risk exposure more systemically and tracking indicators of potential global climate pathways toward net zero in key industries and geographies.
- Continuing to analyze, learn from and communicate our progress through our ***Funded Status Report*** and *Task Force on Climate-related Financial Disclosures*, available on the **climate change section of our website**.



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