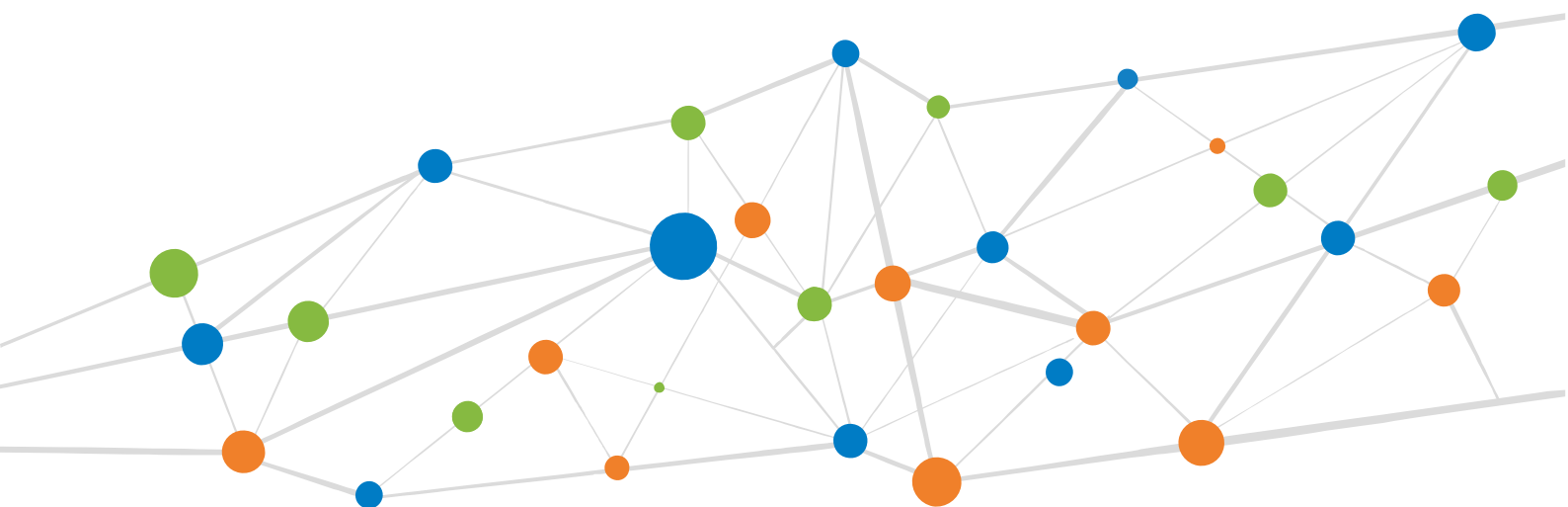


Climate-savvy OFS

Pilot Project Report for OPTrust

December 2018



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Preface

Dear OPTrust team,

Please accept our heartfelt thanks for your cooperation in this pilot project. Your trust in our company and your willingness to accept 'innovation risk' has enabled our team to develop a version 1.0 of a groundbreaking methodology for the integration of climate-related risks into strategic investment decision making. We are confident that the methodology and underlying data will be a valuable tool in effectively managing these risks going forward for both OPTrust and other investors.

Best regards,

The Ortec Finance Climate-Savvy OFS team

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Executive Summary

An urgent knowledge gap

Currently there is a disconnect between existing scientific data describing various global warming pathways and how to use this information to integrate climate change impacts into traditional state-of-the-art financial performance, risk assessment and economic scenario analysis at the strategic level. Current analysis focuses on bottom-up climate-related risk analysis and reporting (e.g. climate VaR, carbon footprinting), but does not consider top-down integration via macro-economic risk analysis into ALM and long-term strategic asset allocation (SAA).

However, empirical research has shown that over a longer time horizon (10+ years) more than 80% of returns and risk are the result of the SAA, implying the importance of proper top-down analysis. There is increasing consensus that climate-related risks will have a significant impact on macro-economic risk drivers that are key inputs in determining optimal SAA. Thus, optimal choices at strategic level are only truly optimal if climate change is taken into account.

The pilot project's objective and approach

The objective of this pilot project was to develop – in collaboration with leading academic researchers and pioneering clients including OPTrust – a 1.0 version of a forward-looking climate-savvy economic and financial scenarios set, based on which climate-aware ALM/SAA analysis can be done. The unique methodology that was developed during the pilot is based on combining very well-respected and established climate, macro-economic and financial modelling. Via this methodology both transition and physical climate-related financial risks and opportunities were integrated in forward-looking strategic investment decision-making.

Global warming pathways modelled

Every energy transition or global warming pathway increases risks to investors. It is unlikely that investors can insulate themselves from climate risks completely. Climate-related financial risks are recognized as being 'unhedgeable' and 'systemic'.

In the context of the pilot, three global warming pathways have been modelled: limiting global warming to 1.5°C (disorderly transition), global warming of 3°C by 2100 (currently most likely pathway based on Nationally Determined Contributions (NDCs)), and global warming of 4+°C by 2100 (higher warming scenario including insights on extreme weather events). The climate-savvy Ortec Finance Scenarioset (OFS) distinguishes impacts between short- (now-2030), medium- (2030-2050), and long-term (2050+) horizons. The model runs up to 2100 which is in line with the time horizons of most climate science models.

Key findings from the pilot

1. **Top-down, macro-economic & systemic climate risk perspective delivers new insights.** The pilot has established that it is crucial for investors to consider the macro-economic and systemic implications of different global warming pathways (top-down approach). The currently dominant holdings-based focus (bottom-up approach), on its own, may be myopic in its scope as it mainly considers companies

and sectors, but misses the structural impacts on the (global) economy as a whole, and how this in turn affects an investors' overall performance. Traditional strategies of exclusions, best in class approaches, and diversification may not be enough (or in conflict) to adequately manage the systemic climate-related financial risks (both transition and physical) investors are exposed to via the wider macro-economic outlook, e.g. growth, inflation, etc.

The results show that...

2. **For a globally diversified investor, a transition to stay under 1.5°C warming, even a severely disorderly one, is preferable over a 4+°C scenario.** However, there are material differences across regions; largely determined by the relative energy efficiency of the economy and dependence on carbon intensive production and exports.
3. **At a global level, a steep economic transition to limit warming to 1.5°C may entail significant opportunities for economic growth, perhaps even above current market expectations** – the infrastructure investments required, research & development and employment generated are strong drivers of growth and competitiveness. The more orderly the transition, the more pronounced these economic and investment opportunities become. Geographies that are perceived to be well-placed to manage the transition may even be regarded as 'safe havens' with regards to transition risks for investors. If well-managed, these additional capital inflows can further drive growth in those 'transition-ready' economies.
4. **The time to act is now – even if physical climate-related risks may only become financially material on a longer time horizon.** The expectation that physical climate-related financial risks are likely to only materially manifest as of mid-century is no reason to be complacent as an investor today. The window of opportunity to keep 1.5°C within reach is very short (circa 10 years).
5. **If action fails today and the transition to a low-carbon, climate-resilient economy is not completed by mid-century, our economies will be locked into a higher global warming pathway where the global economy is likely to increasingly and structurally slow down.** The negative impacts of a 4+°C pathway take over the impacts of a disorderly transition to 1.5°C around 2030-2080, depending on the country.

In addition, the pilot highlighted the following learnings...

6. The climate-savvy ALM analysis permits investors to **fulfill increasingly stringent disclosure requirements and upcoming regulatory compliance:** IORPII, EU Sustainable Finance Package, TCFD, UN PRI.
7. **Supporting strong climate action through informed strategic choices:** Gained insights enable portfolio optimization for a chosen global warming pathway (that matches investment beliefs/goals/targets), while at the same time ensuring the portfolio is robust for other global warming pathways.

8. **There is no silver bullet when managing climate-related financial risks.** Each step in the investment process requires a different forward-looking scenario-based approach. Assessing the risk to the overall portfolio (ALM/SAA) requires a different approach than individual mandates. To truly say that you have done your climate-related financial risk management ‘homework’ as an investor, the appropriate methodology should be applied to the corresponding phase of the investment process – from strategy to implementation. Insights from a top-down and bottom-up approach should be combined and placed in the context of the traditional investment process continuum.

Key insights & recommendations for OPTrust

“Describe the resilience of the organization’s strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario” - TCFD report 2017

Conclusions from this climate-savvy ALM study for OPTrust are:

The portfolio results of OPTrust reflect that Canada is particularly vulnerable to the energy transition. Under a steep transition scenario, Canada’s export dependence on fossil fuels combined with its high marginal costs of tar sand extraction would render these fossil fuel exports unviable to continue at predicted rates. In turn, the Canadian economy would need to restructure and ‘make up’ for this 20% of direct fossil-fuel exports, as well as other dependent indirect economic activities related to this industry.

When looking at the higher global warming pathways, Canada is less vulnerable to physical impacts than many other countries due to its geographic location: a slightly warmer planet – at least temporarily - could mean an increase of Canadian land area that is suitable for agricultural production. Note, however, that the potentially increasing impacts of extreme weather events such as storms and hurricanes, are not well-captured within the model yet.

As a result of this comparison, Canada finds itself in a unique position – different even to that of the USA – where it becomes very important to understand the implications of different global warming pathways on macro-economic development more broadly, and OPTrust’s portfolio more specifically.

Although the negative impacts of the 1.5°C pathway on OPTrusts’ portfolio are dominant in the short- and medium-term, the negative impacts of the 4°C take over as of 2080.

Depending on how reality will unfold (see Annex: Signposting), this may take place earlier (in case of a less stringent transition, a better positioning of the portfolio of OPTrust with regards to transition risks or more severe climate impacts).

Climate-related financial risks are dynamic in nature. For the next decade or so, transition-related risks are key, because physical impacts are still relatively modest and, if society is to stay under 2°C, then the transition has to happen in this time frame. If a very steep, and likely to be disorderly transition does not occur, then ‘Paris’ ambitions are unlikely to be achievable. In that case OPTrust may want to prepare to deal with increasing physical climate risks. Monitoring developments in the areas of climate science, technology, policy and consumer sentiments is key for understanding which global warming pathway the

world is likely to be on. Being able to adjust relatively dynamically to this quickly changing landscape is very important.

Supporting strong climate action on the operational level through informed strategic choices: OPTrust could use the gained insights to enable portfolio optimization towards a 1.5°C pathway (that matches investment beliefs/goals/targets), while at the same time ensuring the portfolio is robust for potentially higher global warming pathways.

Additionally, Ortec Finance would like to highlight that any interventions at the ALM level should be a logical, consistent fit with measures taken at the operational level in the portfolio. For example, exclusions, over/underweighting, impact investing and engagement all remain relevant operational tools. The outcome of the ALM analysis may point in the direction of interesting opportunities exactly there where risks are greatest. OPTrust could explore investment opportunities in energy efficient infrastructure and real estate, both globally but also especially in EM.

Finally, even though it is strictly speaking out of scope of the pilot, Ortec Finance feels strongly about the importance of **regulatory engagement** as one of the most powerful tool in an asset owners arsenal to manage climate-related financial risks. Individual action is key, but only if politics, industry, financials and society as a whole come together, we will be able to succeed in building a low-carbon, climate-resilient world within the next few decades. If the Canadian economy is able to transition its economy towards low-carbon industries, transition impacts may be mitigated. Ortec Finance strongly recommends that OPTrust uses its influence as an asset owner and trusted institution in Canadian society to engage with both its final beneficiaries, regulators & government as well as the companies it is invested in on climate-related financial risk. Concrete requests could include the following:

- **Towards final beneficiaries:** Ensuring buy in and support from financial beneficiaries for investment policy geared towards managing climate-related risks is key for having a strong mandate to act. Ortec Finance would encourage OPTrust to continue its open dialogue with final beneficiaries in explaining the nature of the risk that climate change poses to portfolio performance. It may be helpful to openly discuss trade-offs and challenges and to explain OPTrust's choices in managing these risks. We trust that insights from this pilot are a solid base for entering into this dialogue with final beneficiaries.
- **Towards Government/regulators:** Climate-related financial risks can only be managed if both the private sector and the government act in a coordinated manner towards the same goal. Considering the material climate-related financial risks that OPTrust faces Ortec Finance deems it crucial that OPTrust finds its 'voice' and calls for strong policy on reshaping the Canadian economy in order to be resilient to a low-carbon transition. Points that could be made include:
 - The Canadian economy should become significantly more robust to a scenario where demand for its fossil based exports falls away: the Canadian economy is highly dependent on fossil fuel exports. Large customers (US, EU and China) determine the demand for these exports. Technological change, consumer sentiment, legal and policy frameworks could all result in non-fossil fuel energy to become preferable over fossil based energy in these economies. Investing in

local Canadian assets (real estate, government bonds) could be considered excessively risky given this macro-economic exposure.

- Concrete steps the Canadian government could consider taking include:
 - o Introduction of a robust carbon pricing mechanism (at least 75 CAD per ton CO2 equivalent);
 - o Earmarking these revenues for investing in innovation, research and development to decarbonize currently high-emitting industries and support the growth of low-carbon industries;
 - o Earmarked revenues could also be used to ensure that the energy transition is 'socially inclusive'. Financing re-schooling programs and perhaps early retirements for workers in high-fossil sectors as well as subsidizing household investments (housing refurbishments, transitioning to low carbon personal transport) could all be considered.
- **Towards Companies:** engaging with companies is a classic risk-management tool. In Ortec Finance's view, consciously staying invested in carbon intensive assets is warranted if combined with a very strong active ownership policy. However, this engagement is not open ended. If after a concrete period of time (circa 2 years) OPTrust is insufficiently convinced that the asset will be able to innovate (both in terms of product and production process) sufficiently fast to remain profitable in a 1.5°C global warming pathway, divestment should be seriously considered.

Disclaimer: Please note that these conclusions and recommendations are based on the current state of development of the climate-savvy OFS. The climate-savvy OFS will be under post pilot evaluation and development. Future iterations may lead to different insights.

1. Introduction

In any conversation about forward-looking financial risk management, climate-related risks are quickly becoming an integral part of the conversation. This conversation is moving beyond the traditional paradigm of sustainable or responsible investing and towards answering investor questions like: ‘how can I fully embed climate-related risks and opportunities into my investment process?’

This type of question is very timely. First of all because the actual physical effects of climate change are becoming painfully apparent as illustrated by the heatwaves in Europe and extreme wildfires and storms in the US during the summer of 2018. Also because uncertainties about climate regulation, consumer preference and technological developments are increasing. In addition, regulation about climate-related risk measurement and disclosure is gaining momentum.

“Since the 1970’s, fossil fuels have commanded a consistent 60-70% share of the global power generation mix. We think this 50-year equilibrium is coming to an end, as cheap renewable energy and batteries fundamentally remake electricity systems around the world” Bloomberg NEF, NEO, 2018

The challenge is, however, that currently there is a disconnect between existing scientific data describing the various global warming pathways and how to use this information to integrate climate change impacts into traditional state-of-the-art financial performance, risk assessment and economic scenario analysis at the strategic level. Current analysis focuses on bottom-up climate-related risk analysis and reporting (e.g. climate VaR, carbon footprinting), but does not consider top-down integration via macro-economic risk analysis into ALM and long-term strategic asset allocation (SAA).¹

However, empirical research has shown that over a longer time horizon (10+ years) more than 80% of returns and risk are the result of the SAA, implying the importance of proper top-down analysis.² There is increasing consensus that climate-related risks will have a significant impact on macro-economic risk drivers that are key inputs in determining optimal SAA.³ Thus, optimal choices at strategic level are only truly optimal if climate change is taken into account.

A climate-savvy ALM/SAA analysis allows for a strong climate-risk management narrative by investors for regulatory & TCFD reporting purposes. Undertaking a climate-savvy ALM/SAA

Why is it important to integrate climate change perspectives into the OFS?

¹ One of the only attempts of this sort that we have identified is that of Mercer (2015) – Investing in Times of Climate Change (<https://www.mercer.com/content/dam/mercer/attachments/global/investments/mercer-climate-change-report-2015.pdf>). However, the report did not carry out a quantification of climate-related risks from a top-down risk analysis.

² First State Investments (2013). Strategic Asset Allocation. In *Multi-Asset Solutions Research Papers*, Issue 6, September 2013.

³ Stern, N.H., et al (2007). The economics of climate change: the Stern Review. Cambridge University Press, Cambridge.

Wade, K., et al (2014). The Impact of Climate Change on the Global Economy. Schroders.

also helps determine a climate-aware portfolio, and test if, for example, a science-based target portfolio is robust in a higher global warming scenario.

1.1. Objective and scope of the pilot

The objective of this pilot project is to develop – in collaboration with leading academic researchers and pioneering clients – a 1.0 version of a forward-looking climate-savvy scenario set that in turn powers Ortec Finance’s forward-looking (ALM/SAA) analysis software called GLASS.

1.1.1. The pilot in a nutshell

The pilot project, linking scientific climate data to ALM/SAA tooling, explored a novel approach to map potential climate impacts on future risk and return. The pilot combined existing academic research on climate-related risks associated with several global warming pathways and mapped this to key macro-economic risk drivers (namely growth rates per region). The results of this mapping was then integrated into Ortec Finance’s forward-looking scenario set (OFS) that already included a wide array of standard financial and economic variables. For two of the climate pathways, ‘out of model adjustments’ were implemented on top of the climate shocks from the data providers in order to explore key climate risks that were not captured in those datasets. Piloting investors’ portfolios were tested using the new climate-savvy financial scenario sets as the key input for the climate-adjusted ALM/SAA analysis.

What’s new is the combination of well-respected climate and financial models

The resulting insights increased the piloting investors’ understanding of the sensitivities of their investment strategies to climate-related risks. Additionally, the pilot aimed to inform academia of existing knowledge and data gaps to tailor future research to the financial sector practitioners’ needs.

1.1.2. Scope

The climate-savvy OFS encompasses three **climate change (global warming) pathways**: keeping global warming under 1.5°C (disorderly transition), warming up to 3°C in 2100 (current level of political ambition based on formal national strategies), and warming of 4+°C in 2100 (higher warming scenario with extreme events).

What is included in the first version of the climate savvy OFS?

Ortec Finance included climate change impacts stemming from both the **transition-related risks and opportunities** as well as the **physical risks** experienced as a consequence of global warming.

Time horizon: The climate-savvy OFS distinguishes impacts between short- (now-2030), medium- (2030-2050), and long-term (2050+) horizons. The model runs up to 2100, in line with time horizons of most climate models.

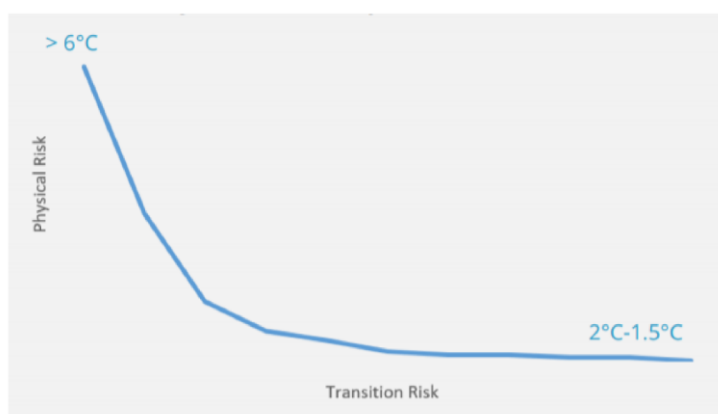
Risk vs. alignment: This pilot was about climate-related risk management, not value-driven decarbonisation/alignment. As a next step (but beyond the scope of this pilot project), investors could base portfolio optimisation decisions on the climate-savvy OFS results, as well as stress-testing any Paris alignment decisions via the climate-savvy ALM tool.

2. Global warming pathways modelled

As emphasized in the literature, every energy transition scenario or global warming pathway increases risks to investors.⁴ It is unlikely that investors can insulate themselves from climate risks completely. Climate-related financial risks are therefore recognized as being ‘unhedgeable’ and ‘systemic’.⁵

Starting to understand the nature, magnitude and differences of risk in various global warming pathways is a first step investors can take in order to start informing themselves on what they can do to minimize negative impacts on risk-return parameters.

Figure 1. Climate-related financial risk ‘trade-offs’ between physical & transition risks (source: APG, 2018)



Two of the three global warming pathways that have been designed in this pilot (1.5°C and 4+°C) are ‘severe but plausible’, and meant to explore the different nature of climate-related financial risks in a very ambitious and disorderly transition pathway, and in a world of extreme warming. The 3°C scenario explores the pathway based on current policies (as indicated in the

NDCs).

It is important to emphasize that in our methodology the global warming pathways are inputs to the financial modelling. The ‘scenario cloud’ that shows how a portfolio may develop in the future are in our context called ‘scenarios’. So, the global warming pathways are the inputs and the climate-savvy scenarios set are the outputs.

The following sections summarize the narratives of the three global warming pathways (a detailed description of each pathway can be found in the separate methodology document).

⁴ Stern, N.H., et al (2007). The economics of climate change: the Stern Review. Cambridge University Press, Cambridge.

Wade, K., et al (2014). The Impact of Climate Change on the Global Economy. Schroders.

⁵ University of Cambridge (2015). Unhedgeable risk. How climate change sentiment impacts investment. <https://www.cisl.cam.ac.uk/resources/publication-pdfs/unhedgeable-risk.pdf>

2.1. 1.5°C disorderly transition pathway

“Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (high confidence)”

- IPCC, 2018

Focus	Exploring a disorderly transition to limit global warming to 1.5°C
Transition risks	Built up from a combination of datasets capturing both trade & energy efficiency effects. <u>Key assumptions:</u> widespread utilization of carbon dioxide removal and available credit to fund the new low-carbon investments.
Physical risks	Locked-in 1.5°C effects from climate scientific datasets. <u>Key assumptions:</u> Currently capturing wildfires, coastal flooding/sea level rise, and agricultural productivity; not modelled – river floods, windstorms, health effects
Out of model adjustment (sentiment/sudden shocks)	Financial sentiment risk included in year 2025 equal to 30% of the 2008 global financial crisis (based on lit. review & expert consultation)

2.1.1. Introduction

The latest IPCC report stressed that society must reduce greenhouse gas emissions drastically from now on to reach net zero emissions around 2050, if society wants to have more than 50% chance of limiting global warming to 1.5°C. This means global net CO₂ emissions have to decline by about 45% from 2010 levels by 2030, which is only 12 years from now. “This requires rapid and far-reaching transitions in energy, land, urban and infrastructure and industrial systems. These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emission reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options.”⁶

Such a transition will have far-reaching consequences especially for high-carbon companies and related investments.

⁶ IPCC (2018). Global warming of 1.5°C – an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. <http://ipcc.ch/report/sr15/>

“We need to shift the world on to a different investment and growth path right now. This is more technically possible than we used to think. But it is politically highly challenging.

- Martin Wolf, Financial Times <https://www.ft.com/content/b1c35f36-d5fd-11e8-ab8e-6be0dcf18713>

2.1.2. Physical risks

First of all it is important to realise that global warming is currently already at about 1°C and the impacts are becoming increasingly visible. The physical risks related to 1.5°C warming are already locked-in to the climate system and will materialise as the world enters into the 2030s⁷. Even with 1.5°C warming, there will be considerable impacts such as increased extreme weather events, some of which are already observed today.

It is important to note that 1.5°C means *average global warming*; temperature extremes on land are projected to warm more than average: extreme hot days in mid-latitudes warm by up to about 3° at global warming of 1.5° and extreme cold nights in high latitudes warm by up to 4.5°C at 1.5° global. Certain regions are at disproportionately higher risk, due to their vulnerability in combination with strengthening of already occurring patterns in the climate system; dry regions will likely face increasing drought, whereas traditionally wet regions are expected to get even wetter.

The dataset used for physical risks in our 1.5°C (and 3°C) warming pathway currently include economic impacts from:

- wildfires
- coastal flooding
- effects on agricultural productivity (for maize, rice, wheat and soy).

It is likely that physical risks are underestimated in our 1.5 (and 3°C) pathway because the above list does not capture all climate-related physical risks (ex. river flooding, migration etc. are not currently included).

⁷ Interviews Ny-Alesund 2018 seminar

2.1.3. Transition risks

The datasets that we have used for this pathway model an emission peak in 2020 and net zero emissions around 2060, in line with the findings of the IPCC (see figure 2).⁸ A combination of different high-ambition policies related to energy supply, transport, buildings, industry, and land use is modelled in order to ‘force’ countries on this climate path. As of 2025, comprehensive, harmonized carbon pricing kicks in, with carbon prices exponentially increasing until 2060.

An important assumption in the 1.5°C pathway is the full availability of carbon dioxide removal (CDR) measures (such as wide-scale afforestation or technological carbon capture and storage).

Without full availability of CDR, it is not possible within the model to keep temperature below 1.5°C. Therefore, without CDR – the emission reduction trajectory would have to be even steeper.⁹ Another important

assumption (and requirement for the temperature target to be achieved in the model) is that there is available credit to fund the new low-carbon investments, with this debt gradually paid back in later years.

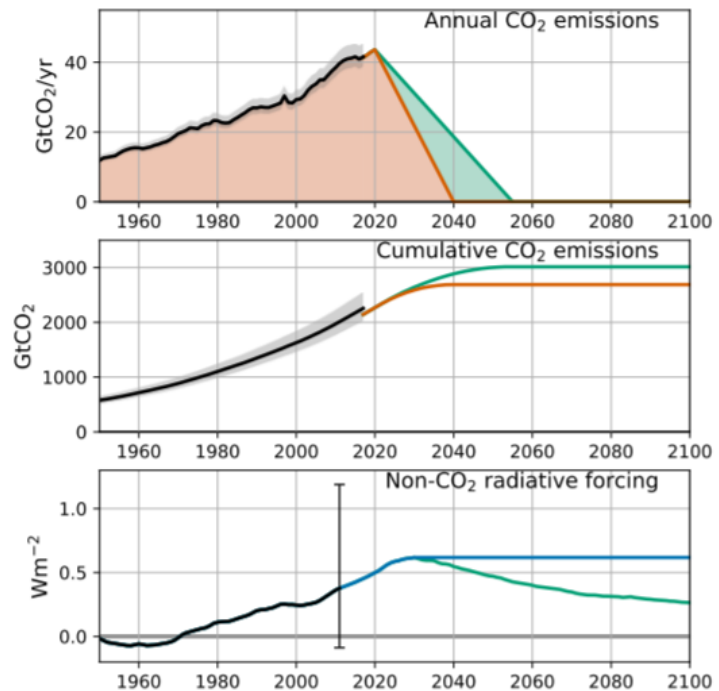


Figure 2. Time-series of (top) annual CO₂ emissions, (middle) cumulative CO₂ emissions, and (bottom) non-CO₂ radiative forcing corresponding to observation-based estimates over the historical period and idealised 1.5°C-consistent pathways (IPCC,

2.1.4. Out of model adjustments (for sentiment/sudden shocks)

The input datasets reviewed assume an orderly transition, meaning that a gradual phase-in of policies is modelled, including a gradual increase of carbon prices. This gives the energy system and related industry time to adjust. However, it is seen as very unlikely by experts that a transition of this magnitude, where we need to globally re-engineer the world’s entire energy system and all related industries and lifestyles, will be orderly.

In order to capture the sense of disorderliness, a sentiment shock has been introduced in 2025, of the size of 30% of the Global Financial Crisis. The size and timing of the shock is based on literature review and expert consultation. Such a sentiment shock may be a result of different drivers, such as abrupt implementation of policy measures; technological breakthroughs, consumer sentiment or legal risks (e.g. pending lawsuits against various oil majors).

⁸ For some geographies a different dataset was used. It assumes carbon neutrality in 2080.

⁹ The capacity of CDR determines the amount of emissions that can be emitted before 2050, but does not influence the timing of reaching net-zero emissions.

2.2. 3°C pathway based on current policy commitments (NDCs)

Focus	This pathway is based on currently announced public policy commitments (NDCs), assuming full and timely implementation.
Transition risks	Risk of a slower, orderly transition. Implementation of policies for low-carbon energy, energy efficiency and climate change mitigation and related investment needs <u>Key assumptions:</u> assuming full and timely implementation
Physical risks	Economic impacts from wildfires, coastal flooding/sea level rise and changes in agricultural productivity considered. <u>Key assumptions:</u> As not all physical risks, feedback mechanisms and knock-on effects such as migration are included, this should be considered an underestimation.
Out of model adjustments (sentiment/sudden shocks)	None

2.2.1. Introduction

As part of the Paris Agreement, countries have outlined and communicated their post-2020 climate actions, known as their Nationally determined contributions (NDCs). Integrated Assessment Model calculations have estimated that the implementation of the NDCs would set us on a pathway for 3°C warming by 2100. Therefore, this pathway is currently seen as most likely, unless significant efforts are taken to reduce emissions drastically within the coming years.

2.2.2. Physical risks

The physical risks over the period to 2050 are similar to the risk related to 1.5°C warming, because of the time-lag in the climate system: the impacts of further warming will start to materialise after 2050 in the Integrated Assessment Model (IAM) that was used to model the physical impacts.

The impacts related to 3°C warming are significantly larger than for a 1.5°C world and there is a larger chance that certain (self-reinforcing) feedbacks will be triggered. However, we have put more effort into developing such physical risks in the 4+°C pathway. Therefore, the physical risks in the 3°C pathway are underdeveloped and so far only include economic impacts from wildfires, coastal flooding and agricultural productivity.

The impact of coastal flooding is the key driver of the GDP impacts, while the impacts of increased incidence of wildfires and reduced agricultural productivity were comparatively small in the underlying modelling. Many physical impacts are not covered in this pathway and non-linear effects are not considered. Further development of the physical risks of the 3°C pathway is one of the main priorities for post-pilot development.

2.2.3. Transition risks

This pathway represents the transition risk of a slower, orderly transition as a result of the implementation of policies for low-carbon energy, energy efficiency and climate change mitigation and related investment needs.

2.3. 4+°C higher warming pathway

Focus	Exploring physical risks including extreme weather events
Transition risks	None (i.e. no transition is happening)
Physical risks	Economic impacts from wildfires, coastal flooding/sea level rise and changes in agricultural productivity, which are non-linearly scaled up after 2050 to better capture additional climate-related physical impacts that are currently not yet well-captured by IAMs. <u>Key assumptions:</u> As not all physical risks are explicitly included, and knock-on effects such as migration and conflict are not yet included in IAMs, this should still be considered an underestimation.
Out of model adjustments (sentiment/sudden shocks)	One major extreme weather event year included in 2035 equal to a 1% worst observed disaster year (-7% shock on global GDP) (based on lit. review & expert consultation)

2.3.1. Introduction

This pathway assumes that no significant efforts are taken to limit global warming, which puts us on track to 2°C warming by mid-century, and more than 4°C by the end of the century if no action is taken to reduce emissions. Temperature paths for 3 and 4°C start to divert around 2040. The impacts of a 4°C pathway relative to a 3°C will therefore start to materialise even later, due to the time-lag in the response of the climate-earth system.¹⁰

2.3.2. Physical risks

Although these impacts seem far away, they are non-reversible and a trajectory towards 4+°C warming will certainly trigger self-enhancing feedback mechanisms and will likely shift the world beyond socio-ecological thresholds into a different state (recently dubbed ‘Hothouse Earth’¹¹). Such a world will have far-reaching impacts on ecosystems, society and economies. Due to linkages in the Earth system, global warming will have many indirect and

¹⁰ Hansen (2005) estimates the climate lag time between 25 to 50 years.
<http://meteora.ucsd.edu/cap/pdffiles/Hansen-04-29-05.pdf>

¹¹ Steffen W., Rockström J., Richardson K. et al. (2018). Trajectories of the Earth System in the Anthropocene. PNAS: <https://doi.org/10.1073/pnas.1810141115>.

emerging effects, which exacerbate other great challenges. Many regions will become uninhabitable due to sea level rise or desertification, leading to casualties and forced migration. In addition, the loss of ecosystem services decreases the buffer capacity of nature. For example, the loss of mangrove forests and reefs means a loss of their coastal protection function, exacerbating damages from storm surges.

To try and capture non-linear effects, the economic impacts from wildfires, coastal flooding and agricultural productivity were scaled up, based on regionally differentiated non-linear responses of economic production to temperature.¹² This leads to dramatic impacts on GDP at the end of the century. However, such data does still not include other sources of potential damages associated with climate change; extreme weather events such as increased incidences of tropical cyclones, or emerging effects such as mass migrations.

2.3.3. Out of model adjustments (for sentiment/sudden shock)

To explore the impact of extreme weather events, we have implemented a financial shock due to a major extreme weather event year which has a size of a 7% decrease in global GDP, based on historic observations of disasters.¹³ This models the effect of a series of different types, intensities and frequencies of climate-related natural disasters occurring across the globe in one year time. The modelled shock size represents the 1% worst observed disaster year impacts. While a rarity in the past, these more extreme disaster years will become more likely in the future due to increased likelihood of disaster occurrence, coupled with increased intensity and duration of the events, combined with higher losses/impacts due to growing infrastructure and population. For illustrative purposes, we have implemented only one such worst disaster year in the 4+°C pathway, randomly chosen to 'hit' in 2035.

In total, the modelled 4+°C pathway can still be considered an underestimation, as it does not yet include all physical risks (e.g. no windstorms) and in particular does not comprehensively cover impacts from increased extreme weather events (e.g. hail, storm).

¹² Burke, Marshall & Hsiang, Solomon & Miguel, Edward. (2015). Global non-linear effect of temperature on economic production. *Nature*. 527. 10.1038/nature15725.

¹³ Felbermayr, G. & Gröschl, J. (2013). Naturally Negative: The Growth Effects of Natural Disasters. CESifo Working paper No. 4439.

3. Methodological approach

This chapter provides an overview of the approach of the pilot project and the development of the Ortec Finance climate-savvy scenarios set. For more details, please refer to the methodology document.

The pilot project was carried out by Ortec Finance in close collaboration with a team of scientific researchers, macro-economic experts, as well as five piloting pension funds and insurance companies. In addition, a sounding board composed of practitioners and academics served as a feedback mechanism¹⁴.

In a nutshell, the integration logic applied in order to ‘tie together’ climate scientific models, macro-economic modelling and financial modelling has been shaped as follows:

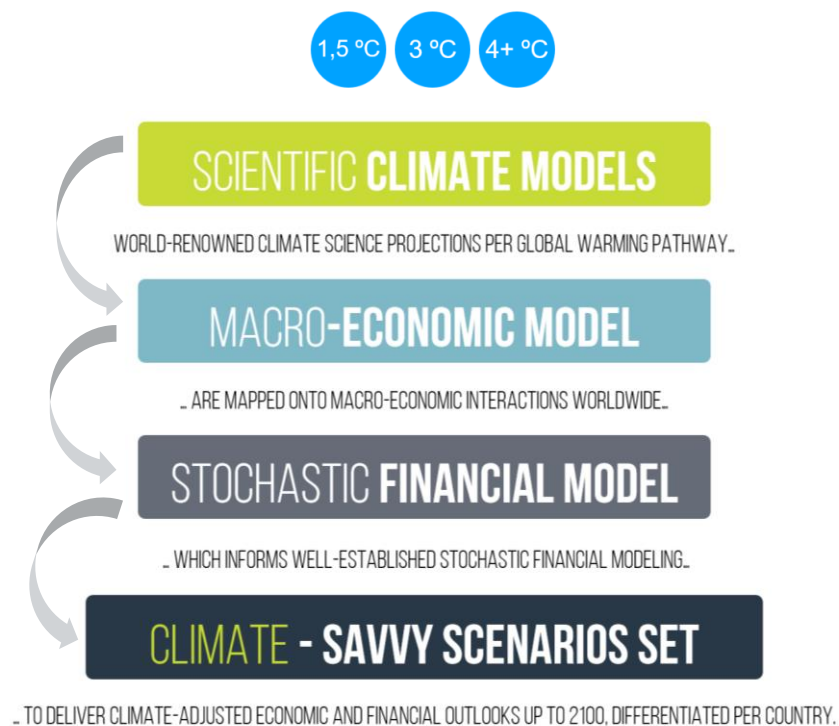


Figure 3. Overview of climate-savvy OFS pilot approach

As shown in Figure 3, we first identified existing climate model projections, which are informed by the magnitude of physical and transition impacts per global warming pathway per country onto macro-economic interactions worldwide. The outputs are deltas in annual growth rates from a baseline that does not use the climate specific inputs. These climate-adjusted GDP shocks per country, per year are then fed into the stochastic financial model of Ortec Finance (the ‘OFS’). The stochastic financial model then models the impacts of the climate-adjusted GDP shocks on a wider range of (600+) traditional financial and economic variables (incl. interest rate, inflation, impacts on different asset classes). It is assumed that

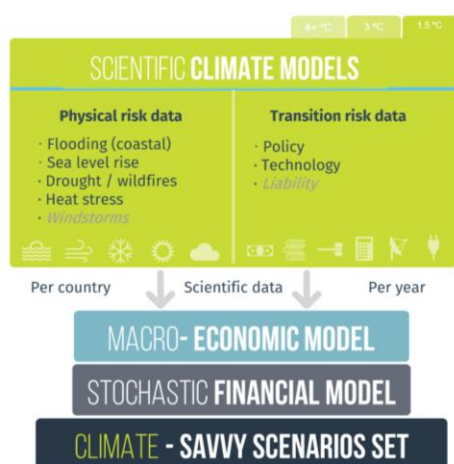
¹⁴ The pilot project is a broad collaboration between AP1, a.s.r., Philips Pension fund, PME, OPTrust, Ortec Finance and leading academic institutions, namely: Cambridge Econometrics, Carbon Delta, CICERO, Potsdam Institute for Climate Impact Research and is further supported by the Institute for Environmental Studies – VU Amsterdam, London School of Economics, Radboud University, Sustainable Finance Lab Utrecht and the University of East Anglia.

the historically established interactions between these economic and financial variables are also valid in the future.

IAMs are limited in their ability to capture non-smooth transitions (shocks). Therefore, they are less fit-for-purpose for modelling a financial shock due to e.g. market sentiment change or a major extreme weather event year. These shocks are modelled directly into the stochastic model using literature review and expert consultation as sources.

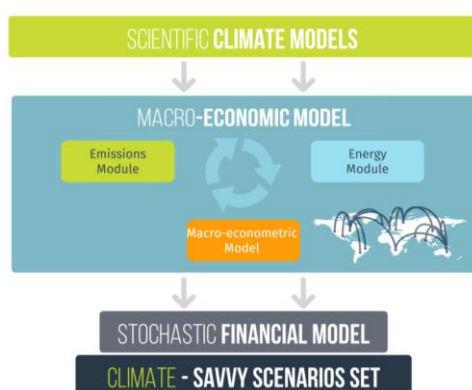
3.1. Climate input data per global warming pathway

Each of the academic input datasets that Ortec Finance reviewed is based on a different approach (different school of economic theory, focus on trade or energy efficiency, different public policy assumptions). Strictly speaking they are not comparable to each other, but rather provide a range of possible outcomes.



The piloting clients requested that Ortec Finance explore a robust range of outcomes, paying extra attention to the outer limits of such a range, and capturing a wide range of impacts. Ortec Finance has analysed the range of datasets corresponding to each of the climate pathways. Ortec Finance chose the datasets that best represent the described climate pathway and that best captured the risks relevant to that specific pathway.

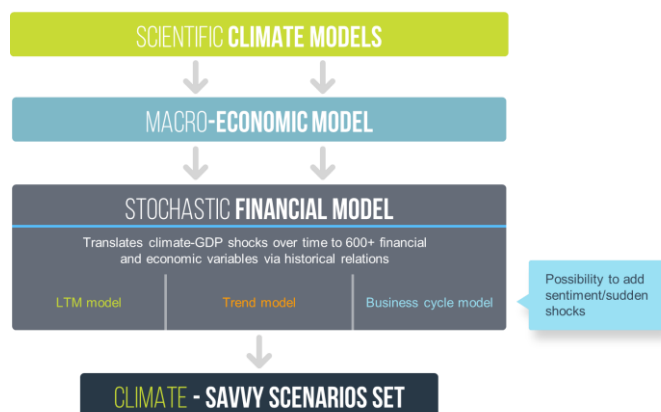
3.2. Climate risks mapped onto macro-economic interactions



The climate/policy projections per year and country for reaching each of the three global warming pathways are then mapped to macro-economic variables via so-called Integrated Assessment Models (IAMs). These are macro-economic models capturing worldwide economic interactions (such as trade), demographic changes, etc., combined with specific energy and environment modules that can 'read' scientific data inputs.

Using the IAMs as a 'translation tool', climate-related physical and transition risks are then expressed in terms of 'climate-GDP' shocks per year per country (again for each of the three global warming pathways). This is now expressed in a format that the OFS can onboard. These climate-adjusted GDP shocks are used as inputs for adjusting the current climate-neutral market expectation.

3.3. Implementation of GDP shocks in stochastic financial model



The different climate-adjusted GDP shocks (physical, transition, sentiment shock) per global warming pathway are delivered as outputs from the macro-economic models. Together with the major extreme weather event shock and market sentiment shock they have been implemented in the OFS. According to the time-dependent nature of the particular GDP shock (long-term, typical business cycle, one year) it has been integrated into the

layer of the OFS model that best suits this time dimension. For example the sentiment shock maps best to a one year, short term, modeling layer in the OFS. In addition to this the horizon of the whole OFS was extended from the current 40 years to 80 years so as to be consistent with the time horizon of climate data input.

Understanding the baseline:

The current 'standard' OFS models current market expectations. That is our baseline. The climate-savvy OFS produces a new scenario set where everything is kept constant except for the climate adjusted GDP inputs. This allows a climate informed scenario set to be compared to a baseline of current market expectations (the 'standard' OFS).

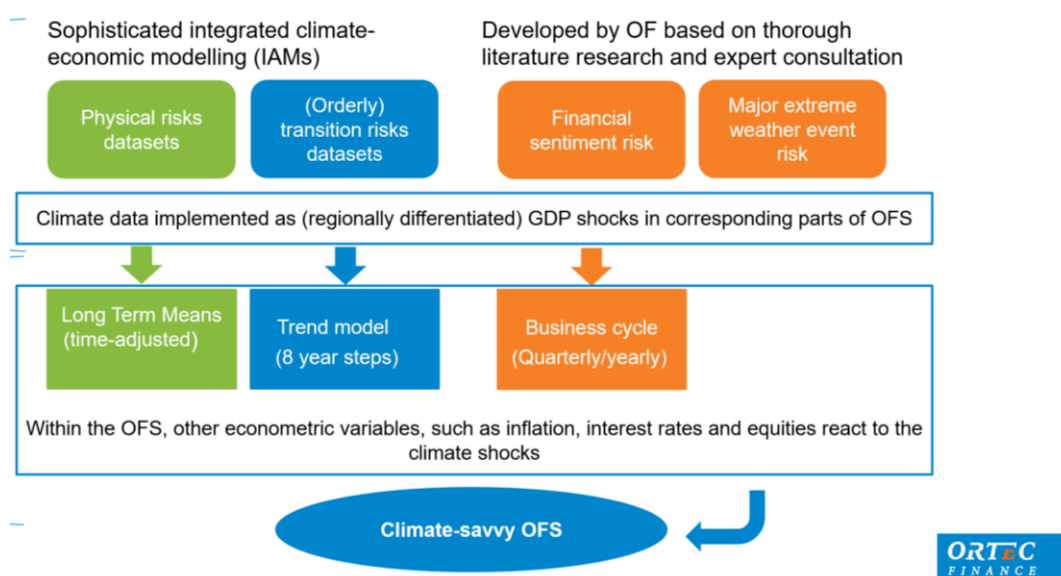


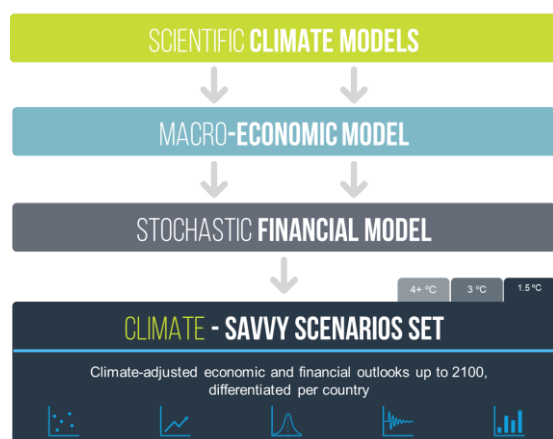
Figure 4. Implementation of climate shocks into the OFS

3.3.1. Key assumptions

Also in Ortec Finance's financial modelling certain assumptions had to be made in order to deliver the functionality needed to 'read' the climate-adjusted GDP shocks per year and per country in a meaningful way:

- **History does not repeat itself but it does echo:** The OFS assumes that historical relationships between risk drivers and asset classes will hold in the future.
- **All other financial and economic variables in the OFS, besides the GDP, have been kept constant:** many inputs for the long term mean framework have been kept constant, such as the long term level inflation, equity carry (dividend yield, repurchase yield), the dilution factor, term spreads, credit spread levels and others. It should be noted that in the current setup all these variables and asset classes are influenced by the climate-adjusted GDP inputs.
- **Climate-adjusted GDP shocks are built up from data with a regional granularity, but the interactions between GDP and other variables are based on historically established relationships at the global level** (i.e. regional data but modelled on interaction patterns observed at the global level): Ortec Finance uses worldwide historically observed relations between 8-year returns of GDP, CPI equity return and so on because Ortec Finance currently does not have well-established historical relations data at a country specific level. Although the directions and orders of magnitude in general make sense economically, it is unknown if these hold for every country, in particular so for developing and recently developed countries.
- **The OFS assumes average long-term economic growth of 1.5%.** It might not be realistic to assume this growth on a 80 year time horizon. However, by determining differences between the climate-savvy scenario set and the baseline scenario set, this effect does not have to influence interpretation of the results.

3.3.2. Climate-savvy economic & financial scenarios set v1.0



Having implemented the described integration logic and assumptions build-up, the piloting team has been able to develop the first-of-its-kind climate-savvy economic and financial scenarios set – version 1.0.

The climate-savvy scenarios set provides climate-adjusted information on various economic and financial variables of Ortec Finance's financial model that then can be used for running a climate-savvy ALM.

4. Outcomes of OPTrust's pilot run

The following bullets summarise key emerging insights from OPTrust's pilot run for each climate pathway:

1.5°C pathway:

- The energy transition leads to negative Canadian GDP growth until circa mid-century, which based on historic relations in the OFS leads to negative interest rates and inflation rates that only recover to baseline by the end of the century. The effects of an ambitious and disorderly transition have a noticeable impact on investment return over the entire horizon.
- The impact of the financial shock in 2025 is small compared to the structural impact of the energy transition.
- Canada is effected more negatively than the US and Europe due to Canada's relatively higher dependency on fossil fuel exports (ca. 20% of total exports) and production (at high marginal costs).

4+°C pathway:

- Canada is somewhat less effected by the major extreme weather event year than US and Europe, based on historically observed relations modelled in the OFS. However, the gradual long-term physical impacts are similar for all three regions.
- Physical risks start to only impact Canadian growth lightly towards the very end of the century. Interest rate and inflation follow this pattern. Only the extreme weather event meaningfully impacts investment return over time, but the effect phases out by circa mid-century.

3°C pathway:

- The 3°C pathway is very similar to the base OFS, because the transition risks are less pronounced and the physical impacts in the 3°C pathway are underdeveloped. Some negative impact on GDP can be observed at the end of the time horizon, due to physical impacts of wildfires, coastal flooding and impacts on agricultural productivity.

Comparing ALM results across the different climate pathways:

- On a fund return level the 4°C scenario is slightly better for OPTrust in comparison to the 1.5°C scenario. Even extreme weather events seem to effect Canada relatively less than other geographies. For Canada the investment return paths associated with the 1.5°C and 4°C global warming pathways cross relatively late, i.e. in 2080. After 2080 the impacts associated with a 4°C global warming pathway will become material and will worsen, while returns associated with 1.5°C will have recovered.
- At face value these finding imply that a global transition to stay within the goals set by the Paris Climate agreement is less beneficial in terms of investment returns for OPTrust than a higher global warming pathway scenario until the end of century.

With this conclusion, the following should be kept in mind:

- The transition scenario represents a worst-case scenario in which Canadian economy fails to adapt quickly enough to decreasing global fossil fuel demand. It is possible for Canada to adapt in some extent to such expected developments, in which case the negative impact of an energy transition might be smaller.
- The relative 'safe haven' that Canada may be in the face of physical climate risks could lead to climate-related migration from harder hit areas towards Canada. Also increased unrest, instability and conflict in other parts of the world may become a threat to the Canadian economy. These risks have not yet been captured in the current climate-savvy OFS.

5. Conclusions and Recommendation

Conclusions from this climate-savvy ALM study for OPTrust are:

The portfolio results of OPTrust reflect that Canada is particularly vulnerable to the energy transition. Under a steep transition scenario, Canada's export dependence on fossil fuels combined with its high marginal costs of tar sand extraction would render these fossil fuel exports unviable to continue at predicted rates. In turn, the Canadian economy would need to restructure and 'make up' for this 20% of direct fossil-fuel exports, as well as other dependent indirect economic activities related to this industry.

When looking at the higher global warming pathways, Canada is less vulnerable to physical impacts than many other countries due to its geographic location: a slightly warmer planet – at least temporarily – could mean an increase of Canadian land area that is suitable for agricultural production. Note, however, that the potentially increasing impacts of extreme weather events such as storms and hurricanes, are not well-captured within the model yet.

As a result of this comparison, Canada finds itself in a unique position – different even to that of the USA – where it becomes very important to understand the implications of different global warming pathways on macro-economic development more broadly, and OPTrust's portfolio more specifically.

Although the negative impacts of the 1.5°C pathway on OPTrusts' portfolio are dominant in the short- and medium-term, the negative impacts of the 4°C take over as of 2080.

Depending on how reality will unfold (see Annex: Signposting), this may take place earlier (in case of a less stringent transition, a better positioning of the portfolio of OPTrust with regards to transition risks or more severe climate impacts).

Climate-related financial risks are dynamic in nature. For the next decade or so, transition-related risks are key, because physical impacts are still relatively modest and, if society is to stay under 2°C, then the transition has to happen in this time frame. If a very steep, and likely to be disorderly transition does not occur, then 'Paris' ambitions are unlikely to be achievable. In that case OPTrust may want to prepare to deal with increasing physical climate risks. Monitoring developments in the areas of climate science, technology, policy and consumer sentiments is key for understanding which global warming pathway the world is likely to be on. Being able to adjust relatively dynamically to this quickly changing landscape is very important.

Supporting strong climate action on the operational level through informed strategic choices: OPTrust could use the gained insights to enable portfolio optimization towards a 1.5°C pathway (that matches investment beliefs/goals/targets), while at the same time ensuring the portfolio is robust for potentially higher global warming pathways.

Additionally, Ortec Finance would like to highlight that any interventions at the ALM level should be a logical, consistent fit with measures taken at the operational level in the portfolio. For example, exclusions, over/underweighting, impact investing and engagement all remain relevant operational tools. The outcome of the ALM analysis may point in the direction of interesting opportunities exactly there where risks are greatest. OPTrust could explore investment opportunities in energy efficient infrastructure and real estate, both globally but also especially in EM.

Finally, even though it is strictly speaking out of scope of the pilot, Ortec Finance feels strongly about the importance of **regulatory engagement** as one of the most powerful tool in an asset owners arsenal to manage climate-related financial risks. Individual action is key, but only if politics, industry, financials and society as a whole come together, we will be able to succeed in building a low-carbon, climate-resilient world within the next few decades. If the Canadian economy is able to transition its economy towards low-carbon industries, transition impacts may be mitigated. Ortec Finance strongly recommends that OPTrust uses its influence as an asset owner and trusted institution in Canadian society to engage with both its final beneficiaries, regulators & government as well as the companies it is invested in on climate-related financial risk. Concrete requests could include the following:

- **Towards final beneficiaries:** Ensuring buy in and support from financial beneficiaries for investment policy geared towards managing climate-related risks is key for having a strong mandate to act. Ortec Finance would encourage OPTrust to continue its open dialogue with final beneficiaries in explaining the nature of the risk that climate change poses to portfolio performance. It may be helpful to openly discuss trade-offs and challenges and to explain OPTrust's choices in managing these risks. We trust that insights from this pilot are a solid base for entering into this dialogue with final beneficiaries.
- **Towards Government/regulators:** Climate-related financial risks can only be managed if both the private sector and the government act in a coordinated manner towards the same goal. Considering the material climate-related financial risks that OPTrust faces Ortec Finance deems it crucial that OPTrust finds its 'voice' and calls for strong policy on reshaping the Canadian economy in order to be resilient to a low-carbon transition. Points that could be made include:
 - The Canadian economy should become significantly more robust to a scenario where demand for its fossil based exports falls away: the Canadian economy is highly dependent on fossil fuel exports. Large customers (US, EU and China) determine the demand for these exports. Technological change, consumer sentiment, legal and policy frameworks could all result in non-fossil fuel energy to become preferable over fossil based energy in these economies. Investing in local Canadian assets (real estate, government bonds) could be considered excessively risky given this macro-economic exposure.
 - Concrete steps the Canadian government could consider taking include:
 - Introduction of a robust carbon pricing mechanism (at least 75 CAD per ton CO2 equivalent);
 - Earmarking these revenues for investing in innovation, research and development to decarbonize currently high-emitting industries and support the growth of low-carbon industries;
 - Earmarked revenues could also be used to ensure that the energy transition is 'socially inclusive'. Financing re-schooling programs and perhaps early retirements for workers in high-fossil sectors as well as subsidizing household investments (housing refurbishments, transitioning to low carbon personal transport) could all be considered.

- **Towards Companies:** engaging with companies is a classic risk-management tool. In Ortec Finance's view, consciously staying invested in carbon intensive assets is warranted if combined with a very strong active ownership policy. However, this engagement is not open ended. If after a concrete period of time (circa 2 years) OPTrust is insufficiently convinced that the asset will be able to innovate (both in terms of product and production process) sufficiently fast to remain profitable in a 1.5°C global warming pathway, divestment should be seriously considered.

Disclaimer: Please note that these conclusions and recommendations are based on the current state of development of the climate-savvy OFS. The climate-savvy OFS will be under post pilot evaluation and development. Future iterations may lead to different insights.

Annex: Which future to prepare for?

“A tragedy looms on the horizon,” warns Mark Carney. “Our societies face a series of profound environmental and social challenges,” he said in a speech to Lloyd’s of London. “The combination of the weight of scientific evidence and the dynamics of the financial system suggest that, in the fullness of time, climate change will threaten financial resilience and longer-term prosperity. While there is still time to act, the window of opportunity is finite and shrinking.” – Mark Carney, 2015

This Annex further illustrates **why it is important to act now**. Contextualizing the trade-offs between experiencing the consequences of a steep energy transition now versus bearing the costs of higher global warming in the future can be challenging for strategic investment decision-makers. The ALM results of the pilot visualise insights across three different global warming pathways compared to the climate-neutral market expectation. However an asset owner has only one portfolio, and it may be challenging to ‘pick’ one ‘climate world’ on which to anchor strategic investment decision making. For which future to prepare?

Placing probabilities on different scenarios is not in line with most scenario thinking methodologies. Therefore Ortec Finance, together with its piloting clients, identified two additional research topics that would help investors answer the question of ‘what future to prepare for?’:

- (1) Sign-posting of ‘which temperature path is the world currently heading towards?’ and
- (2) When are there ‘points of no return’, i.e. at which points in time is it ‘too late’ to still reach a certain temperature target?

While an in-depth development of these types of analyses is outside of the scope of this pilot project, this annex gives an indication of where we are now in terms of global warming, and where we are likely heading towards, based on a literature review.

Table A1: Signposting summary

What climate-pathway are we currently most on track towards:	Countries are, in aggregate, set to meet the national pledges made as part of the Paris Agreement according to the IEA’s 2018 World Energy Outlook. This puts the world on an expected global warming path of around 3°C warming by 2100. However, in its Climate Change Dashboard, Schoders suggests temperature would rise with 4°C ¹⁵ .		
Points of no return (based on 66% certainty)	1.5°C Now to 12 years, depending heavily on assumptions, including carbon dioxide removal.	3°C 20 years, but with considerable uncertainties about ‘tipping points’.	4°C 50+ years, however the relevance of a ‘point of no return’ for this pathway is questionable.

¹⁵ <https://www.schroders.com/en/lu/professional-investor/featured/climate-change-dashboard/>

1.5°C pathway

Figure 11 shows how many years the global economy can continue with current day emission levels in different global warming pathways. It considers different levels of likelihood for reaching a specific temperature goal. For example, Ortec Finance's 1.5°C pathway is based on model results for about 66% likelihood of staying below 1.5°C. The analysis of CarbonBrief indicates that if we want to stay under 1.5°C warming with more than 66% likelihood, we have just 4 years left.

However, these numbers were based on the 5th assessment of the IPCC (2014) - in the latest IPCC report (2018) the carbon budget for 1.5°C was adjusted, resulting in the message that **we have about 12 years until the carbon budget is exhausted. This means global emissions need to peak before 2030, and we need to reach net-zero global emissions within 25 years (by 2040).** Reaching net zero later (in 2055), leads to a lower probability (<50%) of limiting warming to 1.5°C, see figure 12.

Figure 11. "Carbon Countdown" by CarbonBrief (2017): How many years of current emissions would use up the IPCC's carbon budgets for different levels of warming?

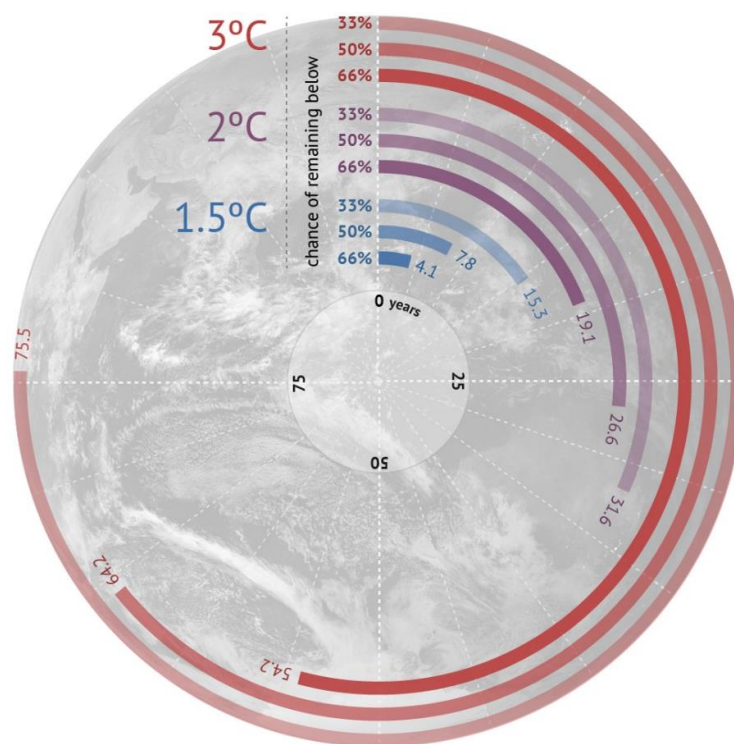
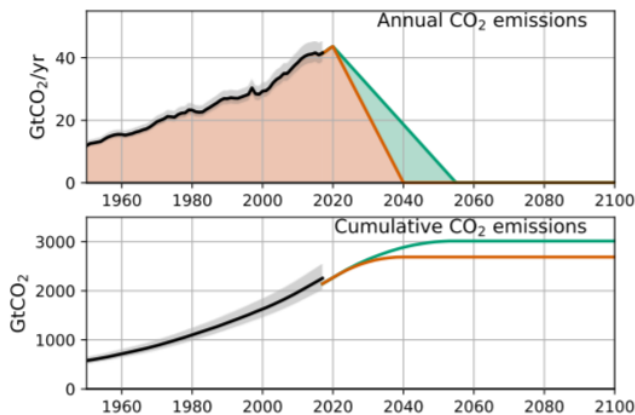


Figure 12. Time-series of annual CO₂ emissions, cumulative CO₂ emissions in 1.5°C-consistent pathways



Carbon budgets are a simplified way of measuring the additional emissions that can enter the atmosphere, if the world wishes to limit global warming to levels such as 1.5°C.

Assumptions and uncertainties

The budgets associated with 1.5°C are particularly sensitive to different assumptions and uncertainties. These uncertainties include the Earth's climate response to carbon emissions, the role of non-CO₂ emissions, and especially climate feedbacks. To illustrate, the size of the uncertainties in the climate budget could influence the timing of bringing carbon dioxide emissions down to net-zero by ± 15 –20 years.¹⁶

An important assumption in the IPCC special report on 1.5°C (2018) is large-scale use of negative emissions in the future, which makes up for emitting far more than the budget would allow without carbon removal. Deploying carbon removal at the scale that climate models assume is untested.¹⁷ We need to also keep in mind that the higher emissions are in the near term, the greater the required emissions reductions in later decades for limiting warming. Steep rates of emissions reductions are far costlier than more gradual rates of decline. They also risk of failing to achieve the 1.5°C.¹⁸

"The next few years are probably the most important in our history,"
 - Debra Roberts, IPCC

¹⁶ <https://www.wri.org/blog/2018/10/according-new-ipcc-report-world-track-exceed-its-carbon-budget-12-years>

¹⁷ <https://www.wri.org/blog/2018/10/according-new-ipcc-report-world-track-exceed-its-carbon-budget-12-years>

¹⁸ <https://www.wri.org/blog/2015/11/insider-why-are-indc-studies-reaching-different-temperature-estimates>

Exceeding 1.5°C warming

Our 3°C pathway is based on the modelling of the NDCs and thus the likelihood to limit warming to 3°C is 100% in the underlying model. Even when countries fulfill their NDCs, we will likely (>66% chance) blow through the carbon budget of 1.5°C by 2030 and will be on track for further warming till 3°C by 2100.¹⁹ The 3°C warming pathway is currently seen as most likely, considering current policy pledges.

Figure 13 indicates that we would have 54 years with current emissions before the carbon budget for 3°C is exhausted. This means that we have 54 years to act and make sure the world does not end up on a 4+°C pathway.

However, when certain non-reversible and self-reinforcing feedback mechanisms are triggered, the same carbon budget may lead to greater warming. Such mechanisms, related for example to carbon release from permafrost thawing, may already be activated with 1.5 or 2°C warming.

FAQ1.2: How close are we to 1.5°C?

Human-induced warming reached approximately 1°C above pre-industrial levels in 2017

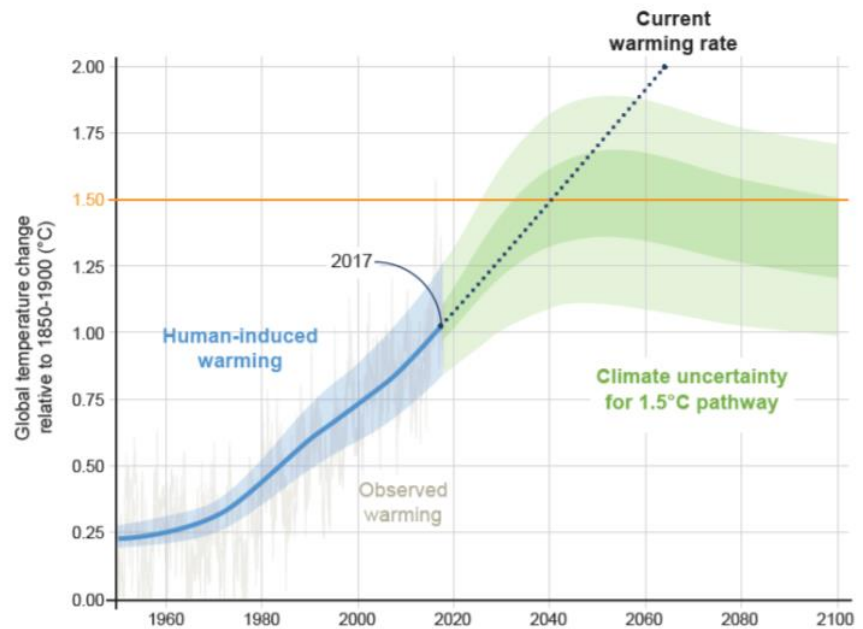


Figure 13. http://report.ipcc.ch/sr15/pdf/sr15_faq.pdf

¹⁹ <https://www.wri.org/blog/2018/10/according-new-ipcc-report-world-track-exceed-its-carbon-budget-12-years>

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