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REDUCING CARBON RISK IN INSTITUTIONAL PORTFOLIOS

Why reducing portfolio carbon matters
How one large pension fund is accomplishing this at modest cost

June, 2019

CANDRIAM
A NEW YORK LIFE INVESTMENTS COMPANY

It becomes hard to argue that climate change has not reached mainstream science.

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> *As the presumed effects of global warming, such as the rising number of abnormal weather events, are becoming more tangible, its economic costs become obvious.*

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EXECUTIVE SUMMARY

When the world's largest mining company declares *"we recognise global climate change science, as laid out by the United Nations Intergovernmental Panel on Climate Change"* [1], it becomes hard to argue that climate change has not reached mainstream science.

This explains why, across the globe, investors are finding it in their best interest to integrate climate risk within their investment considerations.

Investors are joined by regulators, calling for institutional investors to integrate climate change as a fiduciary duty. For example, the US Department of Labor pension guidance has progressed from a 1998 statement allowing that pension plan sponsors 'could' integrate Environment, Social, and Governance factors, to stating in 2015 that plan fiduciaries 'should' integrate ESG factors – that is, a shift from permissible to required, albeit with little indication as to how one should accomplish this.

A series of issues arises – How do we define and measure ESG factors? Perhaps the most topical metric today is greenhouse gas emissions. Yet, while we can measure a company's emissions, how do we measure the emissions of its suppliers? And do we measure emissions created by a company's products after they leave its control, when they are used by the consumer? How do we translate this into a portfolio metric?

- We analyse the relative merits and portfolio characteristics of two common carbon optimisation strategies used by investors, Exclusion and Optimisation. Our carbon intensity and tracking error simulations showed that an Optimisation approach could produce a significant reduction in portfolio CO_2 with modest tracking error, and minimal industry skew.

- We show that portfolios containing stocks with the lowest carbon intensity generally tended to outperform the global universe whilst the reverse was true for the 'carbon-cutting laggards' over a nine year period starting at the end of 2009.

- We provide a concrete example by describing a tailor-made equity solution which has reduced portfolio CO_2 by over 50%[2], while limiting tracking error below 1% relative to a custom benchmark. At the same time, the solution improves the overall ESG risk profile, and addresses other climate issues requested by the pension fund.

We believe these methodologies will become mainstream in the near future.

> *An Optimisation approach could produce a significant reduction in portfolio CO_2 with modest tracking error.*

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Conviction **And** **R**esponsibility **I**n **A**sset **M**anagement

[1] *Glencore, https://www.glencore.com/sustainability/climate-change, retrieved on March 7th 2019.*
[2] *See results under 'Case Study' section.*

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PART I: ECONOMIC DISRUPTION OF CLIMATE CHANGE

The Tragedy of the Horizon

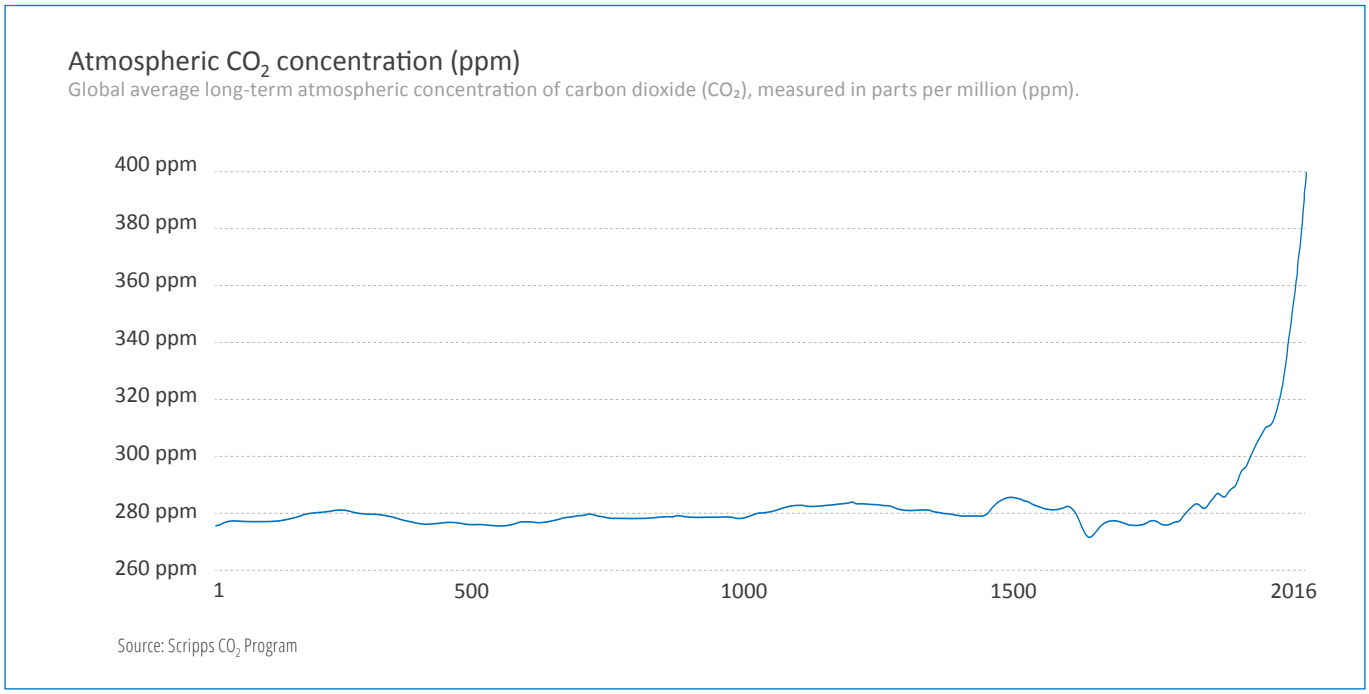
In a landmark speech delivered at Lloyd's of London in September 2015, Mark Carney, the Governor of the Bank of England, spoke of the 'Tragedy of the Horizon' to describe our attitude towards climate change. By the time we will have reached the horizon where climate change is visible and believable by everyone, it will be too late to do anything about it.

That he chose to deliver this speech at the offices of one of Britain's oldest insurance companies, a company engaged in the quantification of the probability and financial impact of extreme weather events, spoke volumes about the systemic financial risks brought about by climate change.

Human Activity is the Primary Cause of Climate Change

The atmospheric concentration in carbon dioxide over the last 2,000 years, shown in Chart 1, illustrates the sudden and massive rise of atmospheric CO_2 since the Industrial Revolution. This is when humanity began to burn fossil fuels on a large scale; to power steam engines, generate heat, and produce steel from iron ore.

CHART 1: Carbon Dioxide over Two Millennia



The CO_2 released from the main five fossil sources since 1751 is shown in Chart 2. The concomitance between increasing emissions from fossil sources through human activity, and the rise of atmospheric CO_2 concentration demonstrated by these two charts, is striking.

Until the early 1900s, most of the fuel burnt was solid, such as wood and coal. With the refinement of the diesel engine at the beginning of the twentieth century, the burning of liquid fuel, that is, oil and its derivatives, rose rapidly. Beginning around 1950, natural gas also became a resource for heating and for power.

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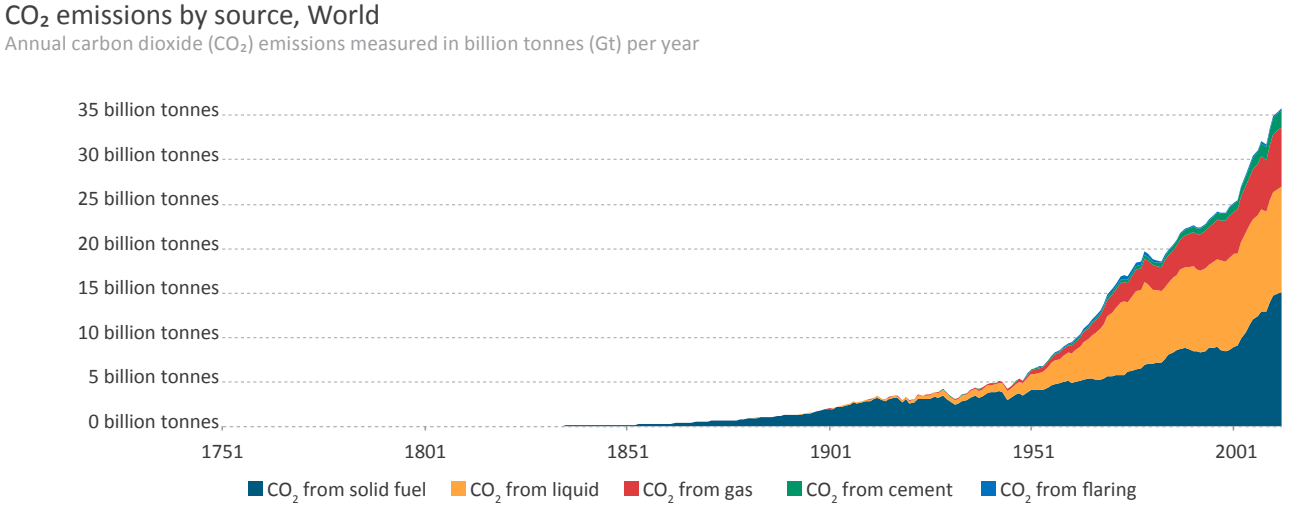
CHART 2: Worldwide Carbon Dioxide Emissions by Source

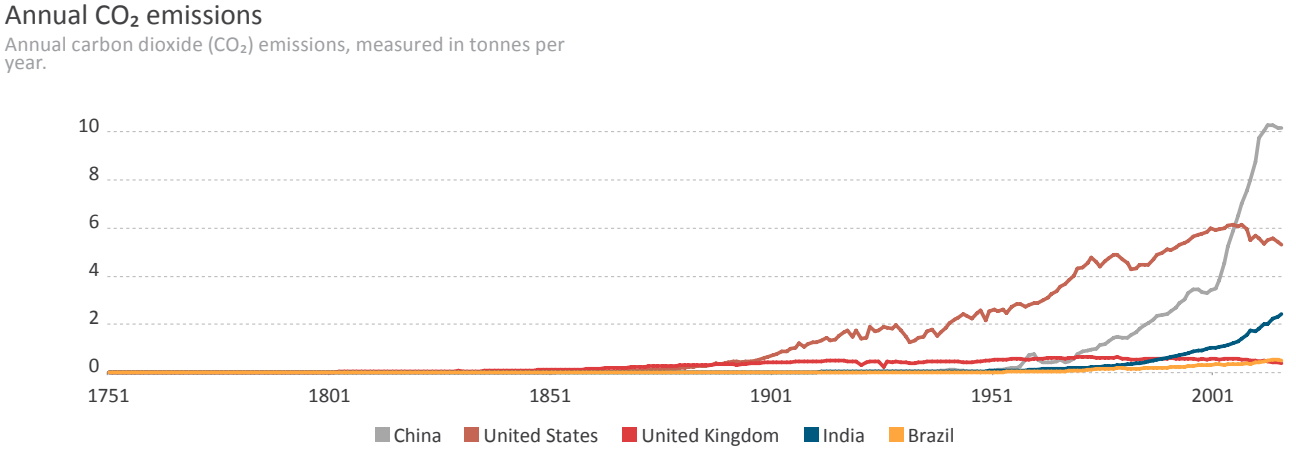


Source: CDIAC data originally sourced from: T.A. Boden, G. Marland, and R.J. Andres. 2017. Global, Regional, and National Fossil-Fuel CO2 Emissions.

Geographic Sources of CO_2 Emissions Amongst Largest Economies

It is often said, with reason, that China is now the largest CO_2 emitter. Its coal power capacity dwarfs that of all other coal-using countries combined. China produces half the annual global steel output. The conclusions of Chart 3, showing the roles of China and the United States as CO_2 emitters, should come as no surprise. But does that make China the country therefore most responsible for climate change?

CHART 3: Carbon Dioxide Emissions Since Industrial Revolution – Selected Countries



Source: Global Carbon Project and CDIAC (2017)

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The 'Stickiness' of Greenhouse Gases

Once CO_2 is released into the atmosphere through the burning of fossil resources, it remains in the atmosphere for generations. Yes, between 65% and 80% is absorbed by the oceans -- but over a period of 20 to 200 years! The rest is removed through natural processes that take much longer. Because of this 'stickiness', most of the CO_2 released since the 1800s by the United States and European countries remains in the atmosphere, producing the greenhouse effect responsible for climate change.

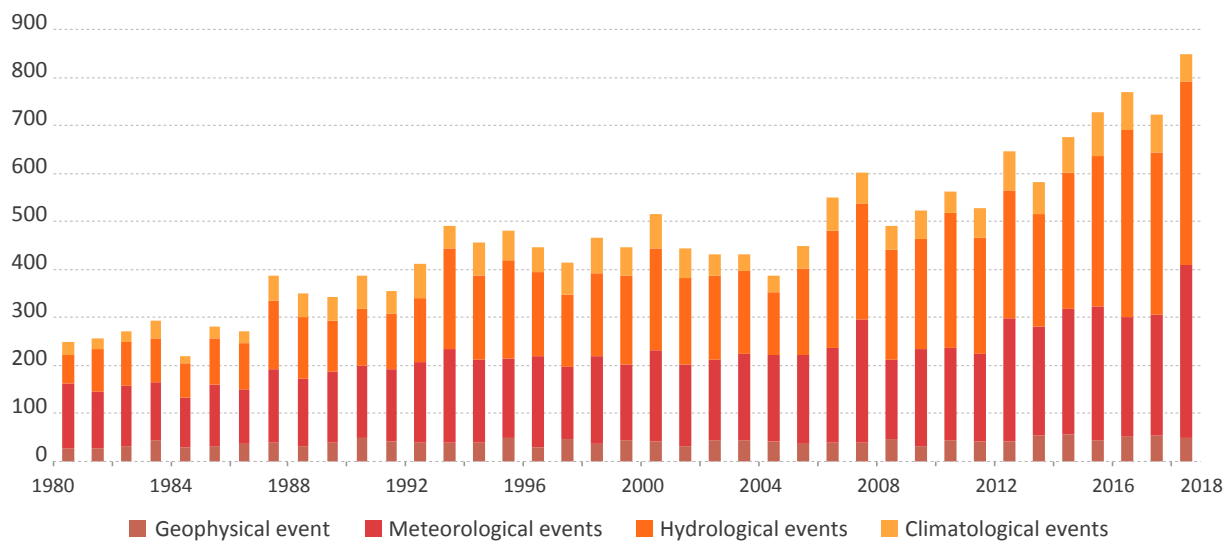
This physical process explains why, even if humanity ceased burning fossil fuels today, the effects of climate change would continue at current levels for decades to come. Worse, because of the lag between CO_2 release and physical impact, some effects, such as ocean acidification, would continue to rise for decades before stabilizing.

Rising Human and Financial Cost

Some consequences of climate change are visible and well-understood. Others stem from non-linear events which, once triggered, can have irreversible and catastrophic consequences for ecosystems. Devastating storms such as those in Houston in 2017 can be expected to become more frequent. Similarly, higher temperature and drier weather conditions are expected to exacerbate wildfires, such as those in California in 2018. This one season of fires ultimately caused the deaths of more than a hundred people, destroyed 10,321 buildings and structures, and eventually led to the Chapter 11 bankruptcy of PG&E, the Californian power supplier.

On a larger scale, over the last 35 years we have already seen a significant increase in the number of extreme weather events[3]. The frequency of these events has roughly tripled – by one definition, extreme weather events have increased from around 200 annually in the 1980s to over 600 per year in recent years.

CHART 4: Natural Disasters by Cause



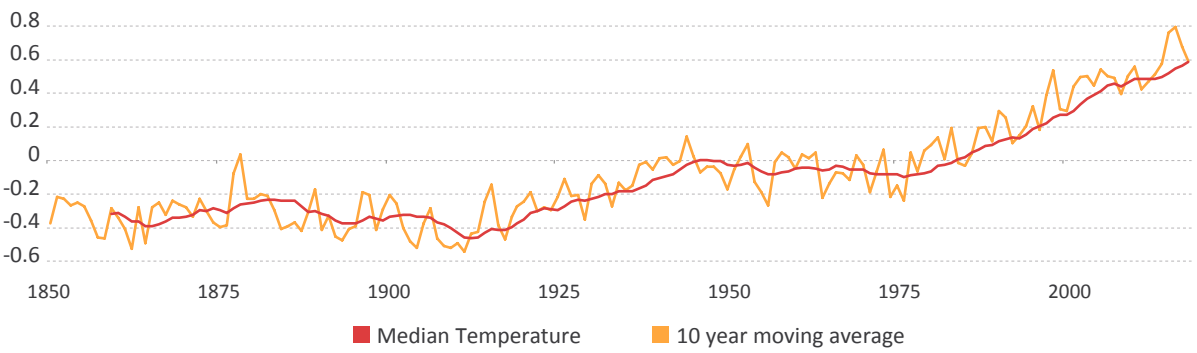
Source: Munich Re

[3] *In its report, Munich Re define an extreme event as an event that has caused at least one fatality and/or produced normalised losses ≥ US$ 100k, 300k, 1m, or 3m (depending on the assigned World Bank income group of the affected country).*

The economic cost of extreme weather events is significant and will likely continue to increase. For example, according to the same source, the three costliest weather events in 2018 amounted to $35.7 billion for the US economy.

These are merely the consequences of a relatively modest rise in average mean global temperature of approximately 0.8 degrees centigrade since pre-industrial times. In a report published in November 2018, the scientists of the Intergovernmental Panel on climate change (IPCC) warned that limiting the global mean temperature rise to less than 1.5 degrees centigrade is essential if humanity is to avoid the worst consequences of climate change.

CHART 5: Global Temperature Anomalies Since Industrial Revolution



Source: Met Office Hadley Centre[4]

As Chart 5 illustrates, we are set on a course that, should CO_2 emissions remain at their current level, will most likely lead to the 1.5 degrees centigrade temperature increase by around 2030.

Likely Consequences of Climate Change – The US Example

In the United States, as in other countries, rising atmospheric greenhouse gases concentration are expected to have severe physical consequences, some of which are already manifesting themselves. A few of the most likely ones, according to the US Environmental Protection Agency, follow:

- **Weather patterns** and amounts of precipitation are being influenced, leading to droughts in some regions of the country, whilst other regions battle torrential rains leading to flooding.
- **Sea levels are rising**. A two-foot rise in global sea levels would lead to a relative sea level rise of 2.3 feet (0.7 meters) in New York City and an increase of 3.5 feet (1 meter) in Galveston, Texas.
- **Ocean acidity levels are increasing**, threatening the food supply for some fish species and causing the extinction of coral reefs.
- **Extreme weather events are increasing** in frequency, intensity, and duration. Hurricanes, storms and cyclones are on the rise; for example, the occurrence of Category 4 and 5 hurricanes is expected to increase significantly.

[4] Temperature anomalies are based on the HadCRUT4 land-sea dataset as published by the Met Office Hadley Centre. Temperature anomalies are given in degrees Celsius relative to the average temperature over the period 1961-1990. These are available at the global level, for the Northern Hemisphere, South Hemisphere, and Tropics (defined as 30 degree north and south of the equator).

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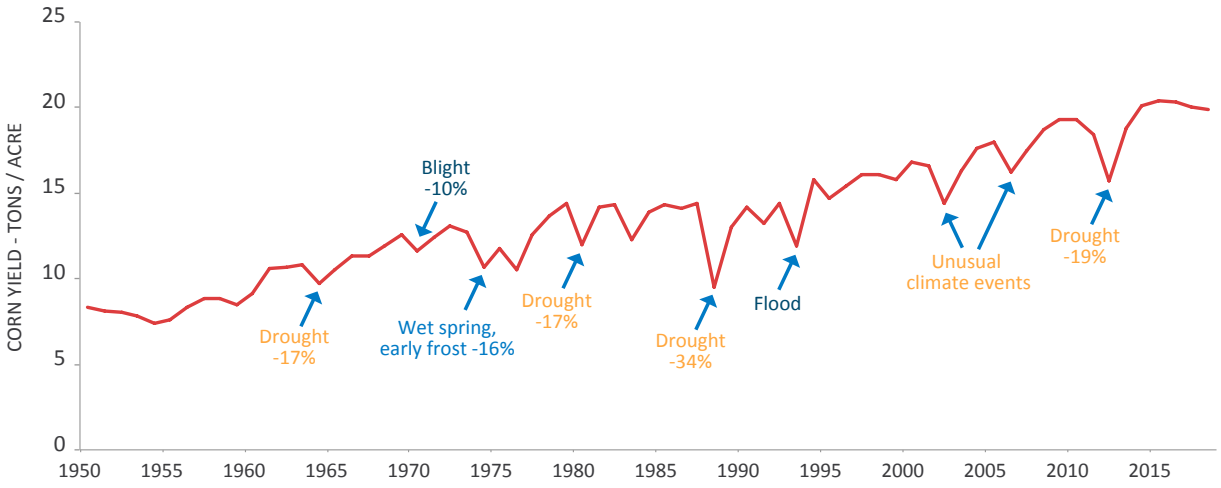
Significant changes in weather patterns have already begun to damage food supply in the United States, through lower crop yields, for instance. Despite technological innovation supplying higher average crop yields, Chart 6 from USDA shows that each episode of extreme weather leads to a significant dent in corn yield.

CHART 6: Crop Disruptions and Weather



Source: USDA, National Agricultural Statistics Service. This is just one example of how the United States is vulnerable to changes in weather conditions. Other dimensions particularly at risk include energy supply, human health, transportation and water resources.

THE INSTITUTIONAL RESPONSE

The Paris Agreement

In the footsteps of other global agreements aimed at alleviating climate change, the Paris Agreement, signed in 2015 and since ratified by more than 180 nations, represents the most significant global coordinated initiative on climate change. Following on the Copenhagen Conference of 2009, the aim of the Paris Agreement is to contain the rise in global mean temperature to less than 2 degrees centigrade above pre-industrial levels.[5]

Following the Paris Agreement, initiatives have been launched which aim to provide investors with better instruments to:

- Understand the impact of their portfolio in terms of CO_2 emissions
- Measure their carbon impact in a way that allows them to compare portfolios
- Reduce their carbon impact through one or several of the approaches presented in this study.

[5] Although the United States played a vital role as power broker to crystallize the final text of the agreement at the COP 21 Conference in Paris, it has since chosen to dissociate itself from this commitment, raising the possibility of withdrawal from the agreement.

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The Role of Investors in Mitigating Climate Change

One can view the role of investors as allocators of capital to various parts of the economy, through direct company stock ownership, through lending to these companies, or through otherwise directing financial resources. These allocation decisions can shape the future of industries. Investment decisions can also impact the climate if they direct capital towards those sectors and companies which are more attuned to the climate emergency.

> *Investors believe that climate change can affect the financial value of their investment.*

Many investors agree that finance is not neutral. Investors have begun to integrate environmental factors in their investment decisions. They do so in part because they believe that climate change can affect the financial value of their investment. ESG investors - that is, those investors integrating environmental, social and governance dimensions in their decisions - take the analytical view that the climate change does not affect all companies equally.

The founding signatories of the UN Principles for Responsible Investment in 2006, amongst them Candriam, established the PRI with the goal of making ESG considerations become widely integrated by investors globally. These 100 founders, and the 2,300 current signatories, share the conviction that by integrating environmental considerations into investment management, we can achieve better risk-adjusted returns.

The Montreal Carbon Pledge and Carbon Disclosure

One year before the Paris 2015 Conference, a group of large institutional investors publicly and formally committed to the annual measurement and disclosure of the carbon footprint of their portfolios. This pledge was supported by the UN PRI and has since been signed by 120 investors, collectively managing over $10 trillion in assets. Amongst them Candriam of course, and also large U.S. asset owners such as the University of California and CalPERS.

Such disclosure and transparency are only a first step, but an essential one, to allow investors and our clients to see the CO_2 emissions inherent in their investments in our funds and strategies and compare them with those of other asset managers.

Of course, to disclose such crucial information, we require the data. Investors are ill-equipped to measure CO_2 emissions at factory level themselves. This basic data is a prerequisite to the availability of regular, reliable and standardised CO_2 and CO_2-equivalent emission data. This is in turn required to calculate each investment's contribution to, or to seek to optimise a portfolio for, a low CO_2 footprint. Fortunately, companies are becoming accustomed to the provision of such information alongside their financial filings. Third-party data providers have made a business of collecting and aggregating CO_2 data for investors.

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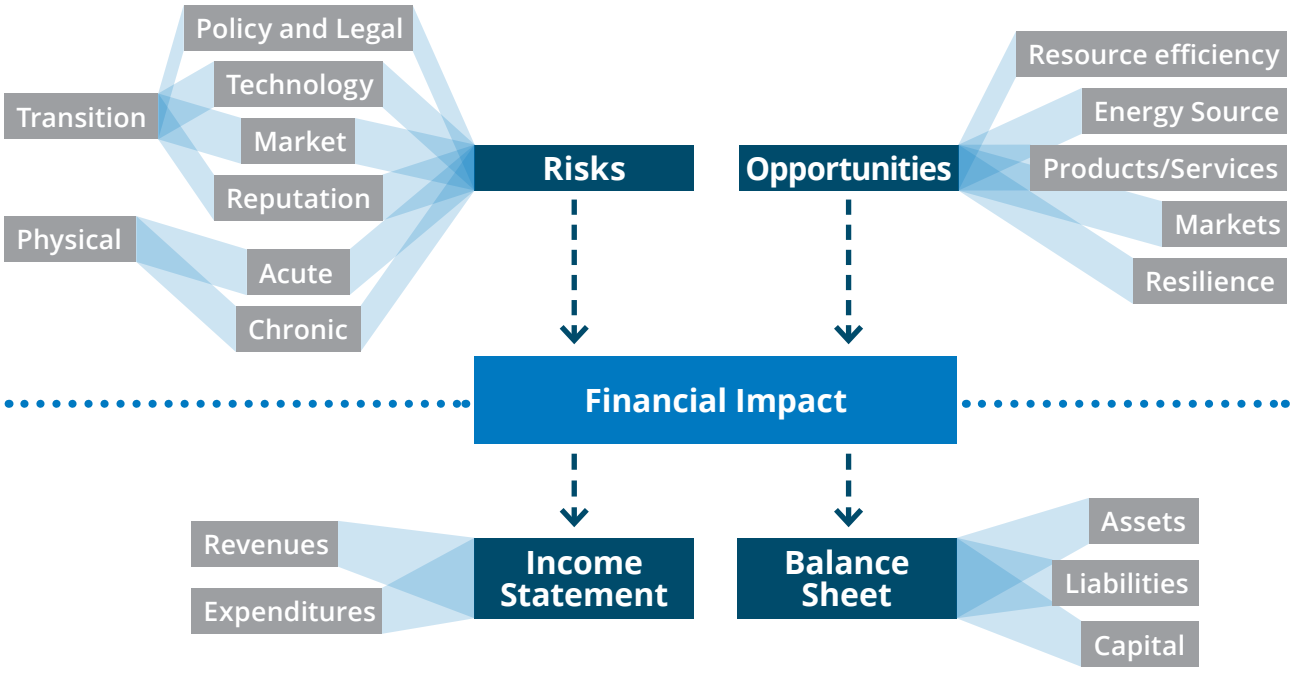
The Task Force on Climate-Related Financial Disclosures

Companies are increasingly aware of the risks and opportunities arising from climate change. Part of this awakening consists of measuring current CO_2 exposure. The Task Force on Climate-Related Financial Disclosure (TCFD)[6] is aimed precisely at this: to provide a common reporting framework allowing companies to capture the risk and opportunities arising from climate change at each step of their strategic and operational processes.

CHART 7: Climate and Financial Reporting Roadmap



Source: TCFD

The TCFD does not primarily concern itself with a company's impact on climate change, but rather with climate change's consequences for the company. The recommendations from the TCFD, launched in 2017, have been gaining acceptance and will become mandatory for PRI signatories by 2020.

[6] The TCFD seeks to develop recommendations for voluntary climate-related financial disclosures that are consistent, comparable, reliable, clear, and efficient, and provide decision-useful information to lenders, insurers, and investors.
The TCFD's 31 members were chosen by the Financial Stability Board (FSB) to include both users and preparers of disclosures from across the G20's constituency covering a broad range of economic sectors and financial markets. The FSB is an international body that monitors and makes recommendations about the global financial system.

Climate-Related Investment Reporting

Regulators in Europe, the United States and Japan are increasing their requirements for transparency on the climate risk embedded in investments held to meet future pension liabilities.

The first essential step by pension regulators was the recognition that integration of ESG factors into investment decisions was compatible with the fiduciary duty of pension fund managers. In the United States, the 1998 Calvert Letter issued by the Department of Labor (DOL) stipulated that sponsors could integrate ESG factors so long as it did not negatively affect financial performance. Then in 2015 the DOL issued an Interpretative Bulletin in which it clarified that:

*"plan fiduciaries **should** appropriately consider factors that potentially influence risk and return. Environmental, social, and governance issues may have a direct relationship to the economic value of the plan's investment. In these instances, such issues are not merely collateral considerations or tie-breakers, but rather are proper components of the fiduciary's primary analysis of the economic merits of competing investment choices."* [7]

In effect, the DOL stated that ESG factors should be part of investment considerations by fiduciary managers.

As the DOL was clarifying the fiduciary responsibility of US managers to integrate ESG factors, the French legislator was passing Article 173. This legislation made it mandatory for French asset owners to disclose their exposure to climate risk[8], and more widely, to integrate environmental and social factors into their decisions.

After three years of implementation of Article 173, it has emerged that the metric used by many of these investors to measure their exposure to climate risk is CO_2 emissions. As mentioned, a number of initiatives have emerged to make CO_2 emissions data available to investors, allowing them, as we will see, to optimise investment portfolios for a lower carbon footprint.

"the DOL stated that ESG factors should be part of investment considerations by fiduciary managers."

[7] *"Interpretive Bulletin Relating to the Fiduciary Standard Under ERISA in Considering Economically Targeted Investments", Department of Labor, 2015.*
[8] *Alternatively, asset owners can explain how climate change does not impact them, under the so-called "comply or explain" principle.*

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THE PITFALLS OF CARBON FOOTPRINT MEASUREMENT

On the face of it, the measurement of a company's carbon intensity, or carbon footprint, seems relatively straightforward: place CO_2 captors at the top of every chimney and exhaust pipe, record emissions over a calendar year, and you have its CO_2 emissions.

However, once investors begin to implement carbon measurement, they face a series of questions pertaining to the range of measurement, and how to treat potential future emissions.

Current Emissions: the Question of Scope

Investors define three measurement ranges, or Scopes, when assessing company CO_2 emissions.

SCOPE 1: CO_2 emissions generated directly by the company's operations are defined as Scope 1 emissions. These are the easiest to measure, as they are under the direct control of the company.

SCOPE 2: Investors also wish to measure emissions caused by the production of power and heat required for the company to operate, defined as Scope 2 emissions.

However, in many sectors, measuring solely on emissions produced by the company or its power/heat suppliers misses a large part of CO_2 emissions for which the company's activities are ultimately responsible.

SCOPE 3: It is estimated that around 90% of CO_2 emissions attributable to the activities of car manufacturers are not emitted by the car manufacturers themselves during production. Indeed the vast majority of the CO_2 attributable to a car manufacturer (at least cars with an internal combustion engine) is produced through the normal utilization of the cars once they have left the factory floor.

To gain a thorough understanding of CO_2 emissions, it is essential to measure these Scope 3 emissions, and add them to the Scope 1 and 2 emissions. But therein lies the challenge: because consumers are not within a company's remit, estimating Scope 3 emissions requires making many assumptions about the way products will be utilised, for how long, etc.

When attempting to quantify CO_2 emissions, investors usually focus on Scope 1 and Scope 2. Data availability of Scope 3 emissions remains both patchy and model-dependent.

For this reason, the analyses we present in this document are based on Scope 1 and Scope 2 emissions. Nevertheless, at Candriam we have the expertise necessary to incorporate Scope 3 emissions in a reliable manner in portfolio construction and evaluation.

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Future Emissions – Reserves and Stranded Assets

The durability and solvency of companies in extractive industries hinge on their capacity to replace current resource extraction -- oil, gas, minerals -- with new discoveries, so that reserves are maintained or increased. Their balance sheets typically show the market value of these reserves as their main asset and source of future revenues. Most of these resources produce CO_2 emissions at both the extraction and consumption stages. Reserves of oil, coal, and other fossil energy which will ultimately be burned to produce power, represent CO_2 emissions potential.

Hence the question increasingly raised by investors: what value do these high–CO_2 resources really have, if their combustion tomorrow seems incompatible with current, let alone future commitments to reduce CO_2 emissions?

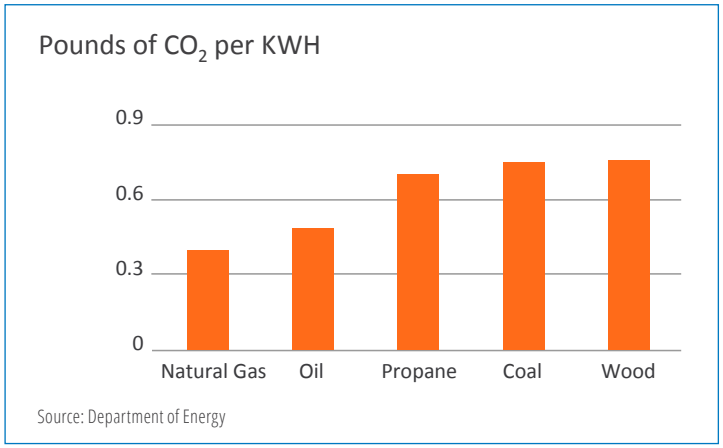
These potentially 'stranded assets' carry a stated value today which may not materialise in the future, and therefore should not be accounted for on the balance sheet. When assessing the value of fossil reserves, investors need to ask themselves about the likelihood that these assets become stranded in the near future.

The Varying Carbon Intensity among Fossil Resources

Fossil fuels are not born equal. Investors keen to improve the carbon profile of their portfolio should not treat them as one category.

Generating one kWh of power by burning coal releases around 40% more CO_2 than the same quantity of electricity produced from natural gas, with oil somewhere in between.

CHART 8: Comparison of Fossil Fuels
Pounds of CO_2 per Kilowatt Hour



Source: Department of Energy

The path to maintaining global mean temperatures to within 2 degrees requires a mix of power sources. For countries already advanced in their transition to renewable energy sources, a switch to near-full reliance on wind, solar and hydro-electric power generation in the near future might be possible. Most countries will continue to rely on fossil energy, to some extent, for the foreseeable future.

The 2-degrees scenario drawn by each country following the Paris Agreement includes different energy mix scenarios in which natural gas, when replacing more CO_2-intensive energy sources, can play a role in reducing carbon intensity.

Investors should bear in mind that many power suppliers are mixed energy producers, combining both fossil and renewable energy within their asset portfolio. As we will demonstrate, excluding power producers purely on their ownership of high-carbon assets can inadvertently exclude major renewable energy providers.

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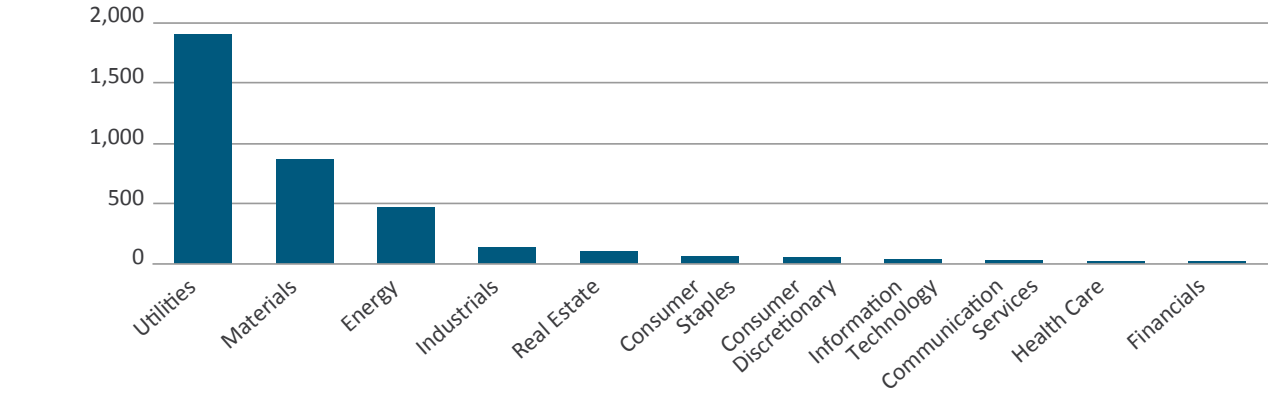
PART II: LOW-CARBON INVESTMENT STRATEGIES

A number of approaches have been created to integrate climate change into investment analysis and portfolio design. We analyse two approaches which are commonly used in practice. Both methods can produce a significant reduction in portfolio carbon intensity, measured as CO_2. Our aim is to address their other effects on investment profiles.

Two Main Approaches to Reducing Portfolio Carbon

Given that the energy, materials and utilities sectors are responsible for most of the CO_2 emissions attributable to the private sector, why not simply exclude these sectors from the investment portfolio? This Exclusion approach is probably the most obvious one.

CHART 9: Current CO_2 Emissions by Industrial Sector



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Excluding these sectors from the portfolio would omit around 11% of the MSCI© US and 14% of the MSCI© World, based on February, 2019 data. This type of approach is commonly used by several low-carbon Exchange Traded Funds, as it offers a simple and effective way to reduce portfolio CO_2 emissions. However, the Exclusion approach leads, by definition, to severe sector biases. These in turn lead to adverse portfolio behaviours in certain markets, and to higher tracking error.

In our simulations, we optimise the portfolio allocation to CO_2 emissions without introducing sector biases. The sector allocation result of each approach is shown in Chart 10.

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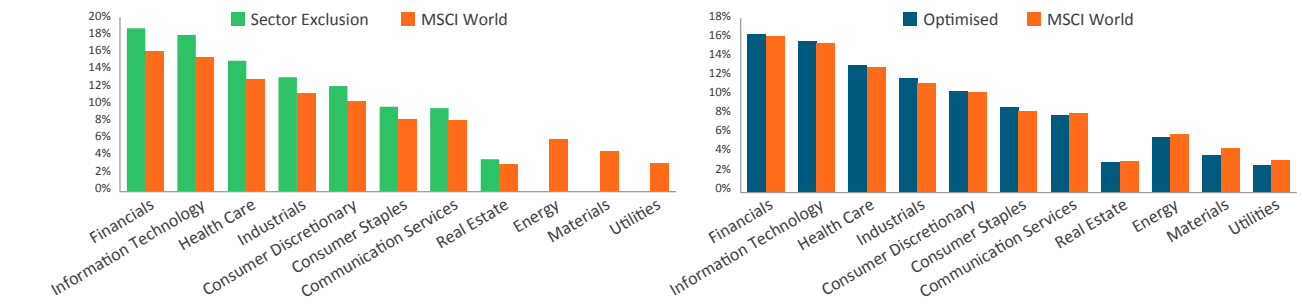
CHART 10: Effect on Sector Weights vs. Benchmark -- Exclusion and Optimisation Methods Compared



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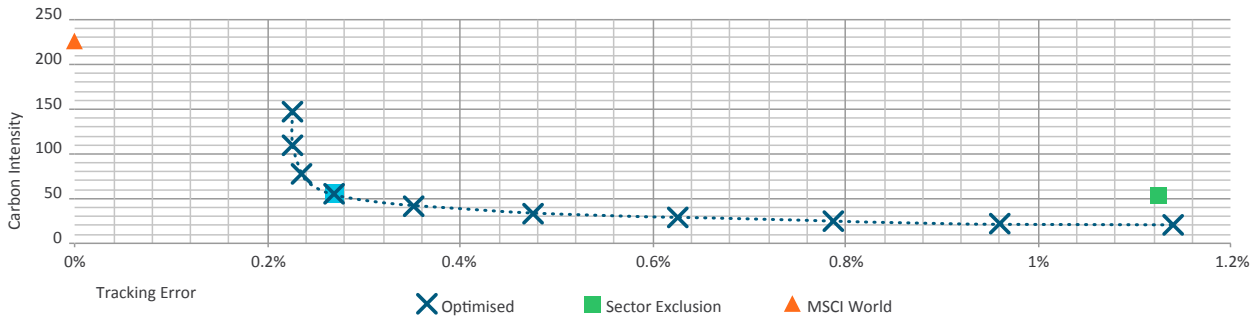
Portfolio Carbon Reduction Approaches Tracking Error under Exclusion vs. Optimisation.

We compared these two approaches in terms of carbon intensity and tracking error, using the MSCI© World Index as the benchmark. All simulations are as of the end of February 2019. In the first approach we excluded the three most carbon-intensive sectors from the universe and reallocated their weights proportionally to the remainder of the portfolio. In the second approach we used a portfolio Optimiser and risk model to minimise the carbon footprint, and constrained the sector weights to be in line with those of the MSCI© benchmark. We limited the number of holdings to 650, about half the number of names included in the benchmark.

The chart below shows the carbon intensity and tracking error of both approaches and the benchmark.

CHART 11: Carbon Intensity and Tracking Error vs. Benchmark -- Exclusion and Optimisation Methods Compared - Portfolio Simulation



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These results are based on simulated or hypothetical results that have certain inherent limitations. Unlike the results shown in an actual record, these results do not represent actual trading. Because these trades have not actually been executed, these results may have under-or over-compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated or hypothetical trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. No representation is being made that any account will or is likely to achieve results similar to these being shown.

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The result of the sector Exclusion simulation is shown by the **green square** in Chart 11. In the simulation, the Exclusion method achieved a 75% reduction in carbon intensity compared to the benchmark represented by an **orange triangle**, but with a relatively high tracking error of 1.12%.

To assess the carbon Optimisation approach, we constructed a series of portfolio simulations with varying combinations of carbon intensity and tracking errors, shown as **blue Xs**. The Optimisation portfolio within this series for which the carbon intensity is similar to that of the Exclusion approach is marked by the **blue square**.

This simulated Optimised portfolio achieved a 75% reduction in carbon intensity, similar to the Exclusion approach, but with a significantly lower tracking error of 0.27%.

The Optimised approach offers a number of important advantages, in our view. Firstly it reduces risks arising from sector biases. This is illustrated in Chart 12, which shows the contribution of industry and stock-specific risks to the tracking error for both portfolios. Industry risk explains the bulk of the tracking error of the Exclusion portfolio, while it explains only a minor portion of tracking error in the Optimised approach.

CHART 12: Attribution of Tracking Error -- Exclusion and Optimisation Methods Compared

	% Contribution to Tracking Error	
	Sector Exclusion	Optimised
Industry risk	83.2%	5.9%
Stock Specific Risk	5.7%	90.1%

Sources: Candriam, MSCI©, Trucost©. ©MSCI. All rights reserved. © S&P Trucost Limited ("Trucost"), an affiliate of S&P Dow Jones Indices LLC. All rights reserved.

Sector biases should not be underestimated. For example, they can inadvertently increase the sensitivity of the portfolio to factors such as commodity prices.

A second advantage of the Optimisation approach is that although the portfolio remains invested in high-carbon sectors, it does so by focusing on the most efficient, or lowest-carbon-emitting, companies within each sector. This contributes to the market signals sent by investors and supports investor campaigns to promote carbon responsibility within high-carbon sectors.

An other advantage of the Optimisation approach is that it enables us to take into account other important dimensions such as "exposure to renewable energy" as well. Many companies with high involvement in renewable energy also happen to be active in carbon intensive-sectors, particularly utilities companies. Many energy providers, including the historically high-carbon-emitting utilities, have been significant investors in renewables technologies as well. Put another way, few utilities are pure renewable players, especially in the US.

This brings us to an interesting question. What is the interaction between the carbon footprint and the investment in renewables within a portfolio and how we can manage it?

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Renewables and Fossils are Intertwined

The portfolio interaction between the carbon footprint, and investment in renewables, can be complex. As already mentioned, many companies with a high carbon footprint are also important actors in renewable energy. Faced with pressures from investors, regulators, governments, and/or customers to reduce their carbon footprint, they can either divest their most carbon-intensive assets, and/or invest in renewable energy production as a counterweight.

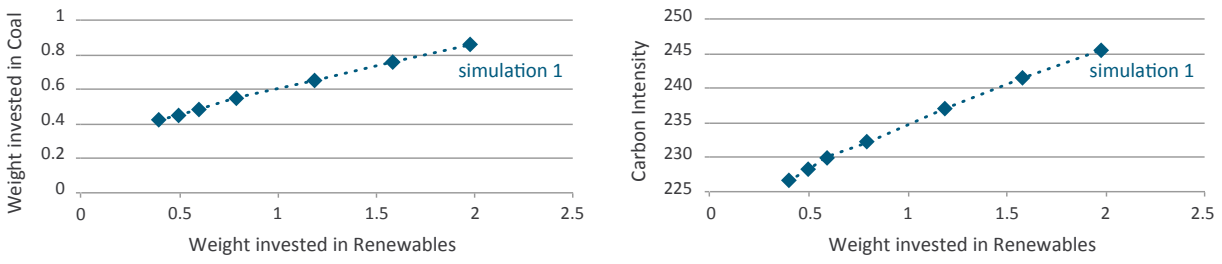
Power producers mixing high-CO_2 generation with renewable technologies are therefore more common than renewable pure players.

A few examples of such mixed power generators include[9]

- Huadian Fuxin Energy of China:
  35% coal power,
  35% wind power, 22% hydroelectric
- Idacorp in the US:
  3 coal power plants,
  12 hydroelectric power plants
- Electric Power Development Co. in Japan:
  38% coal power,
  39% renewable power:

The wide-spread comingling of renewable assets and carbon-intensive assets creates a paradox for investors; by increasing portfolio exposure to renewables they will almost certainly increase the exposure to coal and in turn drive up portfolio carbon intensity. Chart 13 illustrates portfolio trade-offs between coal exposure and renewables, and the carbon intensity versus renewables, for seven sample portfolios. These simulated portfolios aim to minimise the tracking error while achieving a certain percentage of investments in renewables.

CHART 13: The Renewables Investment Quandary – Many Companies Exposed to both Coal and Renewables



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Next, by incorporating additional constraints within the optimisation framework, we were able to construct solutions which accomplish three goals simultaneously: to limit the increase in coal exposure, whilst holding the level of carbon intensity stable, and increasing the investment in renewables. This is illustrated by the green lines in Chart 14.

[9] *Alternatively, asset owners can explain how climate change does not impact them, under the so-called "comply or explain" principle.*

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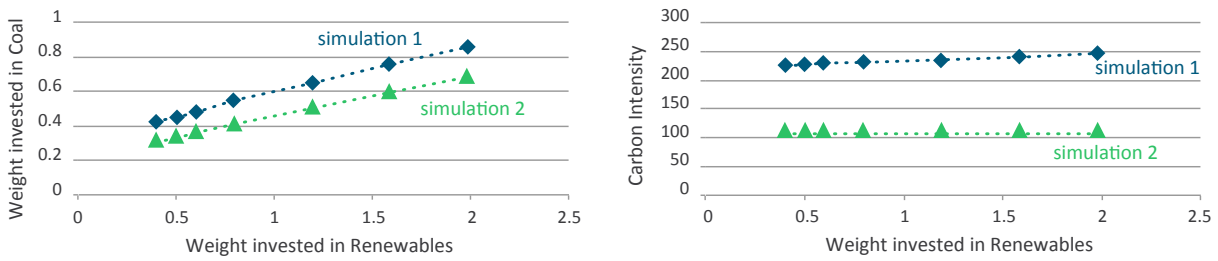
CHART 14: Improved Renewables vs. Coal Allocation Improves under Additional Investment Constraints



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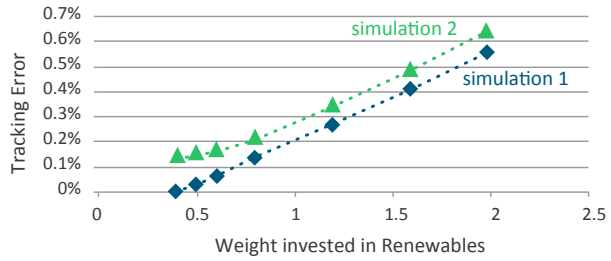
These interesting characteristics were achieved in simulations at the relatively small cost of an increase in tracking error of about 0.10%. This is illustrated by the difference between the two lines in the Chart 15.

CHART 15: Tracking Error of Renewables / Fossil Trade-off Simulations



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We consider that it is more efficient for investors to optimise their portfolio towards a specific carbon intensity in a sector-neutral way, rather than just exclude the most CO_2 intensive sectors, e.g. energy, materials and utilities.

Furthermore our analysis shows that achieving a high degree of investment in renewable energies requires exposure to carbon intensive sectors. This is due to the persistence of dual players, i.e. those who produce electricity from both fossil energy sources and renewable energy sources.

Note: These results above are based on simulated or hypothetical results that have certain inherent limitations. Unlike the results shown in an actual record, these results do not represent actual trading. Because these trades have not actually been executed, these results may have under-or over-compensated for the impact, if any, of certain market factors, such as lack of liquidity. Simulated or hypothetical trading programs in general are also subject to the fact that they are designed with the benefit of hindsight. No representation is being made that any account will or is likely to achieve results similar to these being shown.

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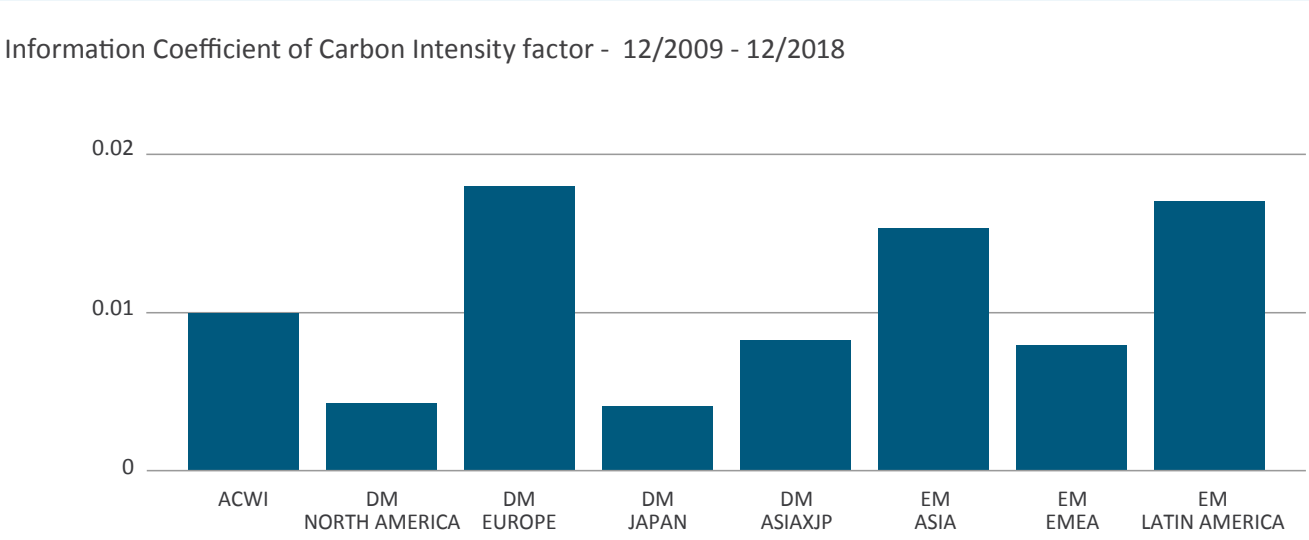
Carbon Optimisation and Investment Results

To estimate the impact of a carbon intensity mitigation approach on investment returns, we analysed the correlation between carbon intensity (CI) and financial returns over a nine-year period, December 2009 to December 2018. To avoid sector and regional biases, we normalised the carbon intensity factor against these dimensions.

Chart 16 shows the Information Coefficient (IC) of the carbon intensity factor within each region over the period. The chart shows that the Information Coefficient was positive in all regions over the period, meaning that, on average, the correlation between carbon efficiency and financial performance has been positive.

CHART 16: Carbon Intensity by Geographic Region – Information Coefficient of Carbon Intensity Factor – Dec 2009 to Dec 2018



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Another way of analysing the financial impact is a decile analysis. We divided the global equity universe into ten equally-weighted portfolios at the beginning of each month, based on the carbon intensity factor. We compared their performance to that of the equally-weighted universe over the subsequent month. The portfolio was rebalanced on a monthly basis.

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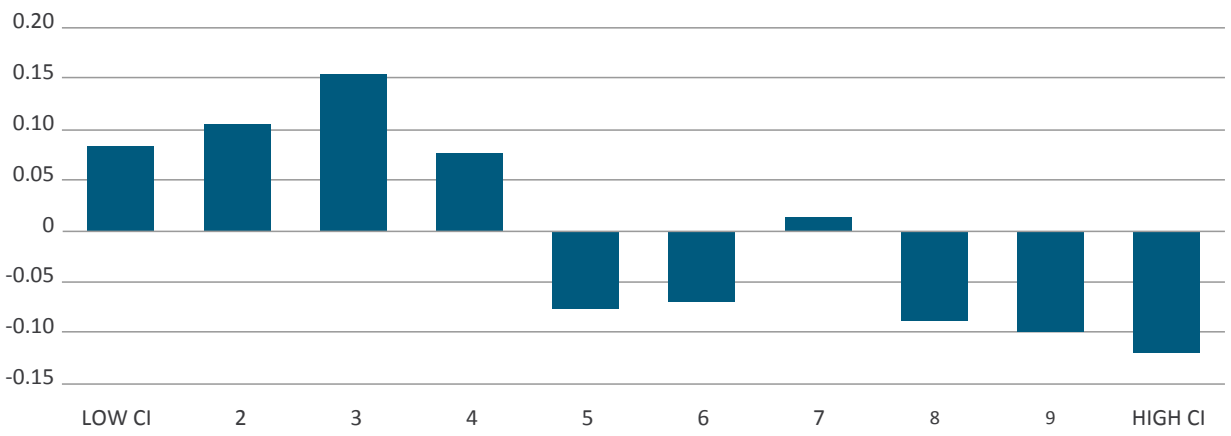
Chart 17 shows that over the nine years, the portfolios containing the stocks with the lowest carbon intensity (Low CI) generally tended to outperform the universe whilst those that exhibit the highest carbon intensity (High CI) tended to underperform.

CHART 17: Decile Analysis of Monthly Excess Return vs. Equity World Universe – Dec 2009 to Dec 2018



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Our analysis shows that the share prices of those companies which made the most progress in carbon reduction outperformed the 'carbon-cutting laggards' over the nine-year period. This might be the result of on-going changes in regulation, combined with a growing awareness by investors regarding the investment risks arising from climate change.

This being said, carbon intensity is only one of the approaches investors can use to decarbonise a portfolio. In the next section, we will describe through a concrete case study how investors can incorporate various climate-related metrics, together with a range of specific ESG criteria, within a portfolio tracking a client-defined benchmark. The resulting portfolio is both reduced-carbon, and meets additional specification.

"Carbon intensity is only one of the approaches investors can use to decarbonise a portfolio."

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PART III: CASE STUDY - CUSTOM LOW CARBON INDEX TRACKING PORTFOLIO WITH ESG OPTIMIZATION

We implemented a tailor-made investment solution for a large European pension fund which incorporates a number of climate related metrics, along with a number of more general ESG parameters. The investment goal assigned by the investor is aimed at minimizing the tracking error relative to a custom benchmark specified by the pension fund. It has been implemented since 2017 in an equity mandate of more than 2 billion euros.

This case study has been presented for illustrative purposes only. Past performance is no guarantee of future returns.

Investment Guidelines Defined Together With the Investor:

The solution had to comply with the following minimum **Climate Change** standards:

- The current CO_2 emissions, or *carbon intensity*, should be *at least 50% below the benchmark.* The goal was to ensure that the portfolio reflected an optimized CO_2 footprint, at least from a Scope 1 and Scope 2 perspective.

- The future CO_2 emissions from *fossil fuel* reserves should be at least 50% below the benchmark. The client was keen to *minimize the long-term potential for stranded assets*.

- Companies held in the portfolio may generate no more than 20% of revenue from coal used for power generation or coal-fired power generation. The aim was to *strike a balance between removing the most CO_2-intensive energy activities from the portfolio whilst investing in utilities transitioning to renewable energies*. This led to the 20% revenue threshold, acknowledging that many utilities, especially in the US, are still reliant on carbon-intensive cash-generating plants to finance their investments in renewable energy.

- Companies held in portfolio may generate no more than 1500 metric tonnes of greenhouse gas emissions per million euros of revenue. Setting of the ceiling for carbon intensity relative to an issuer's size, rather than just a single one-size-fits-all limit on absolute carbon emissions, puts the focus on carbon efficiency, whilst at the same time removing carbon outliers from the portfolio.

- The portfolio should be tilted towards companies active in energy transition. An overall goal of the investor is to *support energy transition*. A 'bonus' is therefore applied by our model to companies acting as solution providers in this area.

The client also requested the integration of **Broader ESG Dimension** related to stakeholder management. Companies included should *show above-average commitment to material ESG metrics*, whilst companies involved in controversial activities are to be avoided. To meet these needs, Candriam set up the following additional investment parameters within the portfolio optimization model:

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- Candriam's proprietary internal ESG score *"Quality of stakeholder management" should be higher than that of the custom benchmark.* Any company in which Candriam invests within an ESG strategy undergoes a stakeholder analysis. We focus in particular on the quality of governance as well as the way the company's human capital and clients are treated, from a strategic as well as operational perspective.

- Companies demonstrating severe and repeated violations of the ten UN Global Compact Principles are excluded. The aim is to remove companies involved in severe and/or recurring controversies relating to human rights, labour rights, environmental risk-taking and governance. We are of the view that the risk of permanent capital impairment arising from such controversies does not warrant the short-term return potential.

- Companies included in GICS industry group *"Tobacco"* are excluded. Our client believes that this sector does not belong in a Responsible portfolio and elected to exclude it.

- Companies involved in the production and/or sales of anti-personnel landmines, cluster ammunitions or depleted uranium weapons are excluded. This exclusion is in line with international conventions banning the use of such weapon systems.

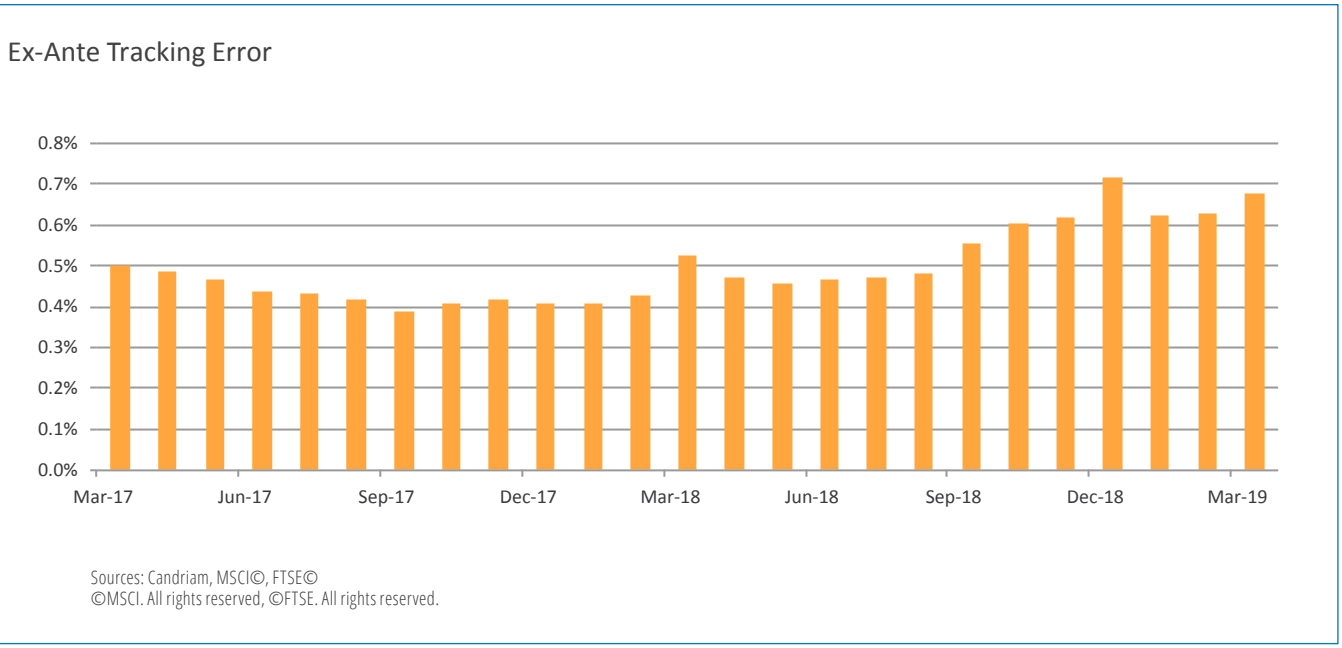
The Implemented Portfolio – Tracking Error Minimisation

The objective of the mandate is to mitigate the climate risk of the portfolio, under a strict tracking error constraint.

Over the period March 2017-March 2019 the gross performance of the mandate was in line with that of the Implemented benchmark while its tracking error was at all times below 1%.

The graphics show the evolution of the ex-ante tracking error (Chart 18), measured by our risk model and the realized tracking error (Chart 19) based on a 6 months rolling window of daily returns

CHART 18: Ex-Ante Tracking Error



Sources: Candriam, MSCI©, FTSE©

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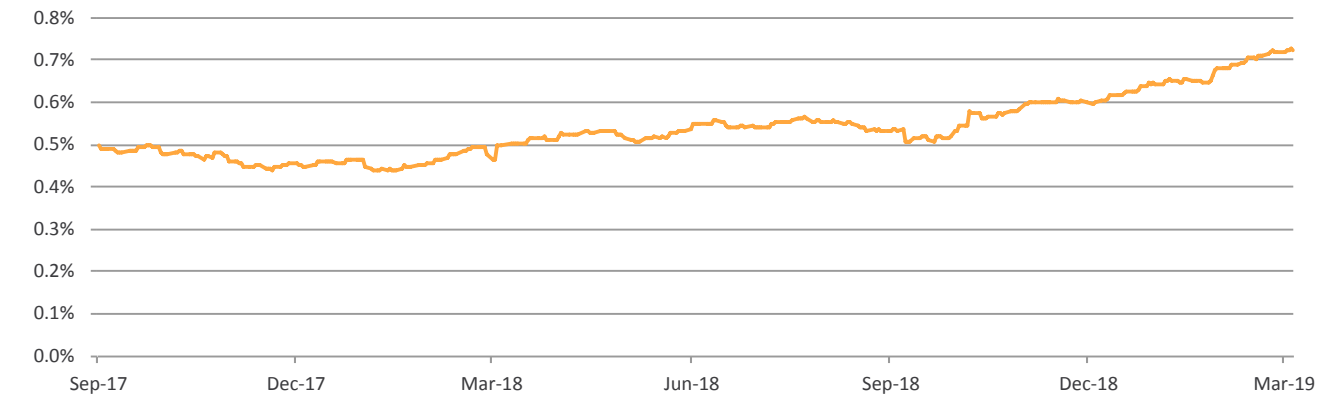
CHART 19: Ex-Post Tracking Error



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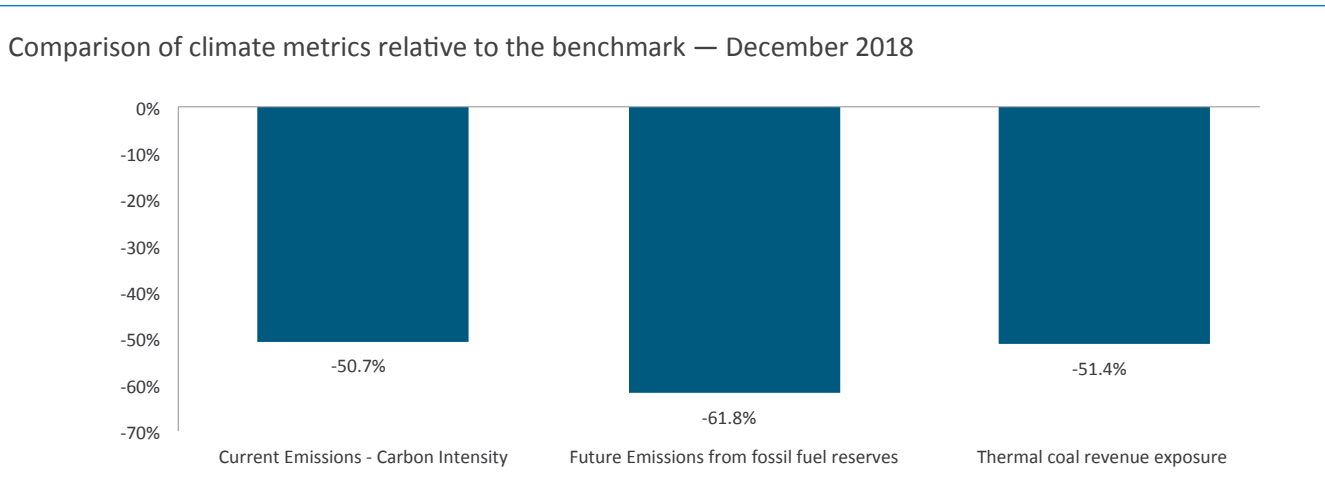
The Implemented Portfolio – Carbon Intensity

Since the focus of this mandate is to build an index-tracking portfolio with a significant lower the overall climate impact of the portfolio we evaluate these criteria by comparing the portfolio's carbon intensity and exposure to coal for power generation to those of the benchmark.

Measures of both current and future CO_2 emissions are less than 50% of benchmark level, as shown in Chart 20. The thermal coal revenue exposure of the portfolio is also significantly below that of the level of the custom benchmark, reflecting the exclusion of companies generating more than 20% of their revenues from coal used for power generation.

CHART 20: Portfolio Carbon and Climate vs Custom Benchmark



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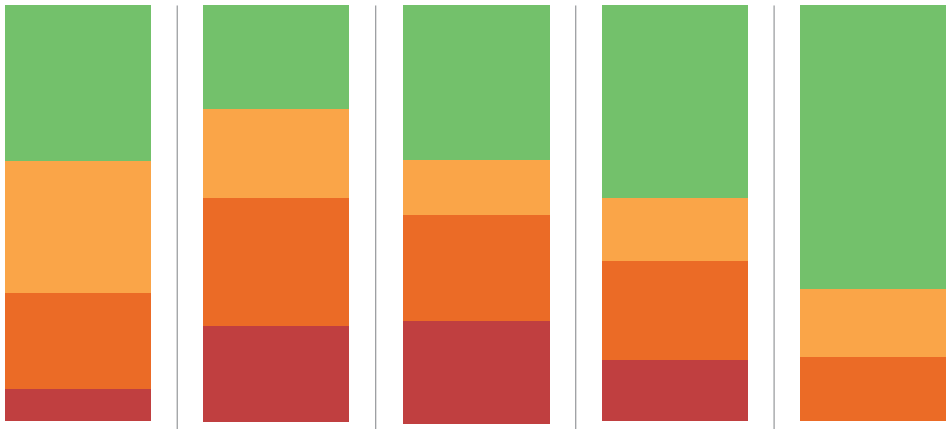
The Portfolio -- Alignment with 2-Degree Scenario

The International Energy Agency (IEA) has formulated a series of energy supply scenarios aligned with the effort to keep the rise in global mean temperature to less than two degrees centigrade, as defined by the Paris Agreement. The goal of theses energy mix scenarios is to provide fossil and renewable energy combinations in line with the 2-degree objective. Chart 21 compares the current energy mix of the portfolio to the International Energy Agency's 2-degree scenarios, as well as to the custom benchmark.

CHART 21: Portfolio Energy Supply versus 2-Degree Scenarios — December 2018

This chart covers the power utility sector, one of the main sources of CO_2 emissions worldwide. Each bar represents a different combination of energy sources. The International Energy Agency (IEA) scenarios 2025, 2030 and 2050 provide a path of energy mixes allowing the World to stay below two degrees Celsius of mean average temperature rise by 2100. Under this scenario, coal is progressively phased out whilst renewable energy sources take over, providing 68% of global power supply by 2050.



	Portfolio	Benchmark	IEA (World) 2025 2 Degree Scenario	IEA (World) 2030 2 Degree Scenario	IEA (World) 2050 2 Degree Scenario
Renewables	37.3%	24.8%	37.1%	46.4%	68.3%
Nuclear*	31.9%	21.4%	13.0%	15.1%	16.3%
Other Fossil	22.9%	30.9%	25.3%	23.6%	15.3%
Coal	7.9%	22.9%	24.7%	14.9%	0.1%

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* Nuclear overweight based on client preference

Based on this analysis the portfolio's energy mix is in line with the IEA's recommendation for 2030. The investor has determined that this allocation satisfies its requirement that the portfolio meets energy transition objectives.

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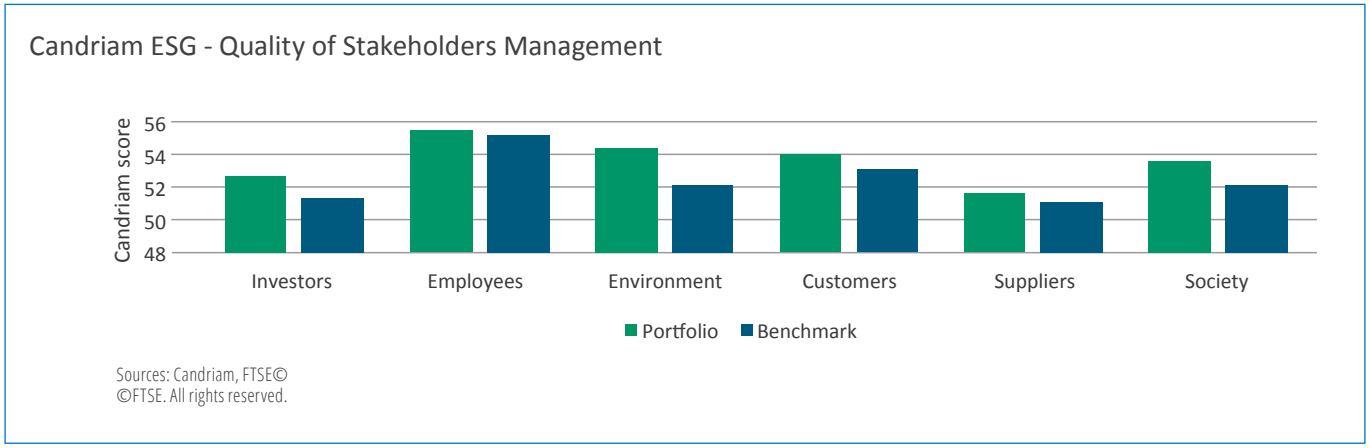
Overall ESG Optimization

We measured the score of the portfolio against ESG metrics representing the six main categories of company stakeholders – investors, employees, environment, customers, suppliers and society. Each ESG metric represents an aggregate of underlying ESG factors selected for their materiality to the particular industry sector. The ESG data combines integrates data sourced from global ESG research agencies with internal research conducted by Candriam's in-house ESG Analysts Team.

The portfolio scored higher than the custom benchmark for each of the six stakeholder types (Chart 22), with a notable outperformance for the 'Environment' stakeholder.

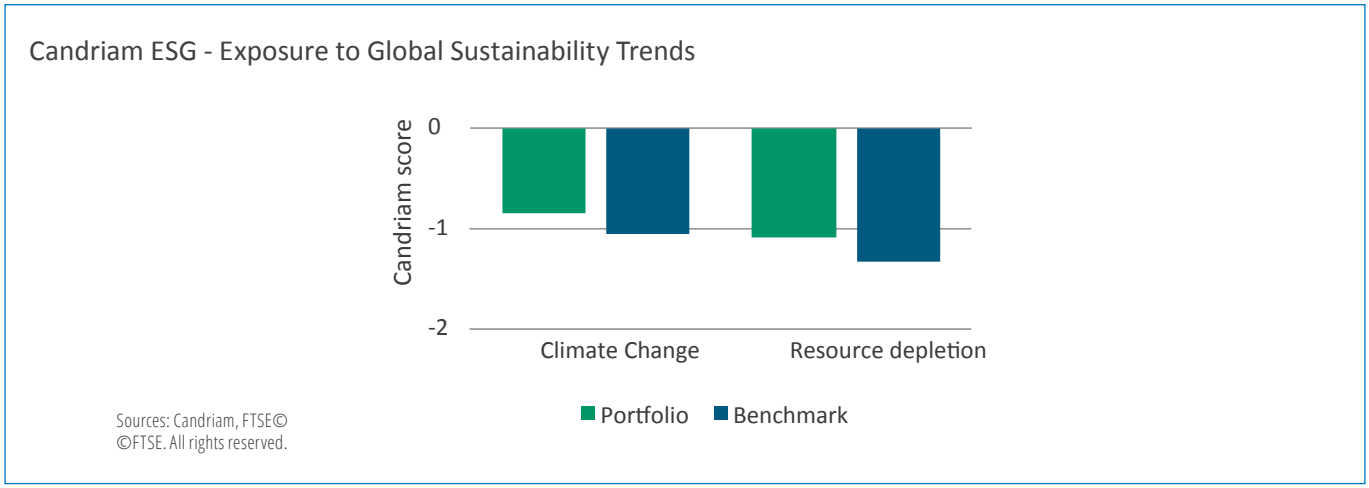
CHART 22: Implemented Portfolio Stakeholder Measures versus Custom Benchmark — December 2018



Sources: Candriam, FTSE©

Finally, we measured the exposure of the based on two of Candriam's Global Sustainability Trends -- climate change, and Resource Scarcity (Chart 23). Unsurprisingly, the portfolio scored better than the custom benchmark against these two metrics as well.

CHART 23: Implemented Portfolio Sustainability vs. Custom Benchmark — December 2018



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CONCLUSION

Global warming has potentially devastating effects on societies, economies, and investments. Only a drastic reduction in greenhouse gas emissions can stop this trend, which is why most nations have started to tackle this challenge through regulation and free market solutions. Investors who choose to ignore this trend face both financial and reputational risk. As we have seen, markets have begun to 'price in' carbon intensity within sectors.

Decarbonising investment portfolios presents investors with several potential benefits; the portfolio can become less susceptible to the risks of climate transition. A reduced-carbon portfolio may become resilient to climate change, and may also become part of the solution leading to a low-carbon economy. Low-carbon investing also sends market signals to companies and policymakers, and contributes to the virtuous feedback loop between carbon pricing and investor behaviour.

Following our simulated solutions, our client case study investor illustrates how a large pension fund can target significantly lower exposure to carbon risk whilst keeping the allocation in line with the market. Over the period March 2017-March 2019 the gross performance of the mandate was in line with that of the benchmark while its tracking error was at all times below 1%. Our goal was precisely to optimize the CO_2 footprint of the portfolio for a given level of tracking error. A well-designed low carbon allocation is best positioned to withstand the increasing regulatory pressure that is likely to emerge in the coming years.

Candriam continues to expand its low-carbon investment solutions, allowing institutional investors to reduce their carbon footprint whilst minimizing tracking error. We are able to achieve this by combining more than 20 years of ESG investment experience with our expertise in quantitative research. Candriam is ideally positioned to offer tailor-made solutions addressing specific climate-related and responsible investing needs.

A well-designed low carbon allocation is best positioned to withstand the increasing regulatory pressure that is likely to emerge in the coming years.

For a complete list of prior investments or more information, please contact your Candriam client relations or business development representative.

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