Supplementary Guide to GPIF ESG Report 2020

Analysis of Climate Change-Related Risks and Opportunities in the GPIF Portfolio

For All Generations

Introduction: Challenges to Address and Key Points of This Report

Foreword

Climate change risk (particularly policy risk) affects all asset classes and securities simultaneously, and cannot be completely eliminated through diversification. Throughout the world, the realization is growing that physical and other climate risks are highly likely to materialize over the long-run. It is with this understanding that GPIF published a series of climate-related financial disclosures in line with the recommendations of the TCFD for the first time in our ESG Report 2018. Here, in addition to measuring our carbon footprint[1] and carbon intensity[2], we conducted a scenario analysis where we provided the results of a transition pathway assessment, which is one way to analyze transition risk.

In our ESG Report 2019 published the following year, in addition to enhancing those disclosures, we also compiled the “Analysis of Climate Change-related Risks and Opportunities in the GPIF Portfolio,” in which we described analysis results in even greater detail and provided a number of different supplemental analyses. In the 2019 report, we used the Climate Value-at-Risk (CVaR) methodology to comprehensively assess the impact of climate change on corporate value through not only “policy risks,” but also “technology opportunities,” as evaluated by environmental technology-related patents, as well as “physical risks and opportunities.” TCFD recommendations encourage the measurement of climate change risks and opportunities in terms of their financial impact, and in this sense, we feel the CVaR analysis is a dramatic step forward.

In this year’s ESG Report 2020, we expanded the scope of the greenhouse gas analysis to encompass the entire supply chain and newly included some alternative assets (domestic real estate) in the group of assets analyzed. We also added an assessment of the anticipated inter-industry transfer of risks and opportunities inherent in the transition to a low-carbon society.

In particular, including “downstream Scope 3” emissions (i.e. indirect emissions generated by the consumption and usage of goods and services sold) in the analysis resulted in a somewhat shockingly large gap with the results obtained last year. On the other hand, these results may actually make more sense as outcomes will naturally vary widely based on how much a given company bears the cost of (i.e. has responsibility for) transition risk, and to what extent they can pass these costs on to manufacturers and sellers.

As we could not adequately describe these extremely complicated and subtle points in the ESG Report 2020, we are once again publishing a supplemental guide and introducing them here.

[1] A measurement of CO2 and other greenhouse gas (GHG) emissions generated by corporate activity. Generally refers to GHG emitted by investee companies in this report.
[2] In this report, generally refers to carbon footprint divided by corporate earnings, GDP or real estate floor area. Measured in GHG emissions per unit.

While the analyses in this report focus mainly on how climate change directly impacts our portfolio, since GPIF is a universal owner that invests not only in domestic listed companies but also in major companies across the globe, the report provides valuable insight into the challenges and risks all Japanese companies, all foreign companies, and by extension, countries all around the world face with respect to climate change. Conversely, the report also examines how valuable the technologies required to solve these challenges are, and the potential business opportunities that arise as a result. We therefore believe this report can act as a useful reference not only for investors but also for other stakeholders as well. Accurately assessing how the climate will change and what the inherent risks and opportunities will be several decades into the future in a practical sense is an incredibly difficult task, and the analysis results need to be interpreted as occurring within a wide spectrum. We hope, however, that the report serves as an importance resource for investors and issuers alike as they think about their own exposure to climate risks and opportunities.

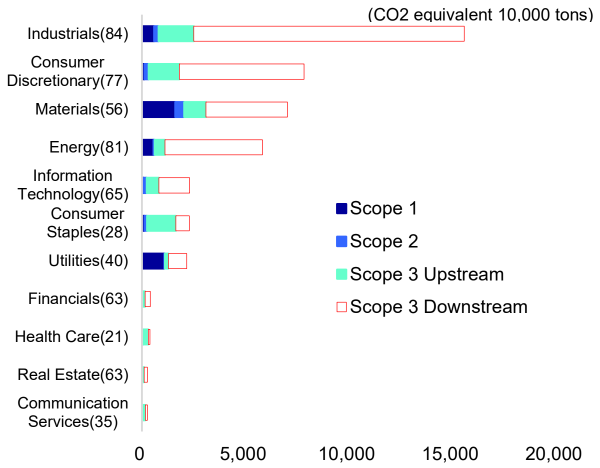
Composition and Analysis Highlights

This paper is divided into an introduction and the main body. The main body consists of four chapters.

In "Chapter 1: Carbon Footprint," we measure the carbon footprint (greenhouse gas emissions [GHG]) and carbon intensity (GHG emissions per unit of revenue) of the Government Pension Investment Fund (GPIF) portfolio using S&P Trucost data. This year, our analysis has been expanded to include the entire supply chain. This broader view confirmed that the carbon footprint of portfolios with a high weighting of companies in the Industrials, Energy, and Consumer Discretionary sectors varies significantly depending on whether the analysis includes Scope 3 emissions (Figure 0-1). It is possible that companies within these sectors can be significantly more competitive by reducing their GHG emissions across the entire supply chain. Compared with the previous year, the total amount of Scope1, Scope 2 and Scope 3 carbon footprint of the GPIF portfolio decreased in fiscal 2020, while the carbon intensity increased.

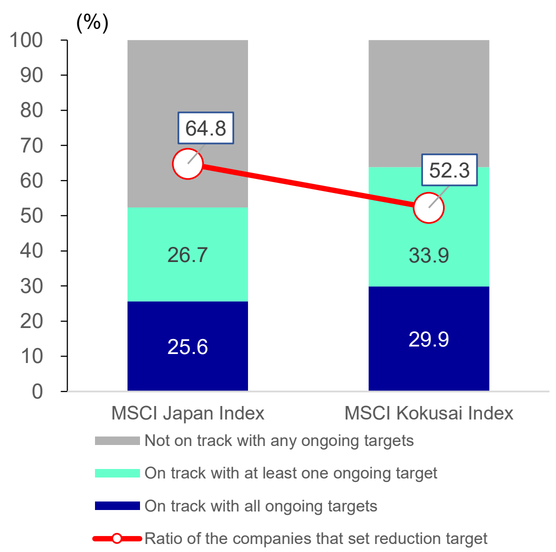
Further, this report includes new analyses that were not included in the ESG Report 2020, such as a review of greenhouse gas emissions (GHG) disclosure and analysis of corporate GHG emission reduction targets. Although domestic equities (domestic companies) lagged in disclosing greenhouse gas emissions data compared to foreign equities (foreign companies), this gap has been quickly shrinking in recent years. On the other hand, in terms of GHG emissions reduction targets, while a higher percentage of domestic companies set targets compared to foreign companies, our analysis showed that many companies currently failed to keep up the pace of emissions reduction with their ongoing targets (Figure 0-2).

Figure 0-1 Carbon Footprint by Scope



Note: Numbers in brackets are ratio of Scope 3 Downstream emissions to the total emissions.
Source: S&P Trucost Limited©Trucost2021

Figure 0-2 Percentage of Companies Setting GHG Emissions Reduction Targets and Feasibility

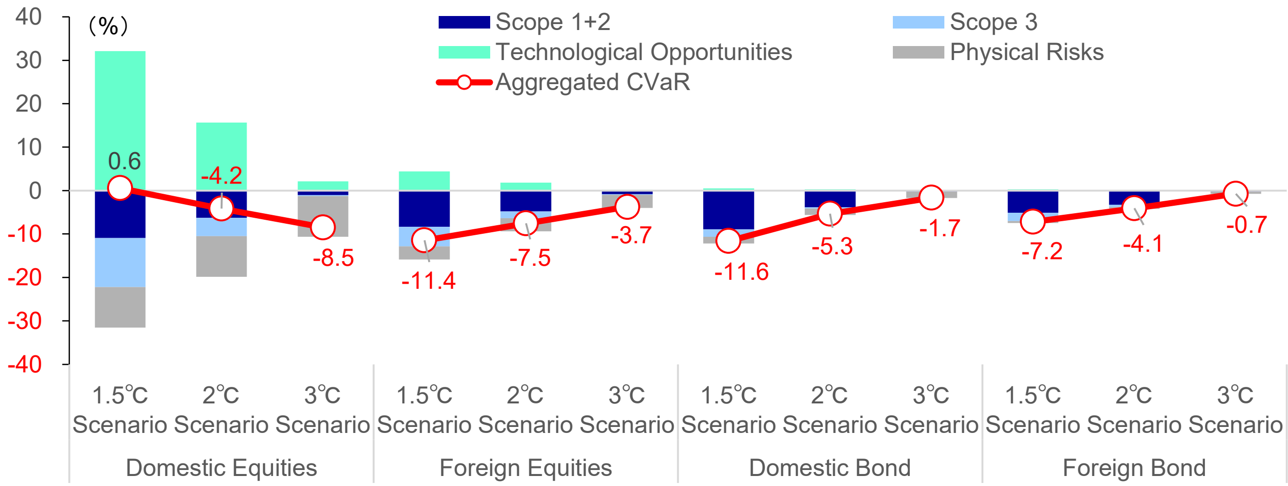


Source: Reproduced by permission of MSCI ESG Research LLC©2021

"Chapter 2: Scenario Analysis of Risks and Opportunities," also conducted the previous fiscal year, analyzes how climate change related risks and opportunities could financially impact GPIF's portfolio (impacts on asset value), using MSCI's Climate Value-at-Risk (CVaR) model. The model enhancement, including the expansion of analytical coverage to Scope 3, drove down aggregated CVaR dramatically. However, at the portfolio level, aggregate CVaR improved year-over-year when comparing the 2019 and 2020 portfolios based on the new model.

Likewise, similar to last year's results, domestic equities showed a higher (positive) CVaR value in the 1.5℃ temperature rise scenario compared to the 2℃ scenario, and the 2℃ scenario CVaR was higher than the 3℃ scenario. This is due to the fact that heightened climate change regulations could increase the value of domestic companies' low carbon technology patents. No such trend has been identified for other asset classes. (Figure 0-3).

Figure 0-3 Comparisons of CVaR by Temperature Rise Scenario



Note1: Physical risks are analyzed under assumptions corresponding to a 4° C–6° C scenario.
Note2: "Scope 1+2" and "Scope 3" indicate policy risks associated with these scopes.
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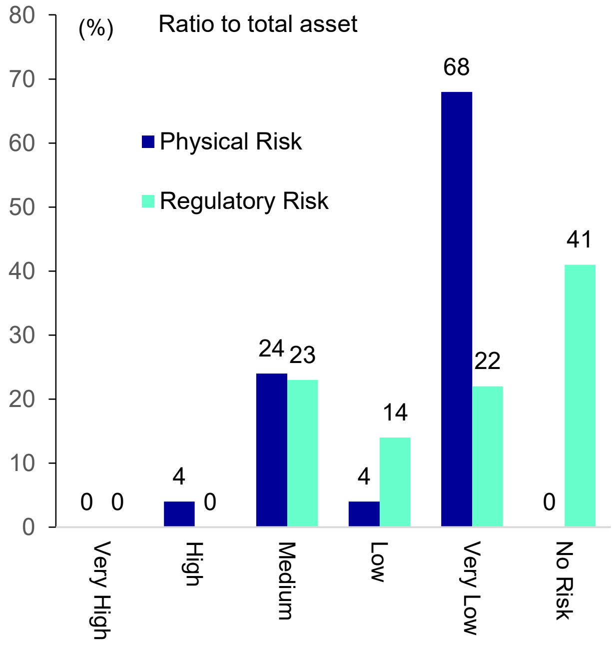
This year, amongst alternative assets, we conducted a CVaR analysis covering domestic real estate assets in which we invest through private placement funds. Domestic real estate assets were exposed to typhoons and flooding risks, but the impact on asset prices were limited for GPIF's portfolio as a whole. (Figure 0-4). However, significant emissions reductions are required to achieve a 1.5℃ scenario.

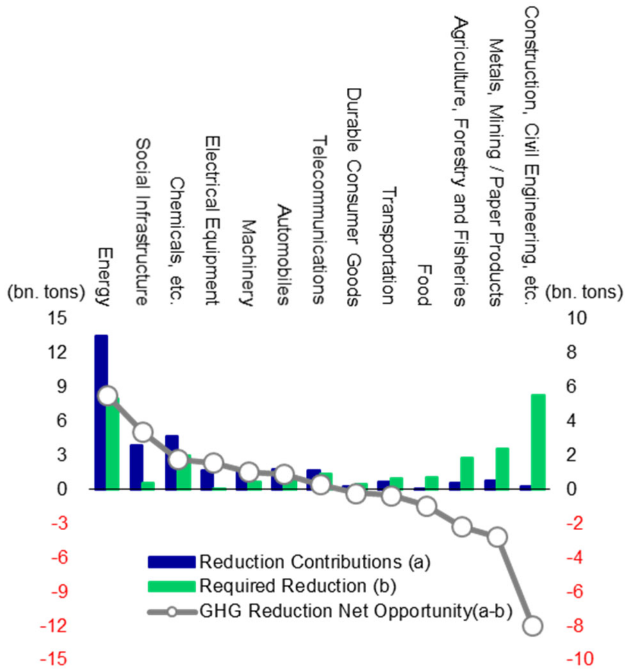
In "Chapter 3: Analysis of Inter-Industry Transfer of Transition Risks and Opportunities," we investigate how risks and opportunities will potentially shift between industries amidst the transition to a low-carbon society. While the CVaR analysis by MSCI in Chapter 2 assumes that these risks and opportunities will be redistributed amongst companies in the same sector (industry), the analysis performed in this chapter by Astamuse assumes that low-carbon technologies will contribute to lower CO_2 emissions across sectors through supply chains, leading to a shift in profit and demand between sectors. Results show that the opportunities far outweigh the risks for the energy, social infrastructure and chemicals industries in the transition to a low carbon society. The analysis also found that Japanese companies in these industries have many promising low-carbon technologies.

Figure 0-4 Real Estate CVaR



Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 0-5 Inter-Industry Transfer of Risks and Opportunities in 2050



Source: Prepared by GPIF based on Astamuse analysis

In “Chapter 4: Other Analysis,” we analyze the revenue opportunities and risks associated with Sustainable Development Goals (SDGs). The SDG Additionality Analysis examines which products and services contribute to the achievement of the SDGs when provided in specific countries and regions and aggregates the results for each company according to its revenue composition. Apart from climate change-related targets, the countries furthest from achieving the SDGs are emerging economies, such as China and India, and developing countries in Africa. The results seem to reflect that domestic companies have contributed less to these regions than overseas companies

Analysis of Climate Change-Related Risks and Opportunities in the GPIF Portfolio

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Chapter 1: Analysis of Portfolio Greenhouse Gas Emissions

Features of GPIF’s Portfolio

Breakdown of GPIF Portfolio by Asset, Sector and GHGs

The analysis looked mainly at four asset classes in GPIF’s portfolio: domestic bonds, foreign bonds, domestic equities and foreign equities. Some alternative assets[3] (domestic real estate in which GPIF invests through private funds, were also analyzed. In the sections that follow, we analyze GHG emission volumes (carbon footprint), transition risks[4], physical risks[5], and opportunities relating to these asset classes using data as of March 31, 2021. Because analysis results are heavily influenced by the investment amount and sector weighting of each asset class, it is important to understand the characteristics of our portfolio prior to interpreting these results. The GPIF portfolio is composed of roughly half bonds and half equities by overall market value (Figure 1-1). As of March 31, 2021, on the fixed income side, domestic bonds accounted for 25.92% of all holdings while foreign bonds accounted for 24.61%. For equities, domestic issues comprise 24.58% of the total portfolio and overseas issues 24.89%. The majority of bond holdings, both domestic and foreign, consist of government bonds (Figure 1-2).

When examining GPIF’s equity portfolio by sector, there is a difference in the composition of the domestic and foreign equity portfolios (Figure 1-3). The domestic equity portfolio has a higher proportion invested in the high-emitting Industrials and Consumer Discretionary, while the foreign equity portfolio has a high proportion in the low-emitting Information Technology (IT), Financials, and Healthcare.[6]

In the corporate bond portfolio, the largest sector for both domestic and foreign bonds is Financials (Figure 1-4). Among domestic corporate bonds, the proportion of Utilities and Industrials is greater than that for foreign corporate bonds. Since Utilities includes electric power companies, this sector is characterized by higher GHG emissions than other sectors. In the foreign corporate bond portfolio, the proportion of energy companies, which have relatively high GHG emission volumes, is greater than that for domestic corporate bonds. On the other hand, the proportion of corporate bonds issued by telecommunication services and healthcare companies, which have lower emissions, is also high.

When we compare the Scope 1+2+3 GHG emissions per million yen of revenue (i.e., carbon

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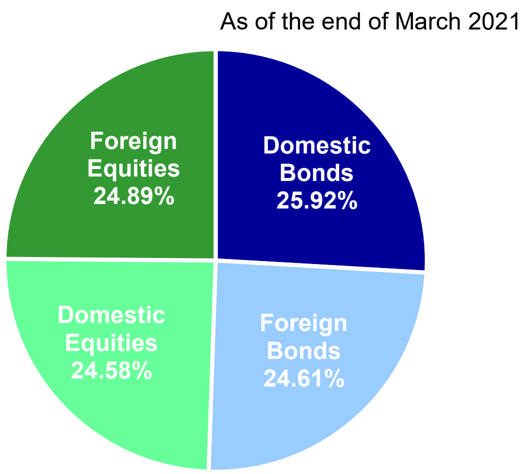
[3] Alternative assets account for around 0.7% of the pension reserve fund. Alternative assets are generally allocated to the four main portfolio asset types according to their characteristics.
[4] Transition risks are risks that arise from policy, technological innovation, demand change, etc. that accompany the transition to a low-carbon economy.
[5] Physical risks are risks from direct damage to an asset, supply chain disruption, etc. resulting from climate change.
[6] Please refer to Figure 1-7 on P.11 for GHG emission.features by sector.

intensity) of domestic and foreign portfolios for each sector, we find a lower carbon intensity in Japanese companies, suggesting that Japanese companies are more carbon efficient than their foreign counterparts (Figure 1-5)

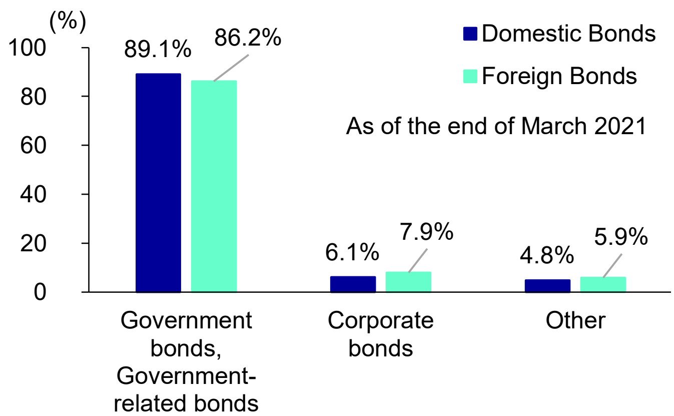
It is important to bear in mind this sector bias in GHG emissions when examining the results of the following analysis. Around 90% of equity investments and 70% of bond investments by GPIF are passive investments, which means our investment is virtually identical to the sector ratios of each benchmark.

Figure 1-1 Breakdown of Portfolio Asset Types (Total for GPIF's Pension Reserves)



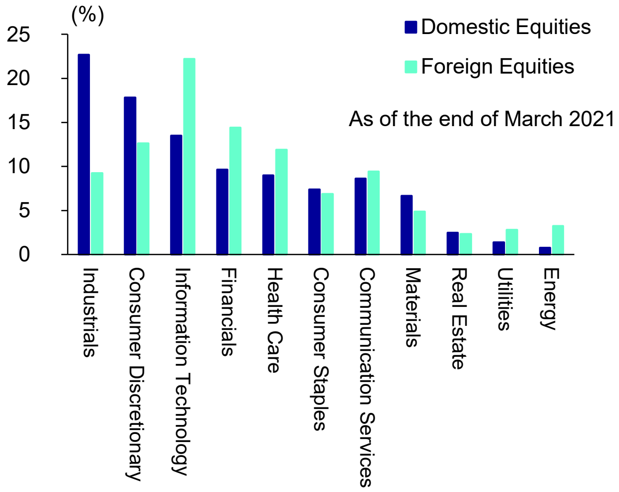
Source: GPIF

Figure 1-2 Breakdown by Category in GPIF Bond Portfolio



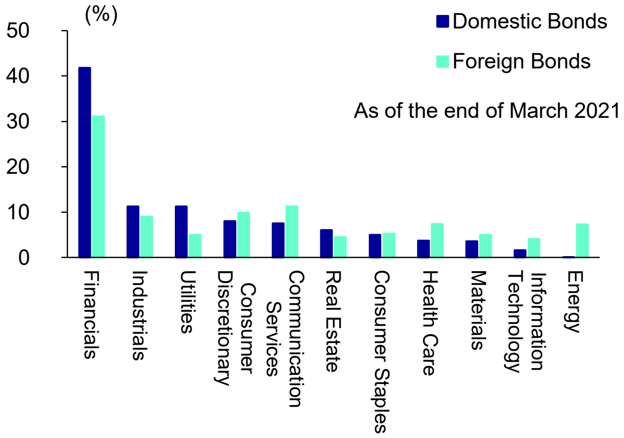
Note: "Other" includes securitized products.
Source: GPIF

Figure1-3 Breakdown of GPIF Equity Portfolio by Sector Based on Total Market Value (%)



Source: GPIF, S&P Trucost Limited©Trucost 2021

Figure1-4 Breakdown of GPIF Bond Portfolio by Sector Based on Total Market Value (%)



Note: Among Domestic and Foreign Bonds, only corporate bonds are analysed.
Source: GPIF, S&P Trucost Limited©Trucost 2021

Figure 1-5 Carbon Intensity by Sector

Greenhouse Gas Emissions per million yen of sales(CO_2 equivalent tons/ million yen)

	Domestic Equities		Foreign Equities		Domestic Bonds		Foreign Bonds	
	Scopes 1+2+3	Scopes 1+2	Scopes 1+2+3	Scopes 1+2	Scopes 1+2+3	Scopes 1+2	Scopes 1+2+3	Scopes 1+2
Communication Services	1.22	0.22	1.09	0.26	1.30	0.35	1.02	0.28
Consumer Discretionary	10.25	0.38	7.57	0.53	9.27	0.34	9.97	0.55
Consumer Staples	4.77	0.59	6.27	0.57	9.57	0.46	10.07	0.69
Energy	25.02	2.41	35.54	3.83	23.31	2.32	34.62	3.51
Financials	0.85	0.04	1.28	0.19	1.00	0.05	1.22	0.05
Health Care	1.13	0.27	1.17	0.14	1.13	0.22	0.88	0.21
Industrials	15.91	0.79	18.98	1.10	9.91	1.23	9.96	1.91
Information Technology	5.59	0.49	3.08	0.43	4.32	0.57	3.08	0.27
Materials	20.20	5.71	27.93	8.46	25.09	9.05	32.15	7.75
Real Estate	3.25	0.33	5.34	0.84	2.77	0.53	3.98	0.58
Utilities	23.50	10.52	29.46	17.14	25.01	15.26	31.75	23.08

Note: Top 3 carbon intensive sectors are highlighted in gray. Among Domestic and Foreign Bonds, only corporate bonds are analysed. Data is as of the end of March 2021.

Source: S&P Trucost Limited©Trucost 2021

Scope of Equities and Corporate Bonds Analyses

Expansion of analysis scope to Scope 3

The scope of GHGs analyzed in this chapter has been expanded from last year and now includes indirect emissions from the consumption and use of products and services (Scope 3 downstream) in addition to direct GHG emissions by companies (Scope 1), indirect emissions from purchased electricity (Scope 2) and indirect emissions from procured products and services other than purchased electricity (Scope 3 upstream) (Figure 1-6). By expanding the scope of our analysis to include Scope 3 downstream, we aimed to account for GHG emissions across the entire supply chain.[7]

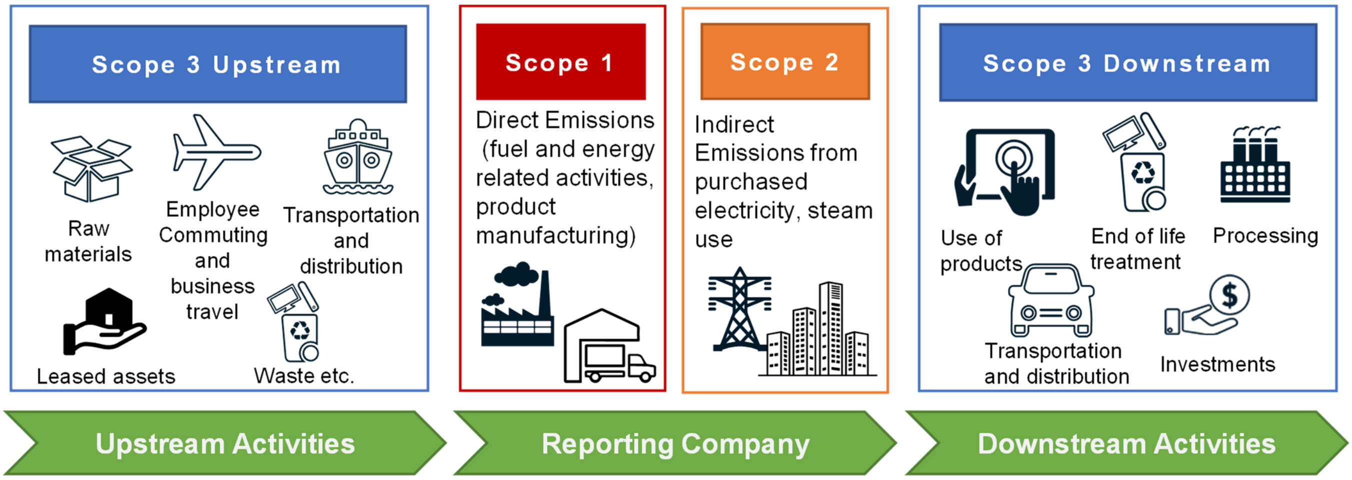
Because the priority was obtaining a more complete understanding of GHG emissions throughout the entire supply chain, the analysis was conducted based on the sum total of Scope 1, 2, and 3 emissions, though it should be stated that including Scope 3 emissions in the analysis of the portfolio's carbon footprint raises the possibility of duplicate GHG emissions (e.g., Scope 1 emissions of one company are included in Scope 3 emissions of another company).

Variations in GHG emissions by sector

By expanding the calculation scope to include indirect emissions from the consumption and use of sold products and services (Scope 3 downstream), the emissions features by sectors are different from the last year's analysis. Looking at GPIF's equity portfolio emissions by sector and scope, Scope 3 downstream accounts for 50% or more of total emissions for 7 of the 11 sectors. This means that analysis result interpretations vary greatly depending on whether Scope 3 downstream emissions are considered (Figure 1-7). The same trend can be seen in the bond portfolio. Both the equity and bond portfolios have a high ratio of Scope 3 downstream emissions in the Industrials, Energy, and Consumer Discretionary sectors. In the Industrials sector, which includes industrial and construction machinery, and the Consumer Discretionary Sector, which includes automobiles and home appliances, the GHGs emitted when products and services are consumed are greater than those emitted in the manufacturing process. This trend is even more evident in the Energy sector: Scope 1 and 2 emissions for oil, coal and gas, such as drilling and refining, are relatively small, whereas GHG emissions from the consumption of these products and services account for more than 80% of the total emissions. For portfolios with a higher weight of Industrials, Energy, and Consumer Discretionary sectors in particular, the results of the analysis change dramatically depending on whether Scope 3 is included in the calculation.

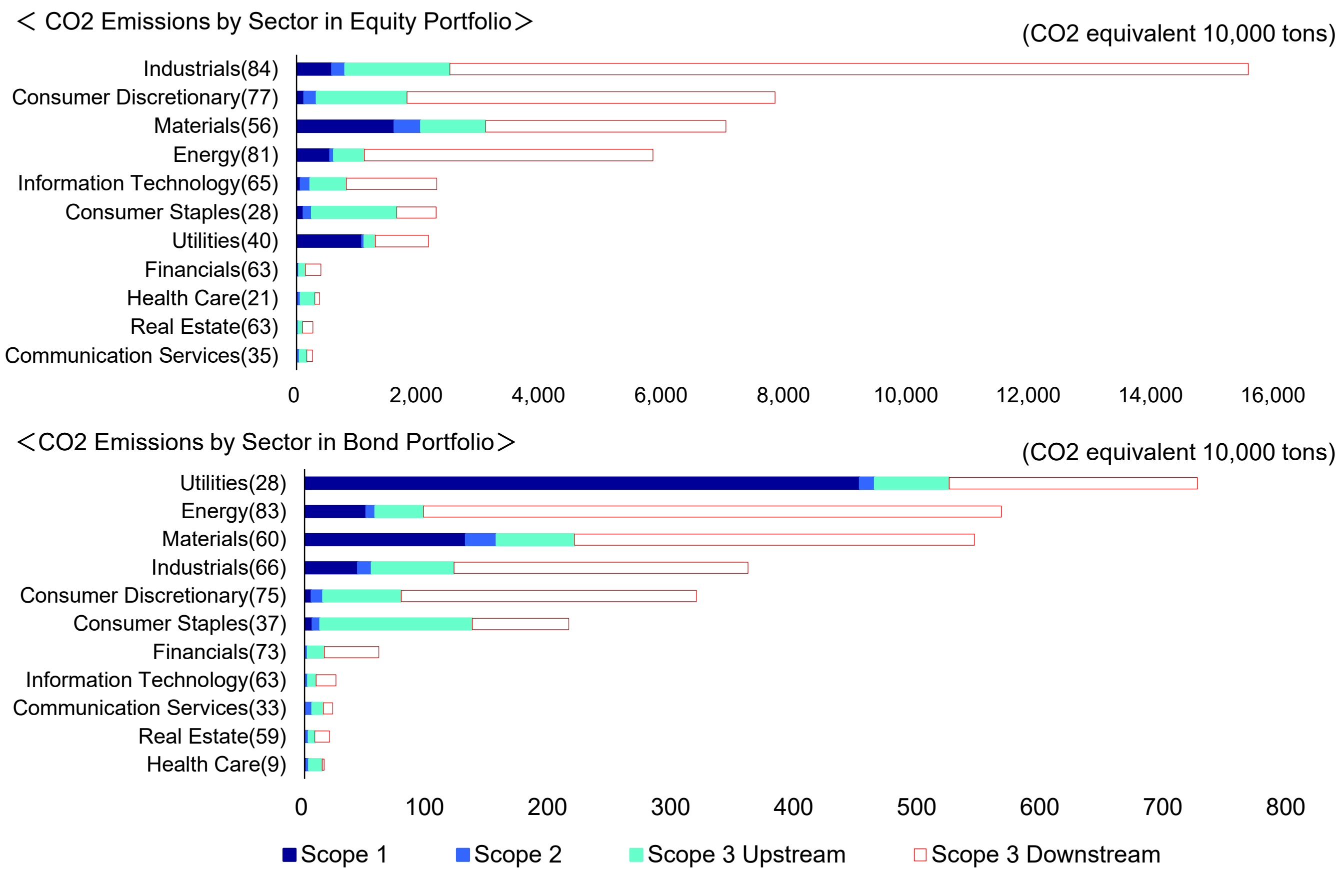
[7]Please refer to P.30 for details on Scope 3 data calculation.

Figure 1-6 Greenhouse Gas Emissions by Scope



Note: The above figure indicates the major activities included in each scope.
Source: Created by GPIF based on the Greenhouse Gas Protocol

Figure 1-7 CO2 Emissions by Sector in Equity and Bond Portfolios



Note: Numbers in brackets are ratio of Scope 3 Downstream emissions to the total emissions
Source: S&P Trucost Limited©Trucost 2021

Carbon Footprint (GHG Emissions) Analysis

Carbon Footprint (GHG Emissions)

This analysis measures the carbon footprint[8] of GPIF's equity and corporate bond portfolios for Scopes 1 through 3, based on the characteristics of Scope 3 downstream emissions. Looking at total emissions by asset class, domestic equities were found to have the highest level of emissions, followed by foreign equities, foreign corporate bonds, and domestic corporate bonds (Figure 1-8). This result is roughly the same as last year's, but does not necessarily mean that domestic companies have more or less carbon emissions than foreign companies. Rather, it reflects the relative size and sector holding of each asset class within GPIF's portfolio.

The breakdown of the portfolio's carbon footprint shows that the combined emissions of Scopes 3 Upstream and Downstream for assets excluding domestic bonds account for about 80% of the total emissions, and about 65% for domestic bonds. As such, calculating emissions across the entire supply chain and enhancing the transparency of these emissions and the potential for reducing them is crucial for companies to take efficient emission reduction measures.

Figure 1-9 shows long-term greenhouse gas emission trends for Scopes 1, 2, and 3, using 100 for fiscal 2017 emissions as a base. The results indicated for Domestic Equities, Foreign Equities and Domestic Bonds, fiscal 2020 saw large reduction of emissions in the four years since fiscal 2017. This may be attributable to the impact of changes in the companies held in GPIF's portfolio and invested amounts, as well as the methodology change in calculating apportioned carbon emissions[9] and COVID-19 etc. Emissions related to foreign bonds increased significantly between fiscal 2018 and 2019. This is likely due to the decrease in the weight of domestic corporate bonds in the portfolio and corresponding increase in the weight of foreign corporate bonds in fiscal 2019. In fiscal 2020, emissions related to foreign corporate bonds also fell greatly.

In addition to analyzing the Scope 1, 2 and 3 emissions, we also calculated the data for Scope 1 and 2 only, and confirmed the differences in the trends of carbon footprints (Figure 1-10). The carbon footprint of domestic equities and domestic bonds decreased more in Scope 1 and 2 than in Scope 1, 2 and 3 combined compared with fiscal 2017.

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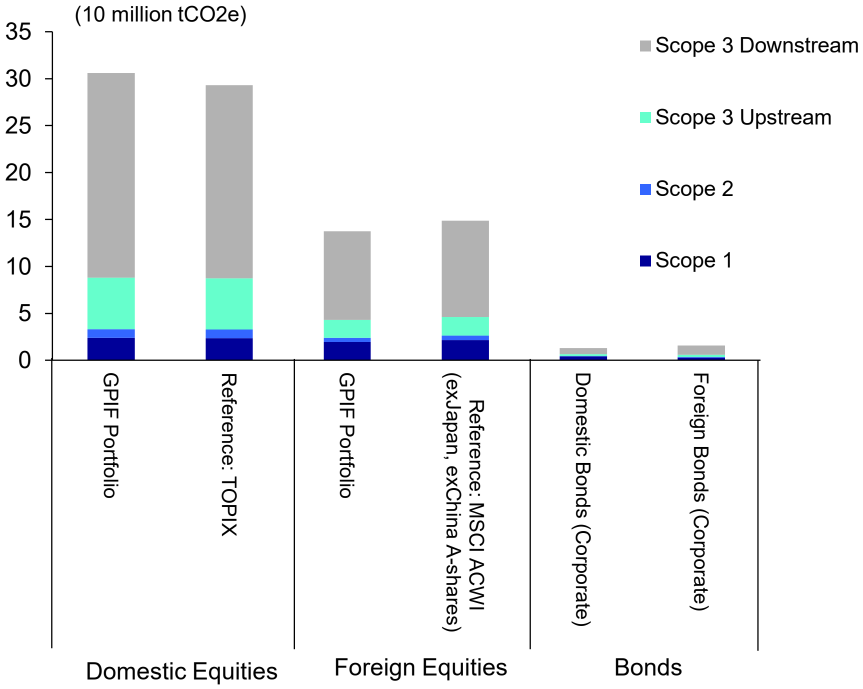
[8] The carbon footprint is apportioned based on the percentage of the equity and bond holdings. The apportion is calculated using the Enterprise Value Including Cash (EVIC) as the denominator at the time of analysis. That is, if an investor owns 1% of a company's equity or bonds, then they also "own" 1% of the company's GHG emissions. We also use Trucost's Environmentally Extended Input-Output (EEIO) model to reduce the double-counting of emissions.

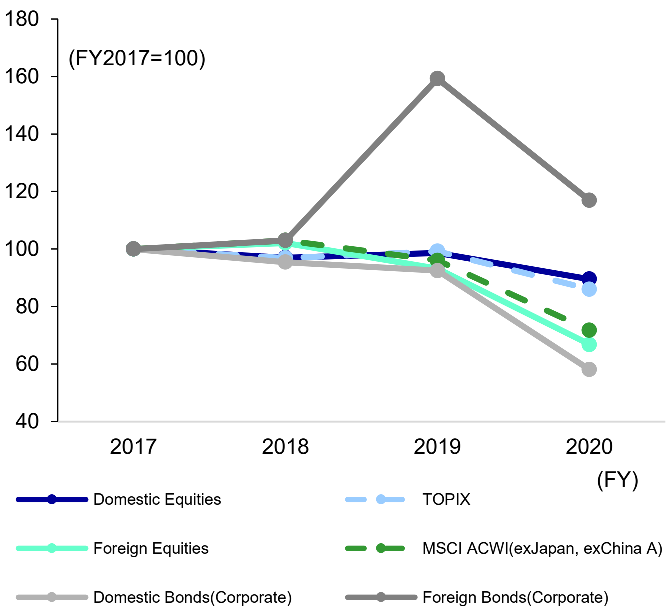
[9] Change in methodology is based on the latest guidance from the Partnership for Carbon Accounting Financials (PCAF). In contrast to the previous years when apportioned carbon footprint was calculated using the Enterprise Value (EV) as denominator, this year Enterprise Value including Cash EVIC) is applied.

Figure 1-8 Carbon Footprint by Scope



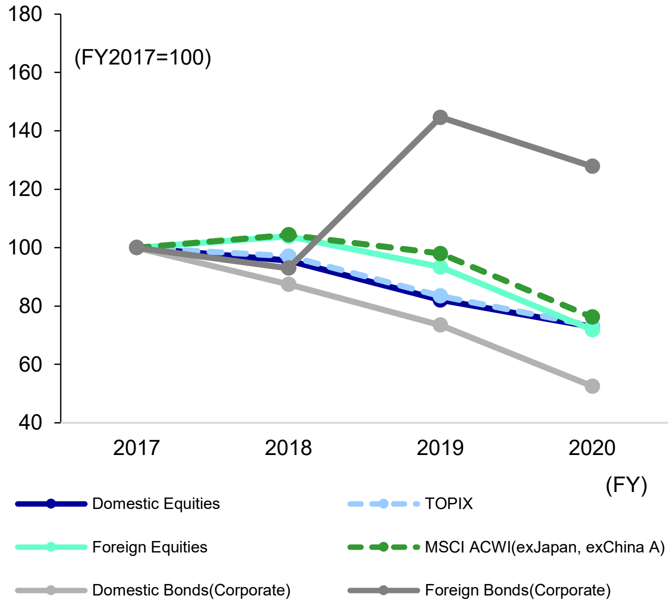
Source: S&P Trucost Limited©Trucost2021

Figure 1-9 Greenhouse Gas Emission Trends (Scope 1+2+3)



Source: S&P Trucost Limited©Trucost2021

Figure 1-10 Greenhouse Gas Emission Trends (Scope 1+2)



Source: S&P Trucost Limited©Trucost2021

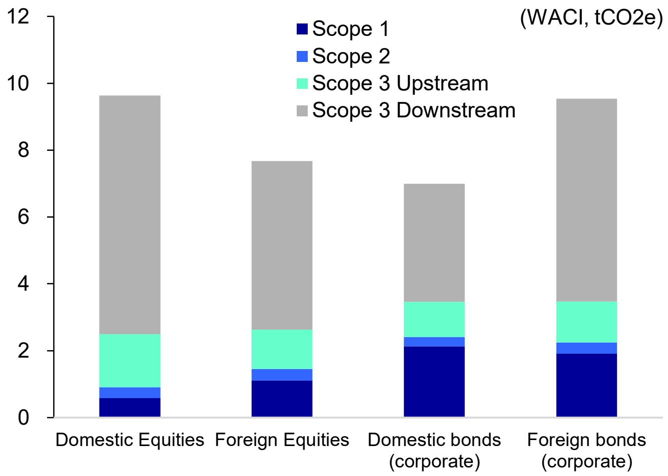
Carbon Intensity Analysis

Carbon intensity by asset

Carbon intensity can be calculated in a variety of ways; for this analysis we adopted the weighted average carbon intensity (WACI) approach for equities and bonds, in line with the Task Force on Climate-related Financial Disclosure (TCFD) recommendations. WACI is calculated by multiplying each company's carbon emissions to revenue (tCO_2e/ million yen) by the weight of that company in the portfolio, then taking the sum of those products to get the weighted average of carbon intensity.

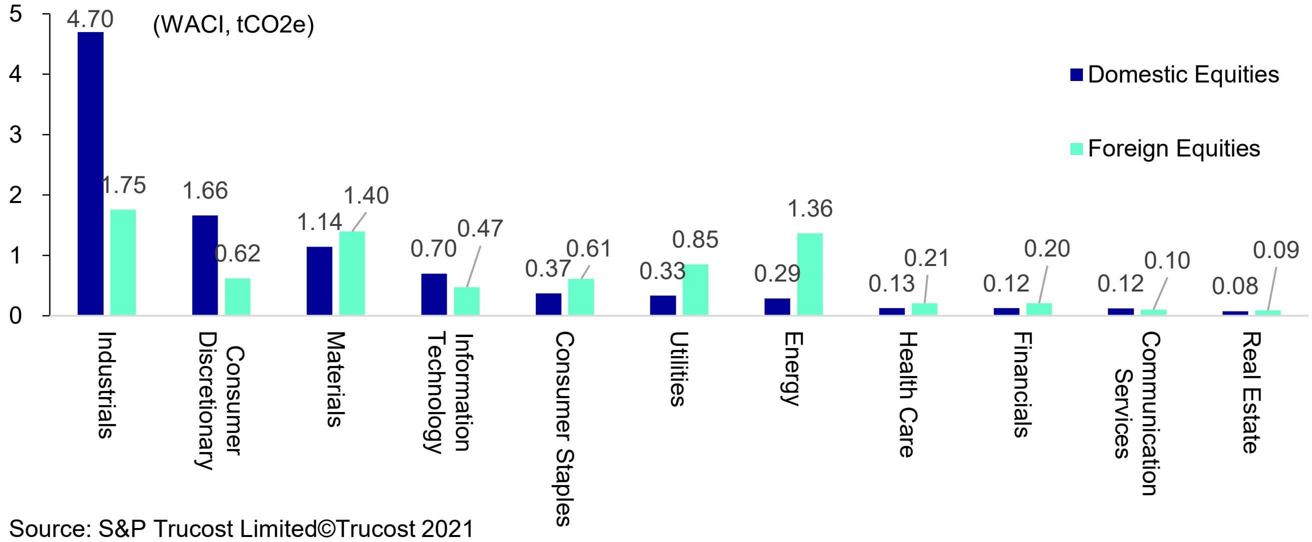
Out of GPIF's equity and corporate bond portfolios, the WACI was particularly high for domestic equities and foreign bonds (Figure 1-11). For the former, Scope 3 downstream emissions accounted for around 74% of WACI, largely due to relatively high allocations to Industrials, Consumer Discretionary and Materials – all sectors with high indirect emissions (Figure 1-12). Foreign corporate bonds, on the other hand, in addition to having higher allocations to several carbon intensive sectors than domestic corporate bonds, also had a higher level of investment in the Financials sector, which has a low carbon intensity.

Figure 1-11 Weighted Average Carbon Intensity (WACI) for Equities and Corporate Bonds



Source: S&P Trucost Limited© Trucost 2021

Figure 1-12 Breakdown of WACI by Sector for Domestic and Foreign Equities



Source: S&P Trucost Limited©Trucost 2021

Performance and Attribution Analysis of Changes in Carbon Footprint

Performance drivers of portfolio footprint changes

This section highlights potential drivers of change for both the carbon footprint and carbon intensity in GPIF's portfolios, covering Scope 1, 2 and 3. There are two main factors that drive changes in the carbon footprint of a portfolio: changes in the quantity of GHG emitted by investees and changes in the proportion of investees owned or financed by the investor.

The results of the carbon footprint performance analysis are shown in Figure 1-13. The analysis breaks down the causes of the carbon footprint change between fiscal 2019 and fiscal 2020 into (1) changes in the quantity of GHG emissions of investees (absolute emissions) only; (2) changes in the proportion of each investee owned or financed by the investor (ownership) only; and (3) the interaction of changes in both absolute emissions and ownership together. The total carbon footprint for the overall portfolio decreased by 17.3% year on year, and the most significant cause of this is attributed to ownership changes. GHG emissions of the companies that make up the portfolio are allocated according to the percentage of shares or bonds held by the investor (ownership ratio). In other words, an investor who owns 1% of a company's equity or bonds is considered to own 1% of the GHG emissions of that company. Until last year, the calculation of percentage of the shares were based on Enterprise Value (EV). However, this year, the calculation method has been changed to use Enterprise Value Including Cash (EVIC) as the denominator for listed companies[10]. Therefore, in contrast to the previous years when EV was the denominator, applying EVIC as the denominator, the number increases, the ownership ratio will naturally decrease. As a result, carbon footprint of the GPIF portfolio may have decreased.

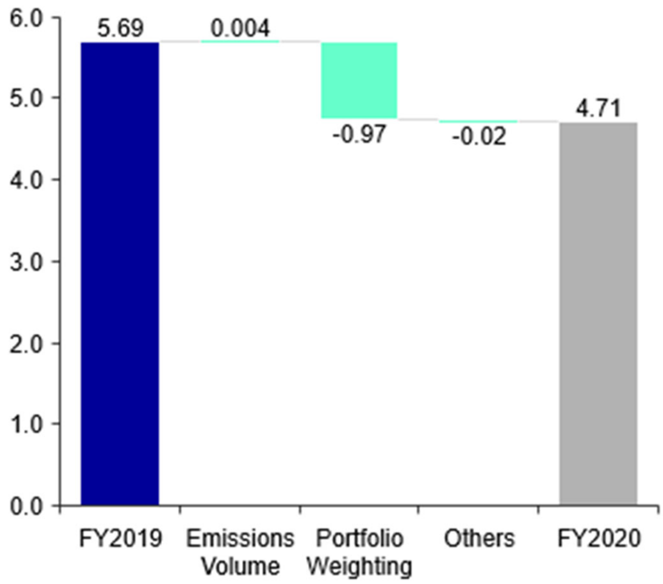
Finally, we analyzed the changes in carbon intensity across the equity and corporate bond portfolio as a whole from 2019-2020 and what the primary drivers of those changes were (Figure 1-14). The performance drivers for change were broken down into four categories for analysis: (1) corporate profits; (2) companies' emissions volumes; (3) weight of each company in the portfolio; and (4) other factors. The carbon intensity of GPIF's equity and corporate bond portfolio increased by 7.9% in the space of a year. The largest contribution was from the change in the weight of each company in the portfolio.The change in the methodology for calculating the percentage of holdings described above will also affect the apportioning of corporate revenues used to calculate carbon intensity. Therefore, the increase in carbon intensity may be due to factors such as the change from EV to EVIC and the shift to a new basic portfolio from fiscal 2020 that reduced the weight of domestic bonds, which tends

[10] Change in methodology is based on the latest guidance from Partnership for Carbon Accounting Financials (PCAF).

to have a low carbon intensity, and increased the weight of foreign bonds, which tends to have a high carbon intensity.

Figure 1-13 Breakdown of Carbon Footprint Performance Drivers for the Total Aggregate Portfolio

(100 million tCO2e)

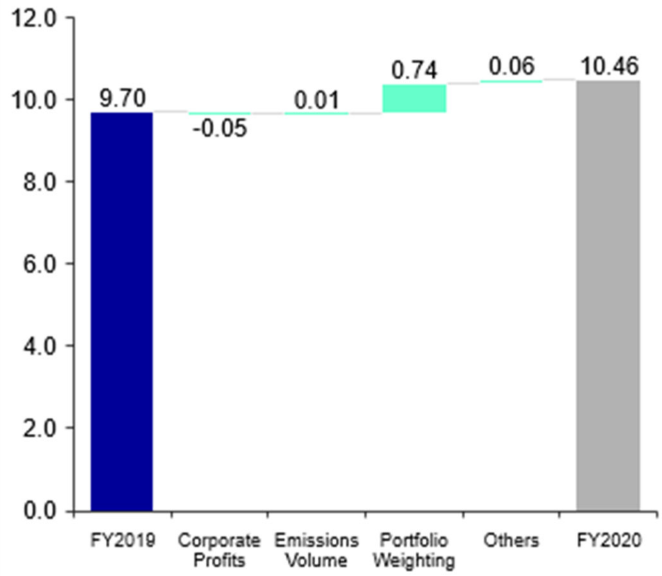


Note: “Other” represents the cross term of “Corporate Profits, “Emissions Volume” and “Portfolio Weighting.”

Source: S&P Trucost Limited©Trucost2021

Figure 1-14 Breakdown of Carbon Intensity Performance Drivers for the Total Aggregate Portfolio

(tCO2e/m JPY)

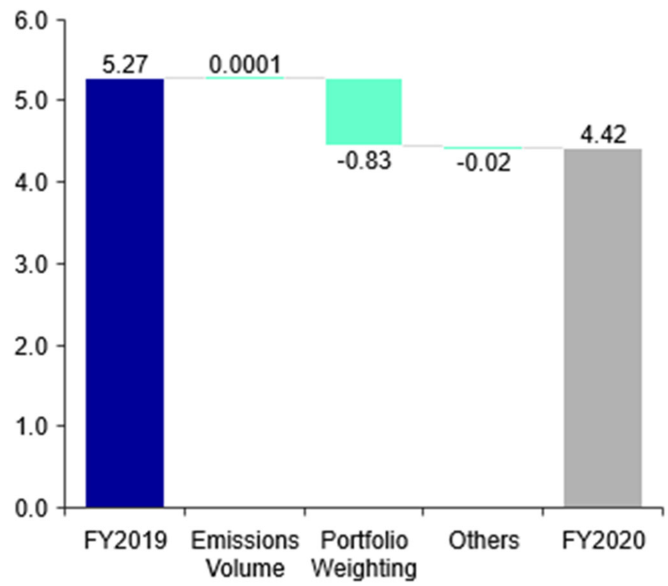


Note: “Other” represents the cross term of “Corporate Profits,” “Emissions Volume” and “Portfolio Weighting.”

Source: S&P Trucost Limited©Trucost2021

Figure 1-15 Breakdown of Carbon Footprint Performance for Equities

(100 million tCO2e)

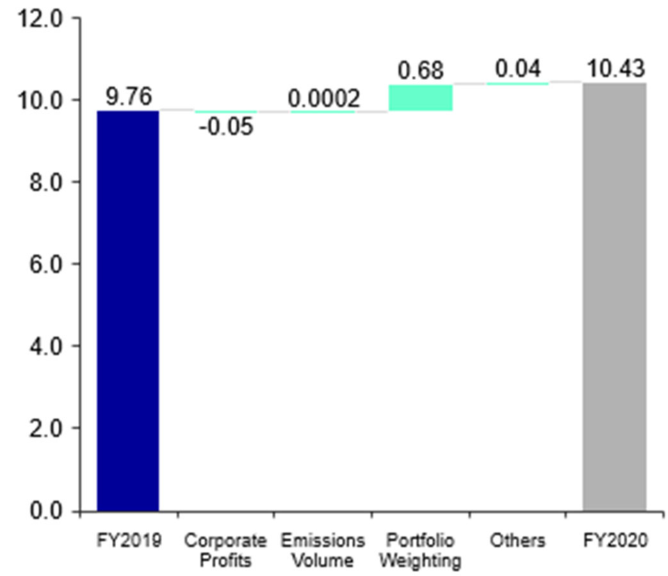


Note: "Other" represents the cross term of "Corporate Profits," "Emissions Volume" and "Portfolio Weighting."

Source: S&P Trucost Limited©Trucost2021

Figure 1-16 Breakdown of Carbon Intensity Performance Drivers for the Equities

(tCO2e/m JPY)

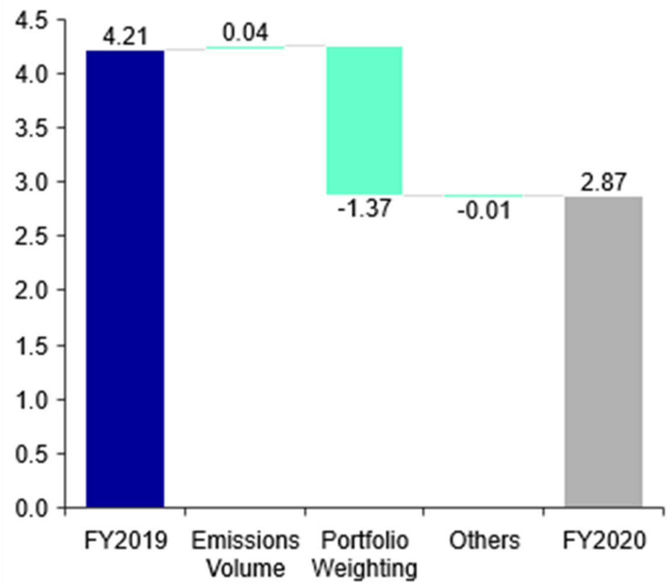


Note: "Other" represents the cross term of "Corporate Profits," "Emissions Volume" and "Portfolio Weighting."

Source: S&P Trucost Limited©Trucost2021

Figure 1-17 Breakdown of Carbon Footprint Performance for Corporate Bonds

(10 million tCO2e)

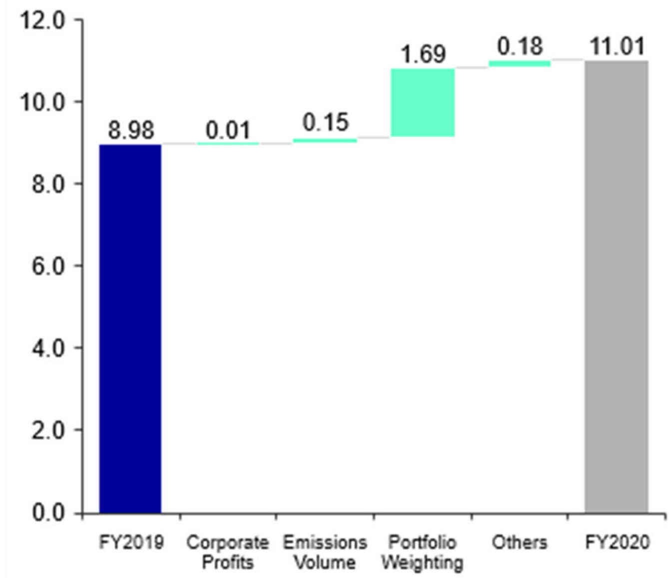


Note: "Other" represents the cross term of "Corporate Profits," "Emissions Volume" and "Portfolio Weighting."

Source: S&P Trucost Limited©Trucost2021

Figure 1-18 Breakdown of Carbon Intensity Performance Drivers for Corporate Bonds

(tCO2e/m JPY)



Note: "Other" represents the cross term of "Corporate Profits," "Emissions Volume" and "Portfolio Weighting."

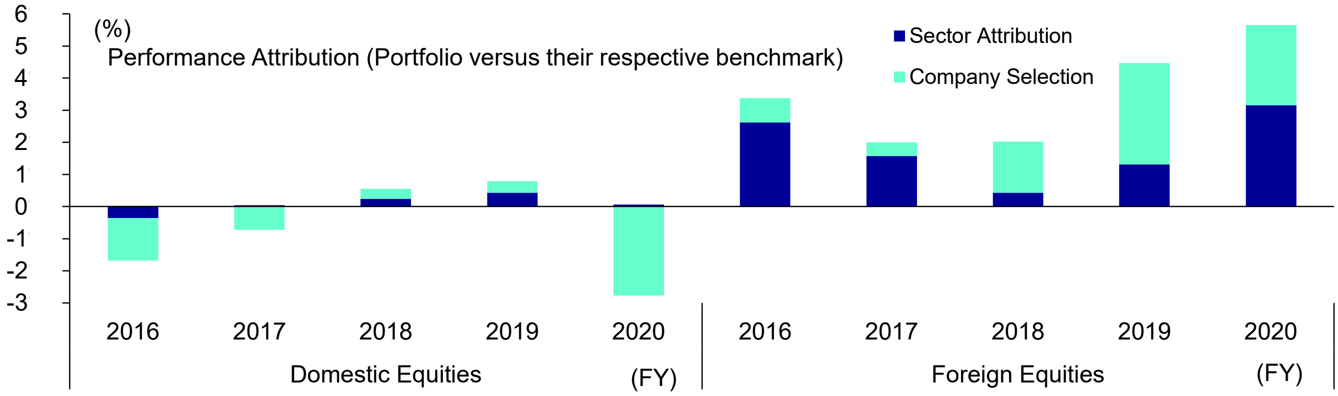
Source: S&P Trucost Limited©Trucost2021

Difference in carbon intensity[11] from benchmark

The factors that cause the carbon intensity to differ from the benchmark's carbon intensity can be broken down into two main areas: (1) sector allocation and (2) company selection. If sectors with high emissions are overweight in comparison to the benchmark, the overall carbon intensity of the portfolio also has the possibility to be higher than the benchmark. However, selecting companies with the highest levels of carbon efficiency (low carbon intensity) among the high emitting sectors may result in a lower carbon intensity for the entire portfolio compared to the benchmark.
Figure 1-19 shows the effect of sector allocation (industry effect) and company selection on the benchmark for each portfolio (individual company effect).

In fiscal 2020, the domestic equity portfolio has higher carbon intensity compared to its benchmark, while the foreign equity portfolio has lower carbon intensity. In the domestic equity portfolio, the effect of company selection in the high-emitting Industrials sector had the greatest impact. Meanwhile, for the foreign equity portfolio, both sector allocation and company selection positively contributed to the decrease in the carbon intensity.

Figure 1-19 Attribution Analysis of Domestic and Foreign Equities and their Respective Benchmarks



Note: Sector allocation effects are determined using the 11 GICS Sector classifications, and the analysis uses the Carbon-to-Revenue intensity metric. A positive value in the figure indicate a lower carbon intensity. In other words, the portfolio has a higher carbon efficiency.
Source: S&P Trucost Limited©Trucost 2021

[11] The scope used to calculate the carbon intensity is Direct Emissions+ First Tier Indirect Emissions. Trucost defines Direct Emissions as the sum of Scope 1 emissions from the GHG Protocol and other emissions from a wide range of GHGs associated with a company's business activities. First Tier Indirect Emissions are defined as the sum of the GHG Protocol's Scope 2 emissions and the emissions of the company's uppermost upstream supply chain (direct suppliers).

Corporate Disclosure of GHG Emissions

Disclosure rates based on the number of companies, the value of holdings, and the absolute GHG emissions

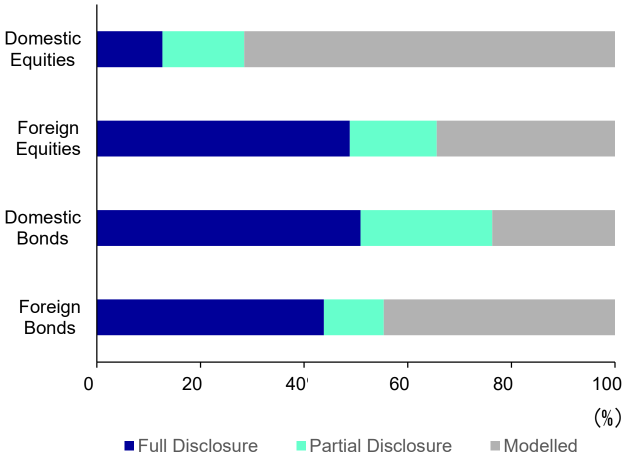
The following analysis examines the status of corporate disclosures of Scope 1 GHG emissions for each asset class held by the GPIF. For each asset class, the following ratios were reviewed: (1) disclosure ratio based on the number of companies (Figure 1-20); (2) disclosure ratio weighted by the value of the company's holdings (Figure 1-21); and (3) disclosure ratio weighted by the company's GHG emissions (Figure 1-22).

In fiscal 2020, the percentage of companies disclosing information on GHG emissions in terms of the number of companies was: domestic bonds (51%), foreign equities (49%), foreign bonds (44%), and domestic equities (13%). When partial disclosures are included, the numbers change: domestic bonds (76%), foreign equities (66%), foreign bonds (55%), and domestic equities (28%). The disclosure ratio for domestic equities, including partial disclosure, remained considerably lower than for other assets.

In fiscal 2020, the disclosure ratio weighted by the percentage of GPIF's value of holdings was: foreign equities (73%), domestic bonds (62%), foreign bonds (58%) and domestic equities (58%). When partial disclosures are included, the number roughly doubles: foreign equities (84%), domestic equities (83%), domestic bonds (82%), and foreign bonds (75%). The holdings weighted disclosure ratios are much higher than the ratio for the disclosure rates as a percentage of companies, because companies with larger market capitalizations are more likely to disclose information. The disclosure ratio by value of holdings for domestic equities is comparable to that of other assets.

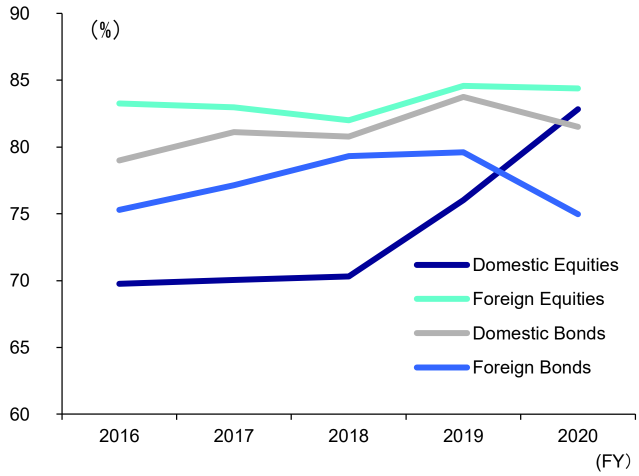
Analyzing the disclosure ratios weighted by corporate GHG emissions in fiscal 2020 resulted in the following ratios: domestic bonds (93%), foreign equities (80%), domestic equities (72%) and foreign bonds (62%). Once again, when including partial disclosure, the percentages increase: domestic bonds (98%), foreign equities (98%), foreign bonds (93%), and domestic equities (87%). The disclosure ratio calculated this way is generally higher than ratios using market capitalization, because companies with higher GHG emissions are more likely to disclose information.

Figure 1-20 Disclosure Rates Based on Number of Companies



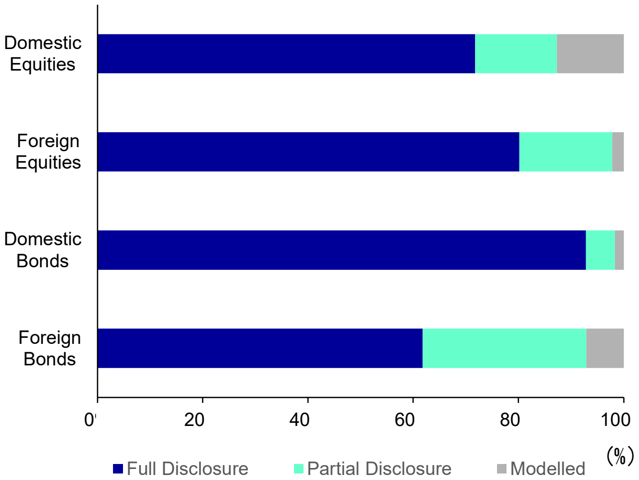
Note: Data is as of the end of March 2021.
Source: S&P Trucost Limited©Trucost 2021

Figure 1-21 Change in Value of Holdings-based Disclosure Rates from FY2016 to FY2020



Note: Includes "Partial Disclosure"
Source: S&P Trucost Limited©Trucost 2021

Figure 1-22 Disclosure Rates Based on Absolute GHG Emissions



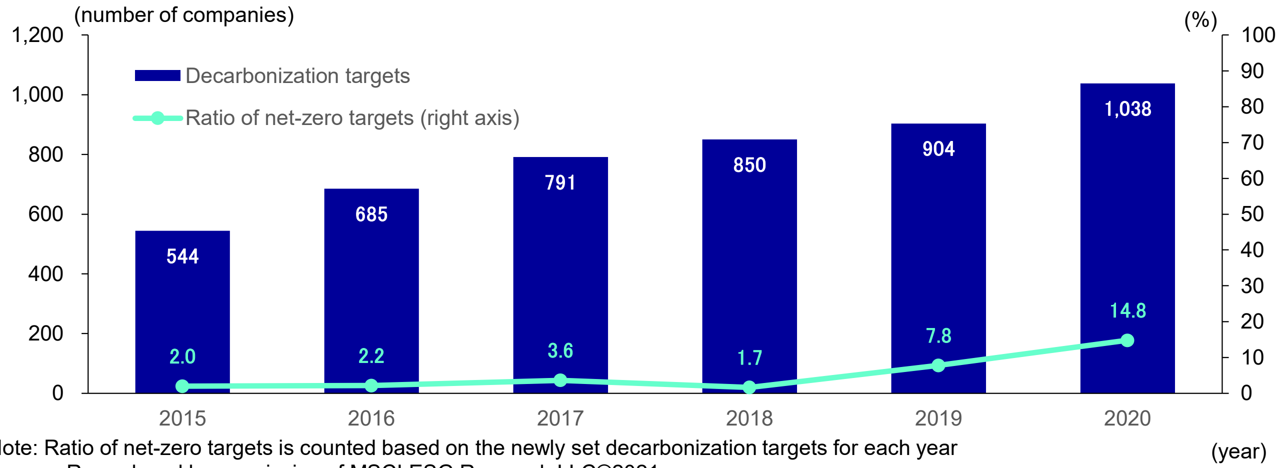
Note: Data is as of the end of March 2021.
Source: S&P Trucost Limited©Trucost 2021

Analysis of Corporate GHG Emissions Reduction Targets

Setting of Corporate Greenhouse Gas Reduction Targets

This section examines corporate GHG emissions reduction target-setting and the progress companies have made in achieving the targets. Figure 1-23 shows that the number of constituents in the MSCI ACWI index that set GHG emissions reduction targets increased from the year 2015 onward. As of the end of 2020, 34.8% of the 2,982 constituents in the MSCI ACWI index set some type of emissions reduction target. Further, an increasing number of companies set long-term targets to bring their GHG emissions to net-zero (net-zero target) over the long term, which amounted to 14.8% of newly set targets in 2020.

Figure 1-23 Number of Companies that Set Emissions Reduction Targets and Ratio of Net-Zero Targets to Reduction Targets Among the MSCI ACWI Index Constituents



Note: Ratio of net-zero targets is counted based on the newly set decarbonization targets for each year

Source: Reproduced by permission of MSCI ESG Research LLC©2021

Analysis of GHG Emissions Reduction Targets for Domestic Equities

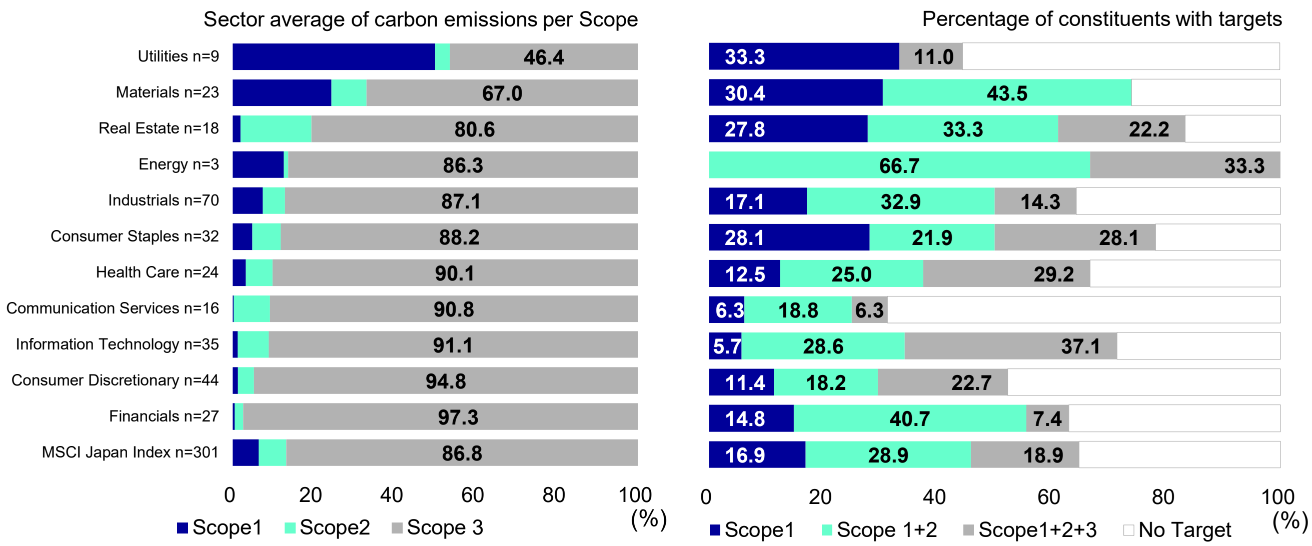
Looking at domestic companies in the MSCI Japan index, 64.7% set some type of emissions reduction target as of the end of March 2021 (Figure 1-24, on the right-hand side). The ratio of Japanese companies setting targets was higher than that of foreign companies in the MSCI Kokusai index[12] (52.3%, Figure 1-26, right-hand side). Some companies set targets to reduce Scope 1 emissions only, while others set emissions reduction targets that cover Scope 2 and Scope 3. Target-setting also differed by sector. Using the Global Industry Classification Standard (GICS®) sector classifications, the ratio of Japanese companies setting targets was higher in the energy, real estate and consumer staples sectors than the communication services and utilities sectors (Figure 1-24).

MSCI also assessed the progress companies in the MSCI Japan index made in achieving their

[12] A representative equity index that indicates equity price trends in developed countries excluding Japan.

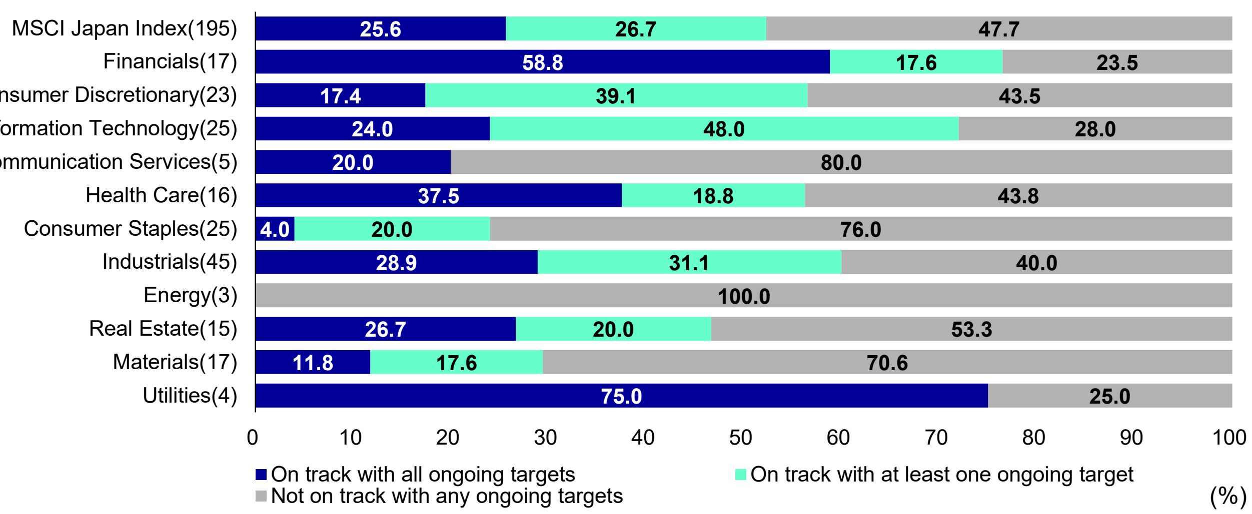
emissions reduction targets based on the track record of their emissions performance (Figure 1-25). Such assessments showed that 25.6% of companies made progress in lowering emissions on track with meeting all their targets and 26.7% were on track with at least one of their targets. On the other hand, 47.7% of companies were not on track to meet any targets and may be challenged to achieve them going forward. While many companies actively set emissions reduction targets, actually achieving them will likely require many to make further efforts to lower emissions.

Figure 1-24 Carbon Emissions by Sector and Targets Among MSCI Japan Constituents



Note: Since emissions are not consistently reported by the issuers, we used either reported or estimated baseline and present emissions for this analysis
Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 1-25 Feasibility of Reduction Targets by Sector Among MSCI Japan Constituents



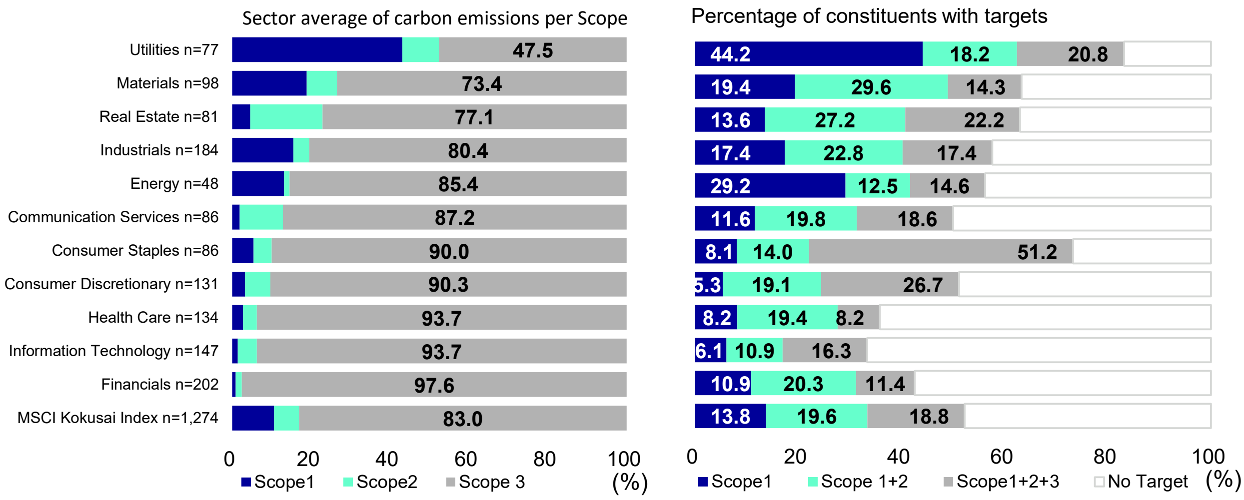
Note: Numbers in ( ) after sector name means number of issuers with targets
Source: Reproduced by permission of MSCI ESG Research LLC©2021

Analysis of GHG Reduction Targets for Foreign Equities

Among the constituents of the MSCI Kokusai index, as of the end of March 2021, 52.3% have set some type of emissions reduction target (Figure 1-26, on the right-hand side). The ratio of foreign companies setting targets was higher in sectors such as utilities, consumer staples, material and real estate, while sectors including information technology and healthcare had relatively low ratios.

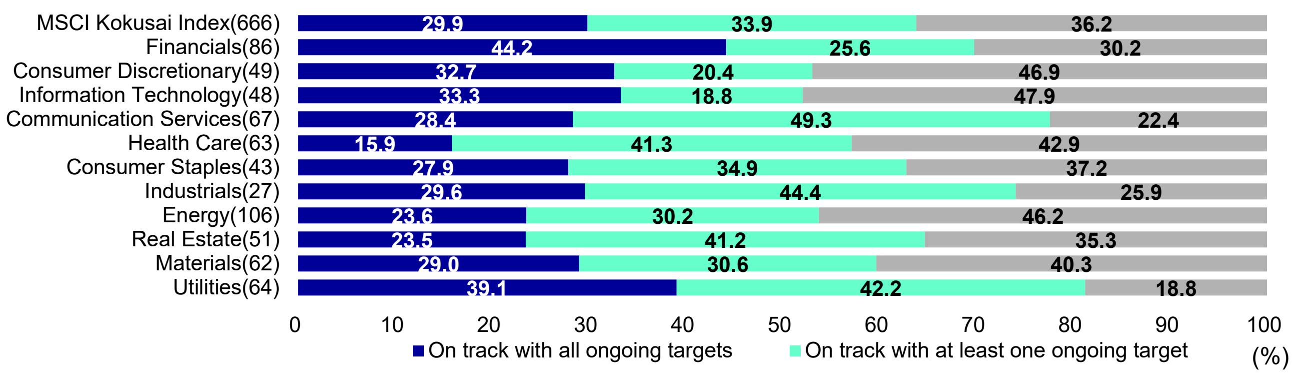
According to MSCI's evaluation, 29.9% of companies that have set targets were expected to achieve all of them, while 33.9% were expected to achieve at least one. On the other hand, 36.2% (Figure 1-27) of companies were unlikely to achieve any target. Although the ratio of companies setting reduction targets was lower than that of domestic equities, the ratio of companies that were expected to achieve their targets was higher than that of domestic equities.

Figure 1-26 Progress in Establishing Sector-Specific Carbon Emissions and Reductions Targets Among MSCI Kokusai constituents



Note: Since emissions are not consistently reported by the issuers, we used either reported or estimated baseline and present emissions for this analysis
Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 1-27 Feasibility of Sector-Specific Reductions Targets for MSCI Kokusai Constituents



Note: Numbers in ( ) after sector name means number of issuers with targets
Source: Reproduced by permission of MSCI ESG Research LLC©2021

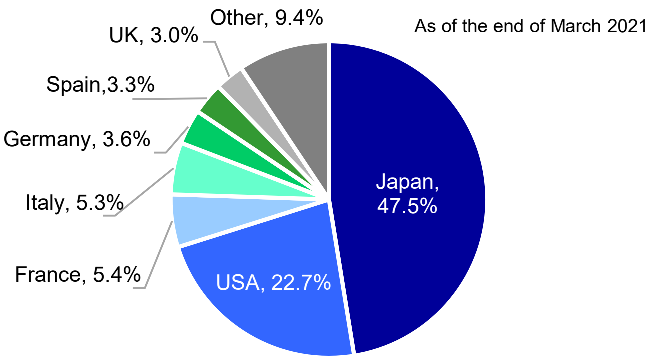
Features of GPIF's Government Bond Portfolio

Analysis of GPIF Government Bond Portfolio

The carbon footprint and other analyses covered so far have examined the equities and corporate bonds issued by companies in which GPIF invests. This section, meanwhile, analyzes sovereign bonds issued by national governments. Considering how the many risks related to climate change will affect government bond prices is an extremely complex problem. These risks, however, undeniably have the potential to affect GPIF's portfolio considering the fiscal burden and other impacts from the response to climate change-related transition and physical risks. There are basically two ways of analyzing climate change risk for government bonds: one is to consider only greenhouse gas emissions produced by the government sector of the nation issuing the bond, while the other takes into account the entire sphere of influence of the nation as a whole, including greenhouse gas emissions generated by the activities of that country's corporations and individuals. The analysis conducted for this report adopts the latter approach.

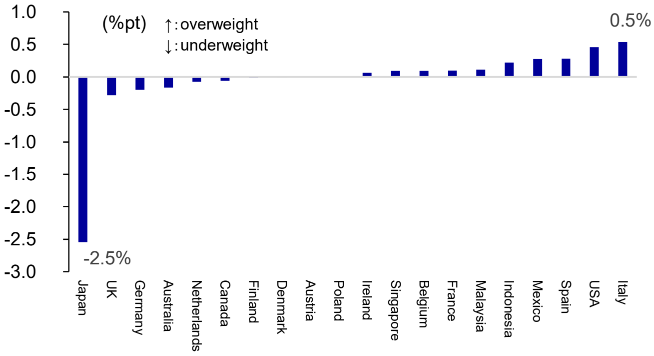
In the analysis of government bonds, just as when analyzing equities and corporate bonds, it is important to understand that results are greatly influenced by factors such as which specific sovereign bonds make up the portfolio. The overall GPIF portfolio of foreign and domestic government bonds (hereinafter, "GPIF's overall government bond portfolio") is made up of about half foreign and half domestic government bonds (Figure 1-28).Based on data as of the end of March 2021, comparing the country weights of the top 20 countries (by amount invested in GPIF's overall government bond portfolio) to a weighted average benchmark of foreign and Japanese government bonds, Japan, the U.K., Germany, and several other countries were underweighted. In contrast, Italy and the U.S., among other countries, were overweighted (Figure 1-29). However, the difference from the benchmark is relatively small in all cases.

Figure 1-28 Weight by Country in GPIF Government Bond Portfolio



Source: GPIF, S&P Trucost Limited©Trucost2021

Figure 1-29 Top 20 Exposure Countries' Portfolio Weights Compared to Benchmark (%pt)



Source: GPIF, S&P Trucost Limited©Trucost2021

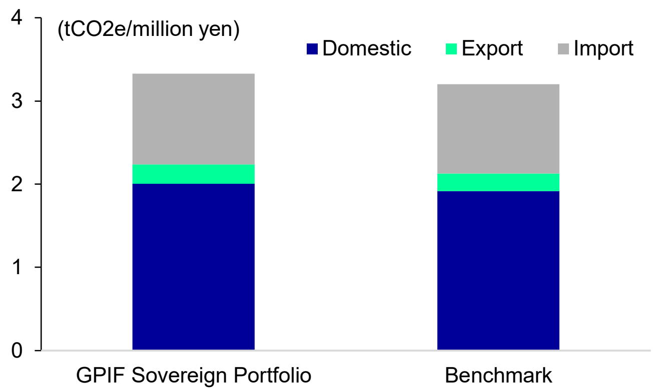
Carbon Intensity of the Government Bond Portfolio

Measuring Carbon Intensity

This section examines the carbon intensity[13] for government bond portfolios, calculated as the amount of GHG emissions divided by the Gross Domestic Product (GDP). While it is also possible to measure the carbon footprint by the absolute level of GHG emissions in an entire country, this measure does not factor in the size and population of each country, making it difficult to correctly understand the actual implications with a simple comparison. Therefore, we conducted an analysis of carbon intensity standardized by GDP.

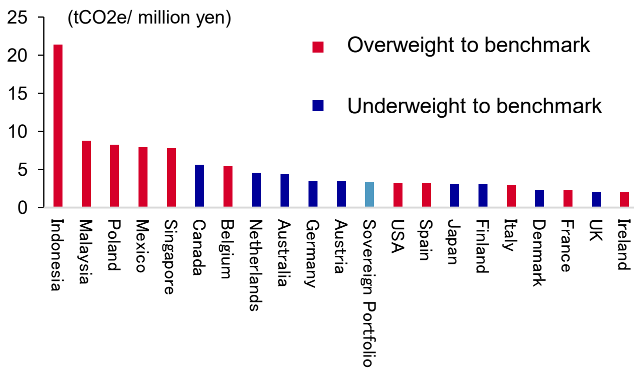
In measuring the carbon footprint of government bonds, the scope of GHG emissions is defined as domestic and import emissions related to intra-regional demand, plus export emissions associated with domestic production to meet overseas demand. To calculate the WACI, we use a weighted average of the country's GHG emissions per million yen of GDP, depending on the percentage of the portfolio held. Below, we show the carbon intensity of (1) the GPIF's entire government bond portfolio; (2) the benchmark, which is a composite of the benchmark of Japanese government bonds and foreign government bonds in proportion to the base portfolio; and (3) the top 20 countries in terms of the amount invested in the GPIF's government bond portfolio.In this analysis, the WACI for GPIF's overall government bond portfolio was found to be slightly higher than the aggregated benchmark (Figure 1-31). This was partly because the portfolio is overweight in bonds issued by countries where GHG emissions are relatively high, such as Indonesia, Malaysia, Poland, Mexico, Singapore and Belgium, indicating that the carbon intensity value of each country and the ratio of each country's holdings greatly affect the carbon intensity results of the portfolio.

Figure 1-30 Carbon Intensity of Sovereign Portfolio



Source: GPIF, S&P Trucost Limited©Trucost2021

Figure 1-31 Carbon Intensity by Country



Source: GPIF, S&P Trucost Limited©Trucost2021

[13] There are several approaches in calculating carbon intensity. The common approaches are (1) Weighted Average Carbon Intensity (WACI), (2) Carbon to Revenue Intensity (C/R) and (3) GHG emissions divided by GDP.

Exposure to Fossil Fuel Activities

Share of apportioned revenues derived from fossil fuel activities

In this section, Trucost data is used to assess the portfolio's exposure to fossil fuels. Figure 1-32 demonstrates the portfolio’s level of revenue dependency on fossil fuel-related activities by sector. As reflected in the chart, domestic bonds have the highest exposure to companies engaging in fossil fuel-related activities. This is due to the high exposure to the Utilities and Energy sectors within the domestic bond portfolio, where the share of total revenue coming from fossil-fuel activities totaled approximately 6.7% in fiscal 2020. Among the different types of fossil fuel activities investee companies engaged in, the portfolio has the highest exposure to natural gas power generation at 4.1%, followed by coal power generation at 1.9% and crude petroleum and natural gas extraction at 0.3%. Although higher than that of other asset classes, the fossil fuel-related income as a percentage of revenue in the portfolio companies of the domestic bond portfolio decreased by about 0.6 percentage points compared with the previous fiscal year.

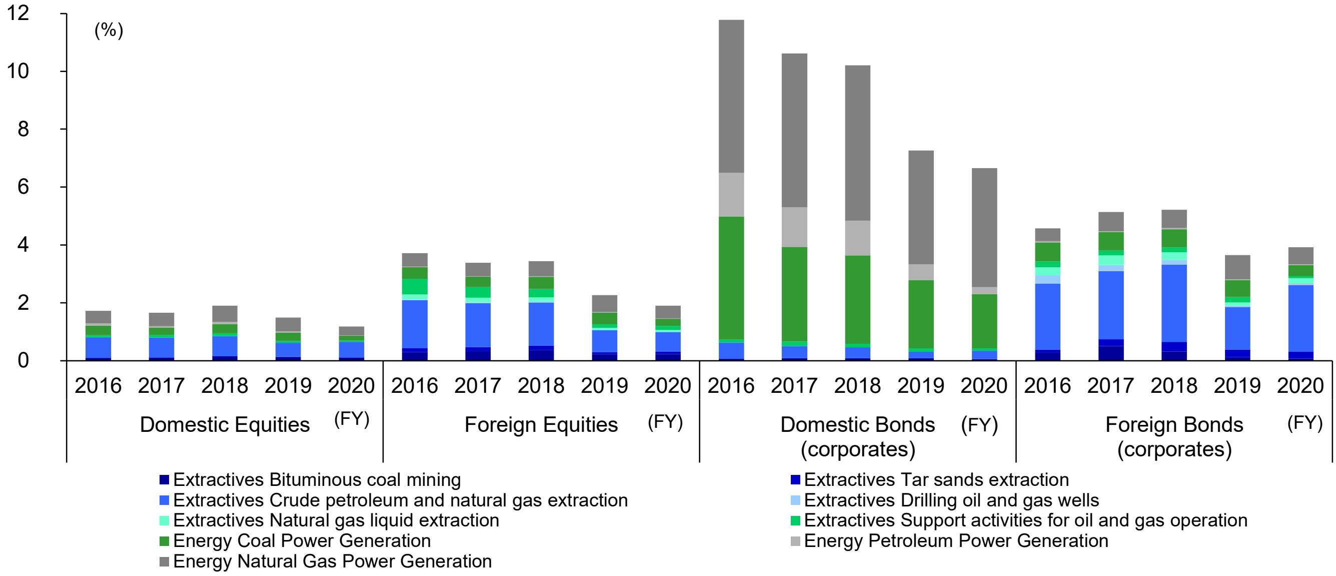
Risk of stranded assets

Potential future GHG emissions from fossil fuel reserves will far exceed the amount of GHG emissions allowed to achieve the international goal of limiting the increase of global warming to less than 2 degrees, as outlined in the Paris Agreement. Assets that may be subject to unexpected impairments, diminished asset values, or liabilities resulting from this transition toward a low-carbon society are called stranded assets. The risk of stranded assets in a portfolio company's fossil fuel-related assets is analyzed from a different perspective by using a measure of the capital expenditures[14] that have been made for future fossil fuel exploration and extraction projects. This indicator is based on the information disclosed by the investee.

Figure 1-33 shows the total amount of capital investment in fossil fuel-related businesses by fuel type. The largest fossil fuel-related capital investment was in the foreign equity portfolio. Capital investment in the fossil fuel-related businesses in GPIF’s foreign equity portfolio has been on a downward trend since fiscal 2018, with a noticeable decline in fiscal 2020 compared with fiscal 2019. This may be because the foreign equity portfolio has a higher exposure to companies engaged in fossil fuel-related businesses than other asset classes, and the fact that Japanese companies do not disclose much information related to their reserves.

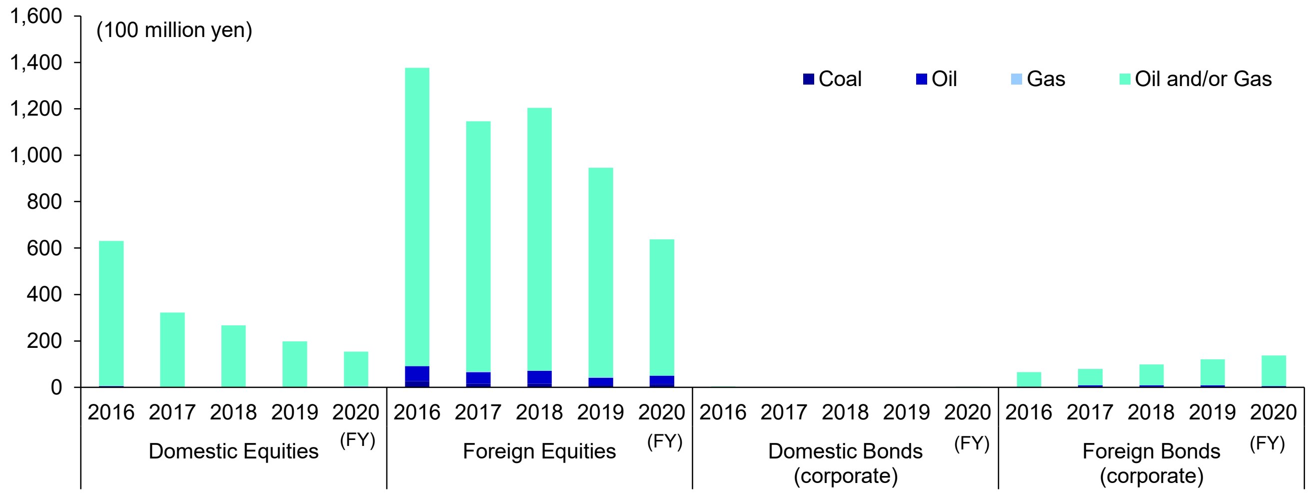
[14] Capital expenditures are expenditures for the purchase or renovation/upgrade of the physical assets of companies involved in coal, oil, and gas exploration: properties, plants, and equipment. Depreciation of physical assets is not considered.

Figure 1-32 Fossil Fuel Related Revenues as a Share of Total Apportioned Revenues



Source: S&P Trucost Limited© Trucost 2021

Figure 1-33 Apportioned Capital Expenditure on Fossil Fuel Related Activities



Note: Total apportioned capital expenditure on fossil fuel related activites, broken down by reserve type.
Source: S&P Trucost Limited© Trucost 2021

(Appendix) Coverage and Scope of Equities and Corporate Bonds Analysis

Coverage of Equities and Corporate Bonds

The analysis of the carbon footprint and carbon intensity of the GPIF portfolio is based on data from S&P Trucost as of the end of March 2021. For equities, the analysis is based on issuer companies included in the Trucost database and have adequate environmental and financial data for the most recent three years. The data coverage ratio was 99.8% for domestic equities and 98.7% for foreign equities on a portfolio weight basis (Figure 1-34).

For bonds, the analysis was conducted for the issuer of the relevant bond (or the listed parent company if the issuing company is unlisted) and the data coverage ratio was 95.7% for domestic bonds and 85.8% for foreign bonds, based on market capitalization.

Figure 1-34 Coverage Rate for GPIF's Portfolio Analysis

	VOH
Domestic Equities	99.8%
Foreign Equities	98.7%
Domestic Bonds (corporate)	95.7%
Foreign bonds (corporate)	85.8%

Source: S&P Trucost Limited©Trucost 2021

(Appendix) About Scope 3 Data Calculation

Scope 3 Upstream Data

Although the disclosure of information on GHG emissions directly caused by a company's business operations (Scope 1) and those caused by purchased electricity (Scope 2) is relatively advanced, only a limited number of companies aggregate and disclose Scope 3 upstream and downstream emissions. This section will explain how Scope 3 (upstream and downstream) emissions are aggregated in Trucost's carbon footprint and other analyses.

Scope 3 upstream emissions mainly refer to those emitted by procured products and services (excluding Scope 2 emissions) (Figure 1-35). Most of the Scope 3 upstream emissions are estimated based on Trucost's EEIO model. The model quantifies the economic transactions for over 450 sectors between (1) sectors that produce goods (outputs) and (2) industries that procure goods (inputs) produced by other sectors in the process of producing outputs. It calculates the amount of expenditure required by other sectors throughout the supply chain, from the procurement of raw materials to the company's business activities. This is then combined with information on the environment to arrive at an estimate of Scope 3 upstream for all transactions between industries in the supply chain. Taking the automotive industry as an example, the manufacture of a single car requires inputs from other industries such as energy, steel, and tire manufacturing. In addition, the energy, steel, and tire manufacturing industries also need inputs, and these goods are exchanged throughout the supply chain. Emissions are calculated by estimating the economic transactions required to manufacture a car across the entire supply chain and considering the environmental information on the expenditures between individual industries.

Scope 3 downstream data

Scope 3 downstream emissions include the processing, use, and disposal of products sold, as well as emissions from leased assets, franchises, and investments (Figure 1-35). Scope 3 downstream data is calculated by different approaches to Scope 3 upstream, and may use data disclosed by companies. In this case, emissions reported by companies in the Carbon Disclosure Project (CDP) climate change questionnaire may be used. However, to ensure quality, disclosed data is not necessarily used as is, and only data that has been verified by a third party and can be confirmed to have been accurately calculated in-house is accepted. To use the data disclosed by companies to the maximum extent possible, data gaps that are not included in the scope of aggregation are filled in using the top-down or bottom-up approach described below (Figure 1-36).

The top-down approach is used when (1) no Scope 3 data is reported at all; (2) no third-party certification of disclosed data is obtained; or (3) only partial data is disclosed. To calculate an estimate using the top-down approach, the verified data available from the CDP is attributed to each of the 158 industry subgroups for each of the Scope 3 categories.[15] This approach makes it possible to estimate emissions when all or part of the Scope 3 data is not disclosed, by using the factor calculated with the public CDP data.

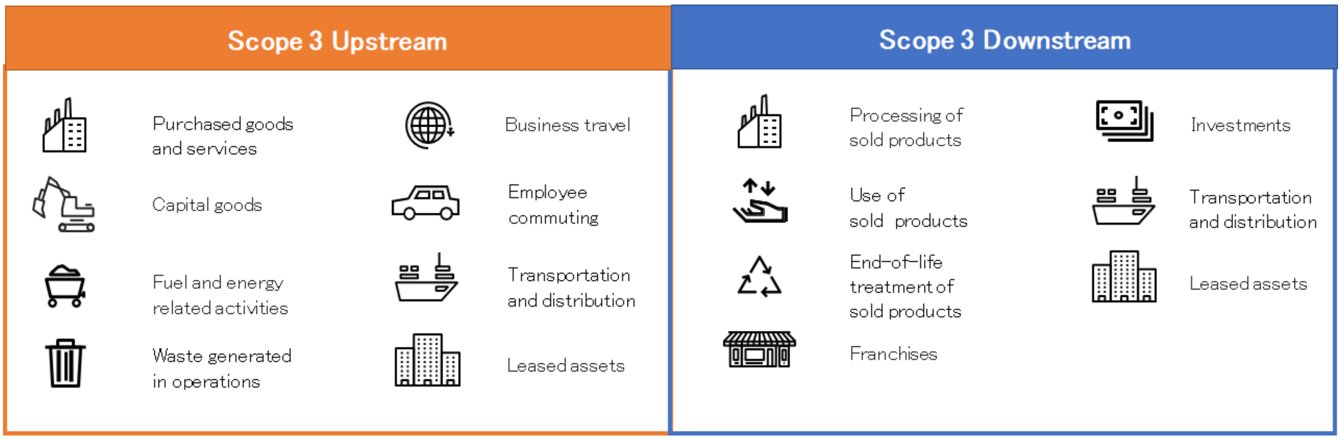
For major sectors, the bottom-up approach may be applied. For example, the annual CO_2 emissions of a car are calculated as the product of the emission intensity of all vehicles sold by the manufacturer (gCO_2/km), the number of vehicles sold, and the total distance driven (km/service life). Note that if a company discloses downstream emissions related to Use of Products Sold, Trucost will use the higher of the disclosed data and estimates. This is to avoid underestimating the risk of Scope 3 downstream emissions.

Limitations in the quantification of Scope 3 emissions

As previously mentioned, one of the biggest challenges in quantifying a company's Scope 3 emissions is the lack of disclosed information. The Trucost approach makes the most of available data and calculates estimates based on disclosed information, but this approach has its limitations. For example, in the top-down approach, estimates are determined by the companies that report Scope 3 data, so if the disclosed companies have low emissions, the emission factors used in the top-down approach may be biased. This reporting bias is inevitable because companies with low Scope 3 emissions have more incentive to disclose their figures than companies with high Scope 3 emissions. Improved modeling of Scope three emissions will require Scope 3 disclosure from more companies.

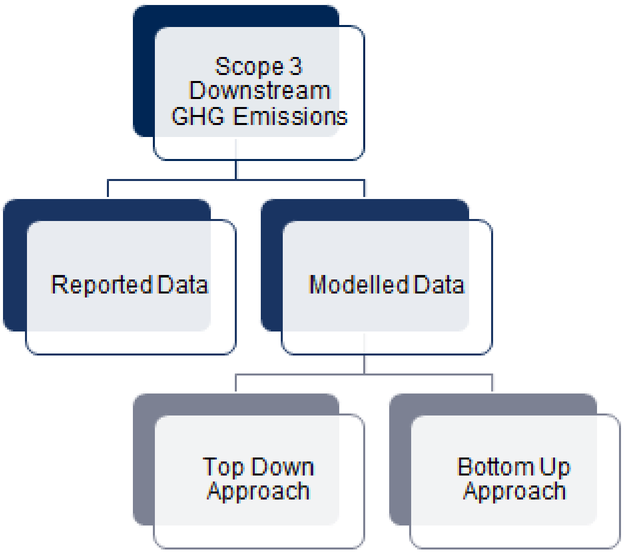
[15] Scope 3 consists of categories 1-15; 1-8 are classified as upstream of Scope 3, and 9-15 are classified as downstream of Scope 3.

Figure 1-35 Activities in Scope 3 Upstream and Downstream



Source: S&P Trucost Limited©Trucost 2021

Figure 1-36 Quantifying Scope 3 Downstream Emissions



Source: S&P Trucost Limited©Trucost 2021

Chapter 2: Scenario Analysis on Risks and Opportunities

Enhancement of Climate Value-at-Risk (CVaR) Analytical Methodology

Impact of Enhancement of CVaR Analytical Models

Following on from last fiscal year, GPIF analyzed the impact of climate-change risks/opportunities on GPIF's portfolios using CVaR[16]. CVaR is a model for measuring the impact of climate change risks and opportunities on enterprise value (EV) and security values. It consists of two components: "transition risks," which is a combination of "policy risks" that measure the impact of regulations on greenhouse gas emissions, and "technology opportunities" that measure profit opportunities from technologies that become more advantageous as regulations are tightened; and "physical risks," which identify the impact of natural environment changes and disasters associated with climate change.

This fiscal year's analysis model has been significantly revamped since last year. Here, we examine the main changes and the resulting impact on the analysis results.

Major changes include:

1. Expansion of the scope of analysis to Scope 3 in analyzing policy risk CVaR
2. Addition of "fluvial flooding" to the analysis of physical risk CVaR.
3. Change in methodology to weight sector-level profit margins by revenue instead of market capitalization

To understand the impact of this analytical method enhancement, we examined how CVaR changes for GPIF's portfolios (aggregate of equities and corporate bonds) using the new and old models (Figure 2-1 (a) and (b)). By applying the new and old models to the data as of March 2020, we find that overall CVaR in the 2°C scenario worsened by 8.3 percentage points, from +1.7% down to ▲6.6%. Looking at the breakdown, both policy risks and technology opportunities decreased, while physical risks remained broadly the same (Figure 2-2).

The most significant impact of these changes was technology opportunities. A breakdown by factor showed that the most significant impact (▲4.3%) was caused by using revenue to calculate weighted averages for the sector-level profit margins used in CVaR calculations rather than market capitalization. Using revenue-based weighted averages is likely to result in more stable data than using market capitalization, which may change significantly due to stock price movements. In addition, the change reduces the excessive impact caused by some large companies with extremely large market capitalizations in industries with fewer companies.

The factors behind changes in policy risks, on the other hand, included the impact of changes in market capitalization (▲1.7%), the impact of expanding the scope of analysis to Scope 3 (▲3.2%)

16 Please refer to P.58 for more information on CVaR analytical methods

and the refinement of Scope 2 (▲1.6%), similar to technology opportunities. Some of these costs were included in Scope 1 in the old model, however, and the resulting transfer to Scope 2 and Scope 3 resulted in positive impact of +4.6%.

Comparing the results of the new model to look at the essential changes in climate-change risks and opportunities in GPIF portfolios over the last year, we saw positive, albeit slight, changes in all components: policy risks, technology opportunities, and physical risks (Figures 2-1, (b) and (c)).

In addition to the enhancement of analytical methodologies and changes in corporate behavior, there are other factors that influence CVaR values, such as stock prices. In this model, if enterprise value, calculated as the sum of equity market capitalization and debt, doubles, the absolute value of CVaR will be reduced by one-half, even if other factors such as the company's climate-change risks and opportunities remain unchanged. Therefore, 2020's historic rise in global equity markets also pushed down absolute CVaR values.

Figure 2-1 Changes in GPIF Portfolio CVaR (Total of Equities and Corporate Bonds) Due to Analysis Model Enhancement

	Old Model	New Model	
	March 2020 (a)	March 2020 (b)	March 2021 (c)
Aggregated CVaR (%)	1.7	-6.6	-5.7
Transition Risks and Opportunities	8.1	-0.4	0.1
Policy Risks	-6.6	-8.6	-8.2
Technological Opportunities	14.7	8.2	8.3
Physical Risks	-6.4	-6.2	-5.8

Note: Based on 2℃ scenario

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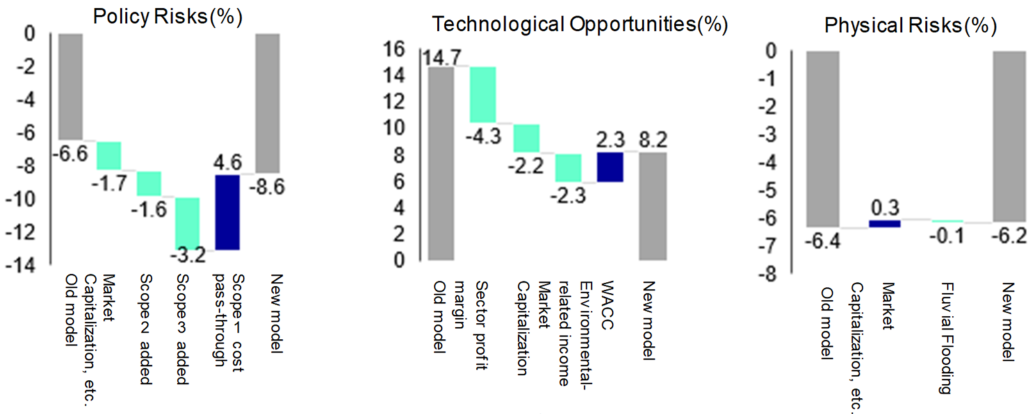
Figure 2-2 Breakdown of Changes in GPIF Portfolio CVaR (Total of Equities and Corporate Bonds) Due to Analysis Model Enhancement by Factor



Note: Data is current as of March 31, 2020 Based on 2℃ scenario
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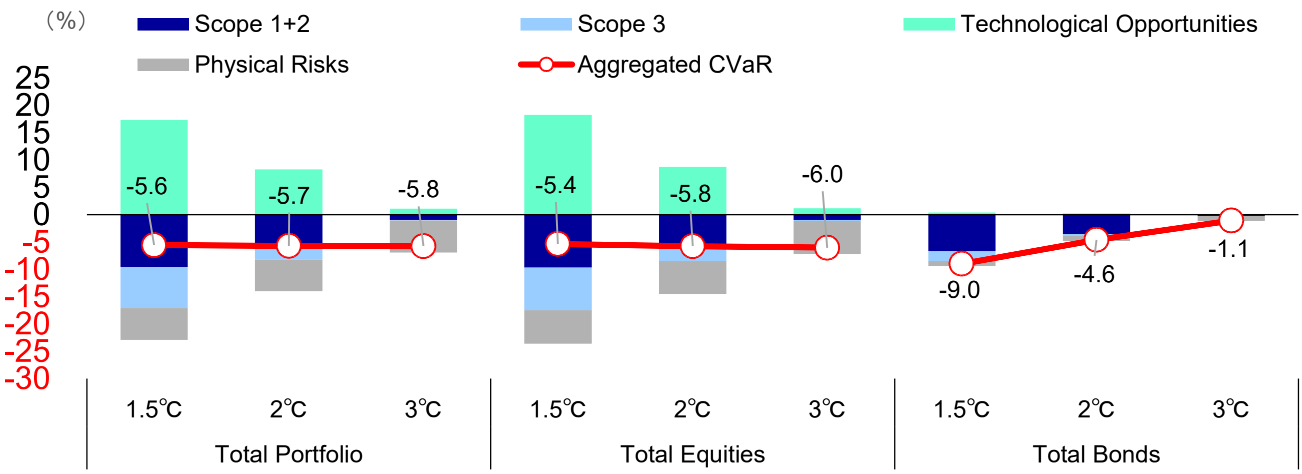
CVaR by Temperature Increase Scenario

Analyzing the Impacts of CVaR on Different Temperature Rise Scenarios

In this report, we calculated CVaR for a scenario in which the global average temperature rise from the pre-industrial period to the end of this century does not surpass 2°C (the 2°C scenario) and conducted our analysis based on the result of those calculations. As CVaR results vary depending on the temperature increase scenario being assumed, we first confirm the CVaR of GPIF's equity and corporate bond portfolio under scenarios in which policies are implemented to limit temperature increases to 1.5°C, 2°C, and 3°C (Figure 3).

To understand the overall trend represented by each of the scenarios, we focused first on aggregate CVaR for the total portfolio and found that the risks to the portfolio are smallest in the 1.5°C scenario, while the negative impact increases more as we move toward the 2°C and 3.0°C scenarios (i.e. less policy restrictions). Compared with last year's report, the gaps in CVaR between each scenario are smaller, owing largely to the analysis model enhancement. However, for both equities and corporate bonds, the impact of technological opportunities and policy risks are higher in the scenarios with greater curbs in temperature rises, indicating that climate policy trends are likely to have a significant impact on corporate value. Investors will have to pay close attention to climate change policy trends going forward as these will play a pivotal role in investment decisions.

Figure 2-3 CVaR by Temperature Increase Scenario



Note1: Physical risks are analyzed under assumptions corresponding to a 4° C–6° C scenario.
Note2: "Scope 1+2" and "Scope 3" indicate policy risks associated with these scopes.
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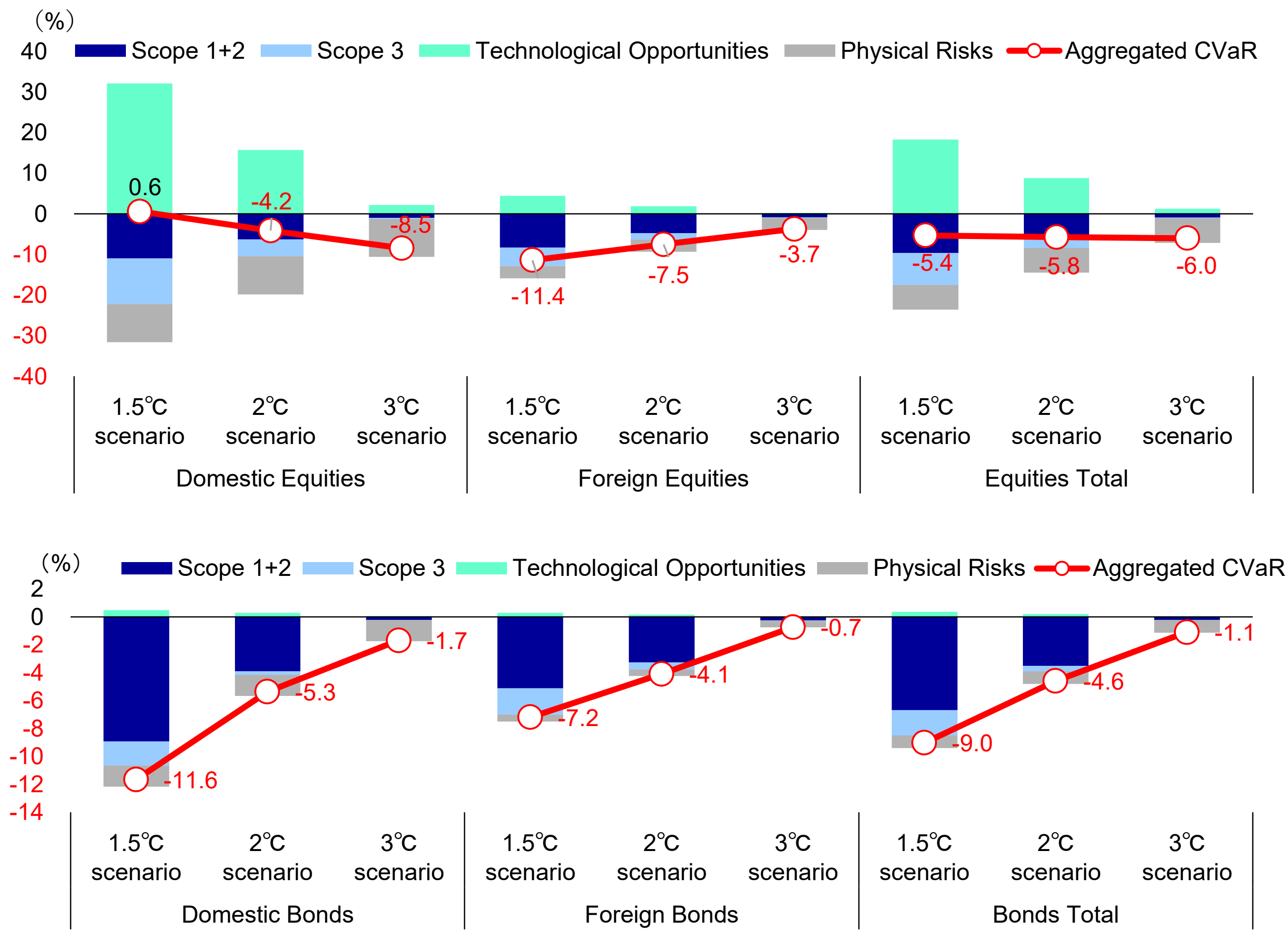
Impact Analysis by Different Temperature Rise Scenario (by Asset Class)

Next, we looked at CVaR for GPIF's portfolio by asset class. Figure 2-4 provides a breakdown by temperature rise scenario. First, a comparison of equities and bonds revealed a clear difference in the impact of technological opportunities. For corporate bonds, increased earnings from technological opportunities could contribute positively to bond prices through reduced default risk, but the impact is limited as the positive impact is capped at par. On the other hand, the positive impacts of technology opportunities for equities were significant due to the effect on super-long-term cash flows accumulating over time. For domestic equities with large patents in low-carbon technologies, the 2°C scenario and 1.5°C scenarios had more positive impacts on enterprise value in terms of overall CVaR than that of the 3°C scenario.

Figure 2-4 CVaR (Equities and Bonds) by Temperature Rise Scenarios



Note1: Physical risks are analyzed under assumptions corresponding to a 4° C–6° C scenario.
Note2: "Scope 1+2" and "Scope 3" indicate policy risks associated with these scopes.
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Technological Opportunities

Technology Opportunities and Patent Scores

The Low Carbon Technology Opportunity CVaR analysis examines how enterprise value and security values are likely to change during the transition to a low-carbon economy as the result of earnings growth stemming from low-carbon technologies. This is calculated based on an assessment of companies' low-carbon technology patent acquisition status and current low-carbon technology-related revenues. The models are based on patent scores developed by the Swiss Federal Institute of Intellectual Property in collaboration with MSCI Climate Research Centre[17].

We saw previously that technological opportunities have changed dramatically from last year due to enhancements made to the analysis model. Here, we investigate the patent scores used to calculate technological opportunities for companies included in GPIF's equity and corporate bond portfolios. While analysis results are affected by the amounts invested in individual companies, the portfolio as of March 31, 2021 examined in this analysis is mainly managed passively, and is generally in line with the policy asset mix. As such, in terms of equities, the portfolios do not deviate significantly from policy benchmarks. The patent score calculation tabulates all low-carbon technology patents held by a given company and reflects any change in the number of such patents. The results of this analysis do not differ greatly from the previous year, with domestic companies in the automotive and energy supply sectors scoring exceptionally high. The inter-industry transfer of transition risks and opportunities analysis introduced on page 65 employs a different methodology to assess the patent competitiveness of decarbonization technologies by county and region.

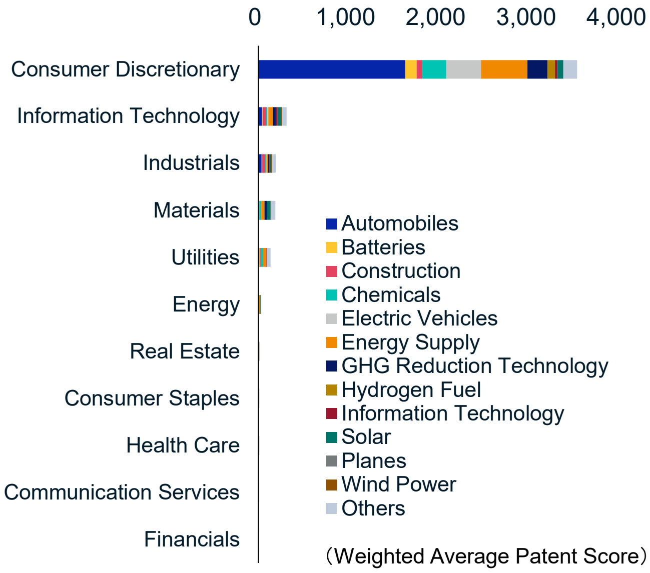
Patent Score: Characteristics by Asset

Looking at patent scores by sector, the consumer discretionary sector, which includes automotive manufacturers, scored markedly higher compared with other sectors in the domestic equities portfolio. Within this sector, “automobiles” had the highest patent score, followed by “energy supply,” “electric vehicles,” and “chemicals” (Figure2-5). In the information technology sector, patent scores are high in “energy supply” and “automobiles.” Meanwhile, in the case of foreign equities, the scores for industrials are the highest, with patents related to aircraft, wind power, and automobiles making major contributions. In the information technology sector, “information technology” scored highly, while “automobiles” scored highly in the consumer discretionary sector, similar to domestic equities (Figure2-6).In the domestic bond portfolio as well, “automobiles” tend to have higher scores in the consumer

[17] For details of the analysis methodology, please refer to P.63.

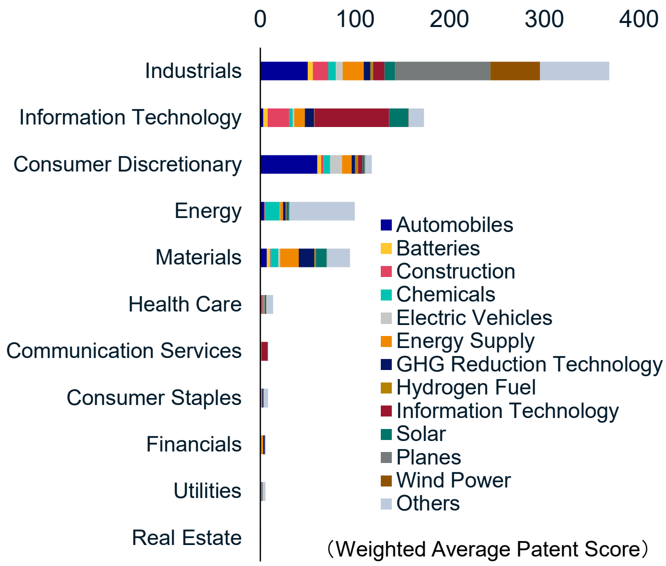
discretionary sector as in the domestic equity portfolio, as does "energy supply" in the information technology sector. For foreign corporate bonds, there was an increase in the weighted average patent scores in"automobiles" and "energy supply" for the consumer discretionary sector (Figures 2-7 and 2-8).

Figure 2-5 Technological Opportunities: Domestic Equity Portfolio



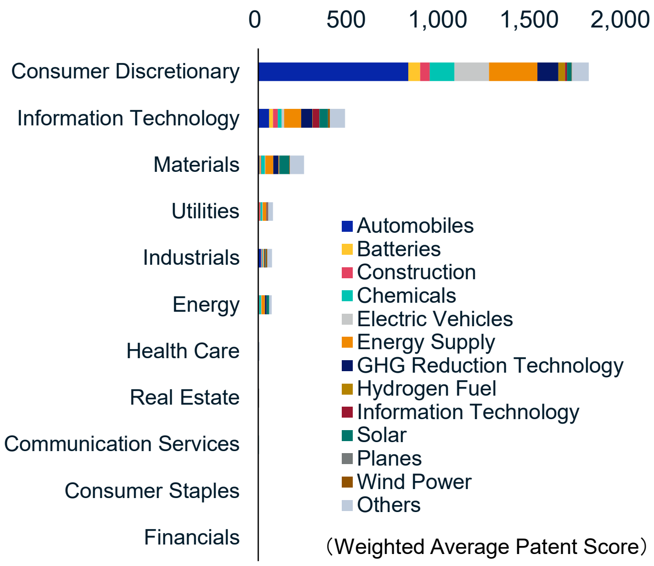
Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 2-6 Technological Opportunities: Foreign Equity Portfolio



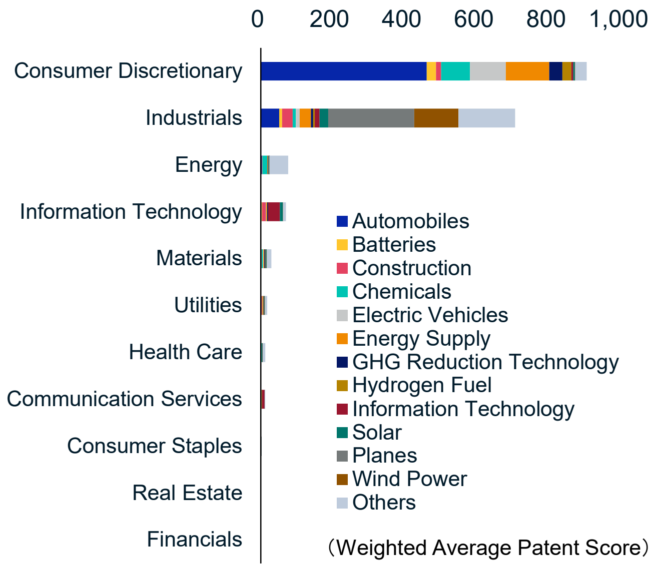
Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 2-7 Technological Opportunities: Domestic Corporate Bond Portfolio



Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 2-8 Technological Opportunities: Foreign Corporate Bond Portfolio



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Policy Risks

Climate-Change Policy-Risk CVaR

We also analyzed policy risks, which, together with technological opportunities, constitute transition risks and opportunities. The Climate Change Policy Risk CVaR (Policy Risk CVaR) calculates the costs incurred by companies by future policies related to climate change, assuming super long term to the end of 21st century. This model analyzes the impact of downside risks to enterprise and security values from policies related to climate change by calculating the estimated future emission reduction costs required by policies related to climate change[18] at the corporate level.

Expanding the Analysis to Scope 3

In the policy risk evaluation conducted in the supplementary guide to last year's ESG Report 2019, we analyzed the Scope 1 and Scope 2 emissions of companies in the portfolio. This year, the scope of the analysis was expanded to include Scope 3 emissions. These emissions consist of "upstream Scope 3," which encompasses the raw materials, services, and labor inputs to companies' production activities, and "downstream Scope 3," which covers the sale of produced goods and services. In the analysis, we focused on changes in Scopes 1 and 2 from the previous year and the magnitude of Scope 3 risks (Figures 2-9～12).

Policy Risk of Domestic Equity Portfolios

For overall policy risk CVaR including Scope 3, results for domestic equities showed that there were greater risks in the energy sector (which includes companies such as fossil fuel mining companies), the utilities sector (which includes electric power and other companies), and the materials sector, while risks in the healthcare, telecommunications services, and financial sectors remain low.

This was a similar trend to last year. Scope 1 and 2 risks decreased across all sectors (industries) from the previous year, including energy (11.5 percentage points), utilities (4.8 percentage points), and materials (9.1 percentage points). This may be largely attributable to the fact that a portion of the costs of reducing emissions were passed through to the corporate value chain as a result of the introduction of Scope 3 in the current fiscal year.

Meanwhile, Scope 3 risks tend to be smaller than those of Scopes 1 and 2 in all sectors as a whole. This is due to the fact that, although absolute Scope 3 greenhouse gas emissions are generally large,

[18] Please refer to P.59 for details of the analysis methodology.

this is not necessarily the case when companies' assumed burden rates are taken into account. By sector, energy and utilities have the highest Scope 3 policy risks, followed by the consumer discretionary sector, which includes automobiles. Conversely, for Scopes 1 and 2, risks for the materials sector exceed those for the consumer discretionary sector. Foreign equities showed the same trend as last year, with risks in the utilities, energy, and materials sectors remaining high.

Policy risks in the utilities sector also increased from last year. Compared with foreign equities, domestic equity policy risks are greater in the energy sector, because certain companies in the sector are weighted more heavily than others.

Policy Risk in Foreign Equity Portfolios

The same trend was observed in foreign equities last year, with substantial risks in "energy," "utilities," and "materials." For Scope 1+2, the change from last year in each sector (industry) showed that while risk declined in most sectors, as was case with domestic equities, the utilities sector experienced a slight increase in risk. This was attributable to the increase in CO_2 emissions from 2018 to 2019 leading to a higher emission reduction amount assigned to each sector to achieve the carbon budget, in addition to higher carbon prices. Focusing on Scope 3, foreign equities also generally tended to have lower risks than that of Scope 1 and 2, with sector-specific results showing greater risks for "energy," "utilities," and "materials," similar to Scope 1+2.

Figure 2-9 Policy Risk: Domestic Equity Portfolio

Sector	Policy Risk CVaR			Change from previous year (percentage points)
		Scope1+2	Scope3	
Health Care	-1.1%	-0.5%	-0.6%	0.1%
Communication Services	-1.2%	-0.6%	-0.7%	0.3%
Financials	-2.1%	-0.8%	-1.3%	0.0%
Real Estate	-2.7%	-1.3%	-1.4%	0.5%
Information Technology	-2.8%	-1.5%	-1.3%	0.5%
Consumer Staples	-6.5%	-3.5%	-3.0%	0.6%
Industrials	-10.0%	-6.5%	-3.5%	1.9%
Consumer Discretionary	-11.0%	-2.6%	-8.4%	1.6%
Materials	-30.1%	-25.3%	-4.8%	9.1%
Utilities	-69.7%	-46.8%	-23.0%	4.8%
Energy	-95.2%	-63.2%	-32.0%	11.5%

Note: Changes from the previous year refers to changes in Scopes 1 + 2

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Figure 2-10 Policy Risk: Foreign Equity Portfolio

Sector	Policy Risk CVaR			Change from previous year (percentage points)
		Scope1+2	Scope3	
Information Technology	-0.8%	-0.5%	-0.4%	0.2%
Health Care	-1.3%	-0.8%	-0.5%	0.1%
Real Estate	-1.6%	-1.3%	-0.3%	0.1%
Financials	-1.7%	-1.1%	-0.6%	0.2%
Communication Services	-1.7%	-1.5%	-0.3%	0.3%
Consumer Discretionary	-3.6%	-1.3%	-2.3%	0.5%
Consumer Staples	-6.0%	-4.2%	-1.8%	1.7%
Industrials	-7.6%	-6.5%	-1.1%	3.5%
Materials	-23.9%	-21.2%	-2.6%	12.3%
Utilities	-36.8%	-32.9%	-3.9%	-3.8%
Energy	-46.6%	-31.3%	-15.3%	17.9%

Note: Changes from the previous year refers to changes in Scopes 1 + 2

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Policy Risks in the Domestic Corporate Bond Portfolio

Looking at corporate bonds, we confirmed that the overall level of policy risk tends to be lower than that of equities. The results for domestic corporate bonds showed significant risks in energy, utilities, and materials. For Scope 1+2, the range of change from last year in each sector (industry) showed that while risks declined in most sectors, utilities experienced increased risk. Focusing on Scope 3, the risk in the energy sector outweighed the risk of Scope 1+2. This was because companies with higher Scope 3 risk than Scope 1+2 risk had relatively high weights in the energy sector for domestic corporate bonds. It suggests that the risk associated with the supply chain, i.e. energy extraction and energy consumption, is greater than that of the policy risk associated with energy production.

Policy Risk of Foreign Corporate Bond Portfolios

The results for foreign corporate bonds revealed significant risks for utilities, energy, and materials. For Scope 1+2, the range of change from last year in each sector (industry) showed a slight increase in risk for most sectors but a slight decrease in risk for utilities and materials. Focusing on Scope 3, overall risk tended to be less than that of the risk of Scopes 1 and 2.

Figure 2-11 Policy Risk: Domestic Corporate Bond Portfolio

Sector	Policy Risk CVaR	Scope1+2	Scope3	Change from previous year (percentage points)
Communication Services	0.0%	0.0%	0.0%	0.0%
Financials	-0.1%	0.0%	0.0%	0.0%
Real Estate	-0.1%	0.0%	-0.1%	0.1%
Information Technology	-0.2%	-0.2%	0.0%	0.1%
Health Care	-0.3%	-0.1%	-0.2%	0.0%
Consumer Staples	-0.4%	-0.2%	-0.2%	0.1%
Consumer Discretionary	-0.8%	-0.1%	-0.7%	0.1%
Industrials	-2.2%	-2.0%	-0.2%	1.7%
Materials	-19.3%	-18.7%	-0.6%	9.3%
Utilities	-24.7%	-23.6%	-1.1%	-15.2%
Energy	-39.7%	-11.7%	-28.0%	35.4%

Note: Changes from the previous year refers to changes in Scopes 1 + 2

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Figure 2-12 Policy Risk: Foreign Corporate Bond Portfolio

Sector	Policy Risk CVaR	Scope1+2	Scope3	Change from previous year (percentage points)
Real Estate	-0.1%	-0.1%	0.0%	0.0%
Information Technology	-0.2%	-0.2%	0.0%	-0.1%
Health Care	-0.2%	-0.2%	-0.1%	0.0%
Communication Services	-0.2%	-0.2%	0.0%	0.1%
Consumer Discretionary	-1.0%	-0.5%	-0.6%	-0.1%
Financials	-1.3%	-1.1%	-0.1%	-1.0%
Consumer Staples	-1.9%	-1.4%	-0.6%	-0.6%
Industrials	-6.7%	-6.6%	-0.2%	-2.8%
Materials	-13.5%	-13.2%	-0.3%	1.1%
Energy	-17.7%	-13.1%	-4.6%	-0.5%
Utilities	-20.6%	-20.4%	-0.2%	4.2%

Note: Changes from the previous year refers to changes in Scopes 1 + 2

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Physical Risks

Physical Risks

In the physical risk analysis, we examined potential deterioration in corporate revenues arising from asset damage and productivity declines caused by climate change-induced abnormal weather, such as floods and extreme heat[19]. At the same time, we also analyzed the potential for increased revenues resulting from such extreme weather. For example, if rising temperatures lead to an improvement in operating rates and a reduction in heating costs in cold regions, the results of the physical risk analysis will be positive. This year, we started analyzing fluvial flooding risk to evaluate the impact of river overflows caused by heavy rain and other factors.

Physical Risk in Equity Portfolios

As was the case last year, physical risks by sector and by portfolio continue to show different trends from policy risks (Figures 2-13, 2-14). Equities were found to be generally riskier than bonds. We also found that domestic equity portfolios in particular, tend to be riskier than foreign equity portfolios.

In the domestic equity portfolio, the utilities and energy sectors were shown to have significant physical risks in addition to policy risks, followed by the financials and consumer staples sectors. On the other hand, the risk to telecommunications services, which was high last year, has decreased due to an increase in the ratio of investment in companies with relatively low physical risks. In the foreign equity portfolio, the financials, real estate, and telecommunications services sectors have significant physical risks. Most of these are caused by coastal flooding and extreme heat. It is likely that financials are affected by the location of physical storefronts, and the consumer staples sector is affected by the fact that many production bases and distribution facilities are located at low altitudes, exposing them to the risk of flooding.

The utilities sector was found to have the highest physical risk both domestically and internationally, which was mainly due to changes in the methodology for assessing physical risk exposures. When estimating the physical risks for each facility, we previously aggregated total corporate revenue by country and allocated this equally across all facilities. The new assessment methodology, however, estimates revenues for each facility location owned by the company based on production activity, which results in a higher risk assessment for utilities engaged in coastal power generation. The Physical Risk CVaR assesses not only the direct property damage incurred when an individual facility suffers flooding or other damage, but also the reduction in revenues associated with the disruption of

[19] For details of the analysis methodology, please refer to P.64.

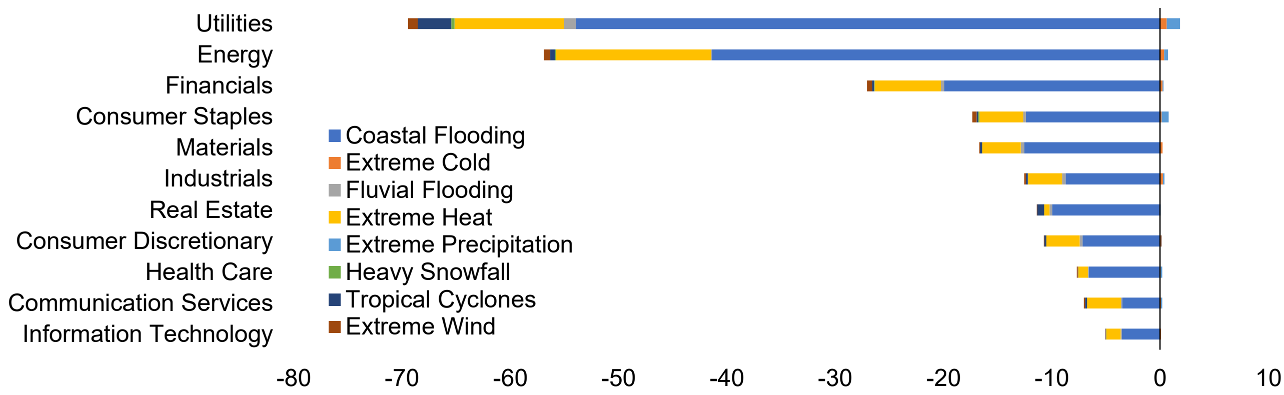
productive activities on a facility-by-facility basis. In the worst case scenario for coastal flooding damage caused by sea level rise, utilities not only suffer direct acute flood damage to power generation facilities, but profits are also expected to decline due to the interruption of power generation business activities. Therefore, the new physical risk assessment method would result in a higher assessment of physical risk if power generation and other production facilities are located on the coast and face flood risk.

For both domestic and foreign portfolios, extreme heat has a significant impact on the energy sector, where temperature increases and other factors are likely to impact fossil fuel mining efficiency and the refining business. Industrials were considered to have high policy risks in both the domestic and foreign portfolios, but the analysis showed that physical risks for this sector are low.

Physical Risk in Fixed Income Portfolios

For domestic bonds, physical risks were found to be highest in the utilities sector, followed by the healthcare, consumer staples, and materials sectors, while for foreign bonds, the consumer discretionary, real estate, and financials sectors had the highest risk (Figures 2-15、2-16). It is likely that the risk of coastal flooding is high in any of these portfolios because of the location of facilities such as storefronts and factories.

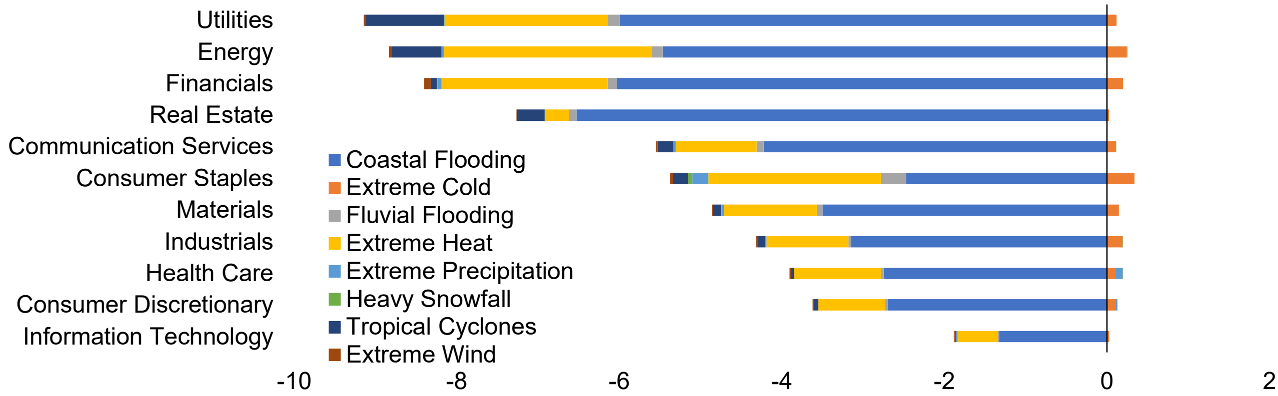
Figure 2-13 Physical Risks: Domestic Equity portfolio



Source:Reproduced by permissionof MSCI ESG Research(c) LLC.

(Weighted Average Physical Risks CVaR, %)

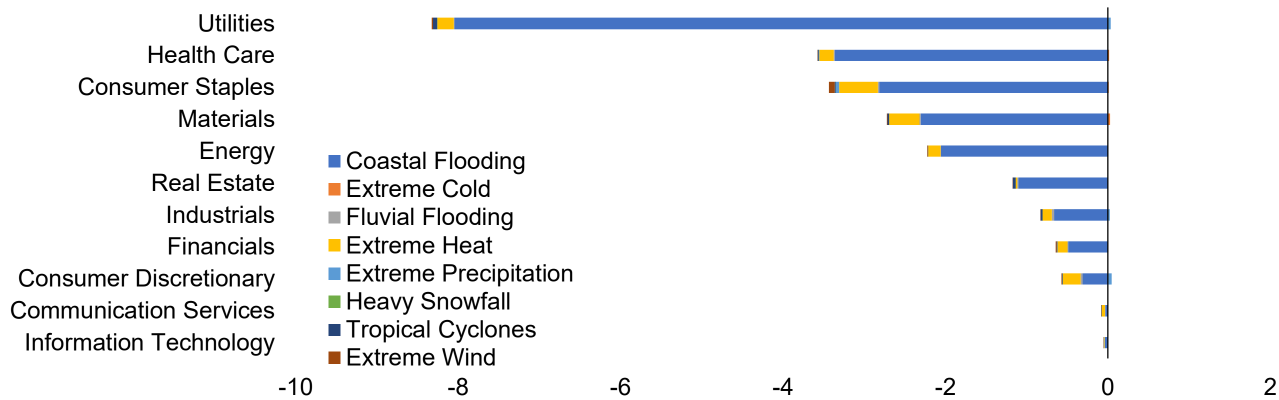
Figure 2-14 Physical Risks: Foreign Equity Portfolio



Source:Reproduced by permissionof MSCI ESG Research(c) LLC.

(Weighted Average Physical Risks CVaR, %)

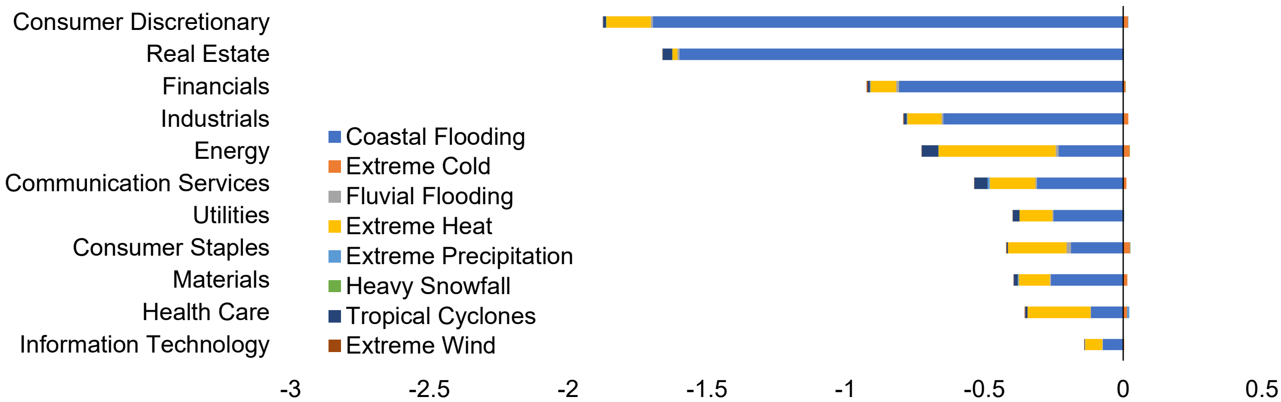
Figure 2-15 Physical Risks: Domestic Bond Portfolio



Source:Reproduced by permissionof MSCI ESG Research(c) LLC.

(Weighted Average Physical Risks CVaR, %)

Figure 2-16 Physical Risks: Foreign Bond Portfolio



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(Weighted Average Physical Risks CVaR, %)

Climate Value-at-Risk Analysis of Government Bond Portfolio

CVaR Analysis of Government Bonds

Last year, we conducted a CVaR analysis of equities and corporate bonds only, but this year, we also conducted the same analysis for government bonds. While the analysis for equities and corporate bonds estimates the impact on securities values, the CVaR methodology for government bonds assesses how the implementation of policies to achieve the 2°C target would affect GDP trends for individual countries through 2050.

In particular, this analysis attempts to answer the following questions:

① Does early achievement of emission reduction targets by 2030 lead to greater transition costs?

② Does the early decarbonization of the economy lead to better economic outcomes than delayed decarbonization by 2050?

③ Do these patterns vary significantly from country to country?

The REMIND Model

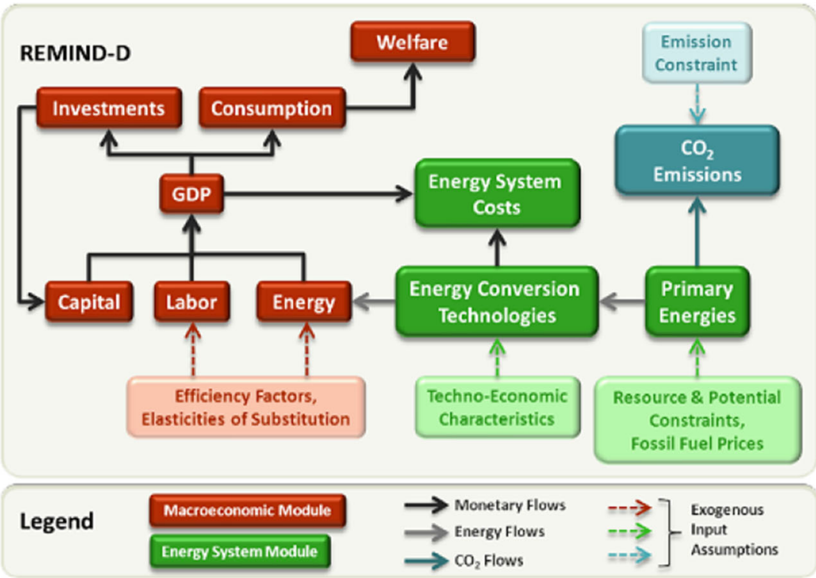
This analysis uses an Integrated Assessment Model. Integrated Assessment Models comprehensively evaluate the interrelationships between macroeconomics, global science, and energy systems. These models use GDP trends, emission targets, and many other data points as inputs, and produce data such as surface temperatures, carbon prices, emission pathways, and GDP estimates as outputs. While economic forecasts usually focus on the accuracy of short-term GDP figures, the integrated assessment model focuses on long term GDP impact. Our analysis also focuses on scenario differences rather than absolute levels of GDP impact.

Specifically, this report uses the REMIND model (REMIND1. 7-MagPIE 3. 0 Integrated Assessment Model), which was developed by the Potsdam Institute for Climate impact Research and was one of the three integrated assessment models adopted by NGFS (the Network of Central Banks and Supervisors for Greening the Financial System) during Phase 1. Although macroeconomic impact analysis using integrated assessment models has been conducted in the past, the results have been difficult to incorporate into investment analysis due to differences in the assumptions made by the various analysis agencies involved. To address this issue, NGFS developed several "NGFS scenarios" that standardize the various assumptions across integrated assessment models.

The REMIND (REgional Model of Investment and Development) model first analyzes the “Energy System Module (Figure 2-17, green and blue)”. In this study, we set a constraint to limit global cumulative CO_2 emissions during 2011 to 2100 to 1,000Gt, which is aligned with a 2℃ scenario. Different carbon prices are also set for each region, and gradually consolidate to one universal price.

Furthermore, each country's capacity for CO_2 elimination (Carbon Dioxide Removal: CDRs), is estimated based on survey results in the REMIND model. After completing all these analyses, the macroeconomic module (Figure 2-17, red) analysis is conducted. The macroeconomic analysis examines three production factors: labor, capital, and energy use. Differences in GDP impact between scenarios are mainly attributable to energy use differences among these production factors.

Figure 2-17 Specifications of REMIND Model



Source: Schmid, Bauer & Knopf. 2012. Climate Change - REMIND

Early Response Scenario and Delayed Response Scenario

Two scenarios were reviewed in this analysis. There is no one single path to achieving the 2°C target by the end of this century; for this analysis, we assumed (1) an immediate 2°C scenario, in which proactive climate action is taken immediately, and (2) a delayed 2°C scenario, in which climate action is delayed. The main assumptions for these two scenarios are as follows:

(1) For the immediate 2°C scenario, we assume that the power generation capacity from renewable energy will rapidly expand in the 2020s, carbon prices will surge throughout the world in the 2030s, and decarbonization efforts will accelerate across the entire economy (Figure 2-18).

(2) For the delayed 2°C scenario, we assume that by 2030 each country will achieve the national targets set in 2016 at the conclusion of the Paris Agreement on the one hand, but on the other that environmentally friendly energy technologies will not become widespread until that year. The analysis also assumes that carbon prices will not rise significantly until 2030 and will rise sharply thereafter (Figure 2-18).

Figure 2-18 Carbon Price Assumptions by Country (US$2010 per t CO_2)

<table>
<tr><th>Carbon Price, Delayed 2C, limited CDR (US$2010/t CO_2)</th><th>2020</th><th>2030</th><th>2040</th><th>2050</th><th>2060</th><th>2070</th><th>2080</th><th>2090</th><th>2100</th></tr>
<tr><td>Japan</td><td>3.3</td><td>13.7</td><td>359.0</td><td rowspan="3">704.4</td><td rowspan="3">1,147.4</td><td rowspan="3">1,644.1</td><td rowspan="3">2,140.9</td><td rowspan="3">2,637.6</td><td rowspan="3">3,134.3</td></tr>
<tr><td>USA</td><td>3.3</td><td>48.7</td><td>376.6</td></tr>
<tr><td>Europe</td><td>5.5</td><td>57.3</td><td>381.0</td></tr>
</table>

<table>
<tr><th>Carbon Price, Immediate 2C, limited CDR (US$2010/t CO_2)</th><th>2020</th><th>2030</th><th>2040</th><th>2050</th><th>2060</th><th>2070</th><th>2080</th><th>2090</th><th>2100</th></tr>
<tr><td>Japan</td><td>3.3</td><td>96.3</td><td rowspan="3">189.3</td><td rowspan="3">308.3</td><td rowspan="3">502.2</td><td rowspan="3">719.6</td><td rowspan="3">937.1</td><td rowspan="3">1,154.5</td><td rowspan="3">1,372.0</td></tr>
<tr><td>USA</td><td>3.3</td><td>96.3</td></tr>
<tr><td>Europe</td><td>5.5</td><td>97.4</td></tr>
</table>

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Analysis Results

Using the REMIND model, we analyzed GDP impact in the early and delayed scenarios for Japan, the United States, and Europe. Results showed that the early response scenarios reached the same GDP level of the delayed response scenarios by at least 2040. Therefore, the cost of taking early action to achieve the 2°C scenario could be lower than delayed action.

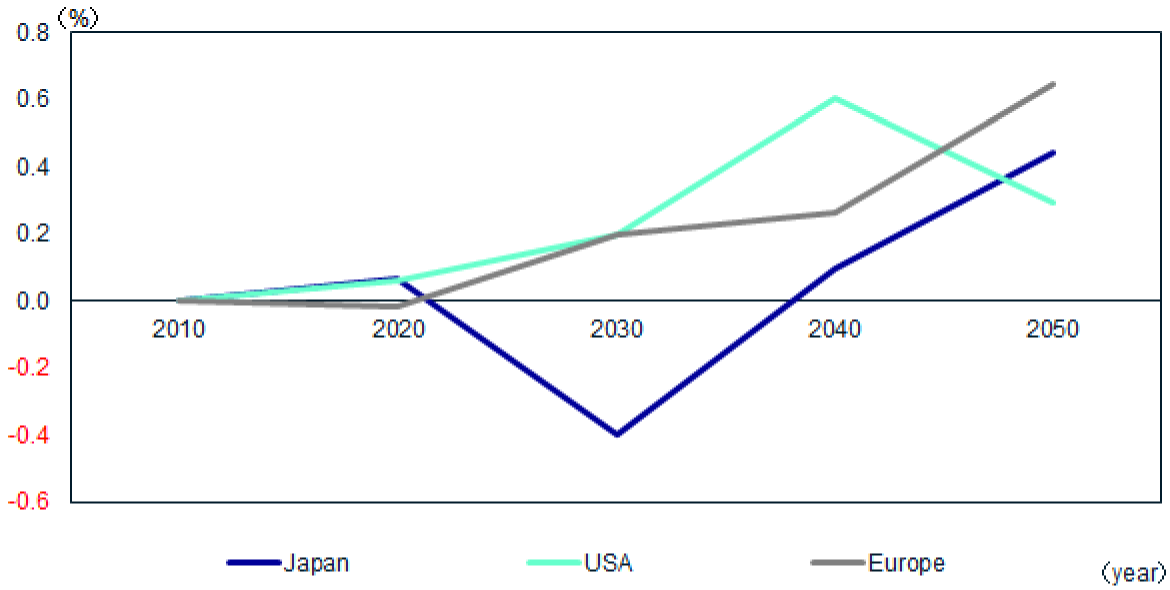
In Japan, the United States, and Europe, each region showed a decline in GDP when climate measures were taken, although the magnitude of the impact varies by scenario and region.

Figure 2-19 shows the difference in the impact on GDP between the immediate 2°C scenario and the delayed 2°C scenario (difference in GDP between the two scenarios). If the value on the graph is positive (negative), it can be interpreted as a positive (negative) impact on GDP if the immediate 2°C scenario is implemented.

In the case of Japan, the immediate 2°C scenario has a negative impact on GDP as of 2030, but a positive impact on GDP as of 2040 and 2050. In the United States and Europe, the immediate 2°C scenario has a positive impact on GDP at all time points—2030, 2040, and 2050. The result of this analysis shows that the immediate 2°C scenario can be expected to have a positive impact on GDP in the long term compared with the delayed 2°C scenario.

Figure 2-19 Analysis of GPIF Government Bond Portfolio: Difference in GDP between Immediate 2°C Scenario and Delayed 2°C Scenario

Country/Region	Immediate 2°C Scenario vs Delayed 2°C Scenario (%)		
	2030	2040	2050
Japan	-0.4%	0.1%	0.4%
USA	0.2%	0.6%	0.3%
Europe	0.2%	0.3%	0.6%



Note: Based on GPIF portfolio as of the end of April 2020

Source: MSCI ESG Research LLC, REMIND-MAGPIE 1.7-3.0, NGFS Phase I Scenarios of June 2020,IIASA 2020

Analysis of Portfolio Global Warming Potential

What is the Global Warming Potential Analysis?

Global warming potential is a measure of the extent to which greenhouse gases emitted by the companies reviewed can potentially contribute to global warming, expressed as an increase in temperature. Specifically, we estimate individual companies' greenhouse gas emission trends through 2100, and gauge how much global average temperatures would increase if all greenhouse gas emissions followed the same path.

In estimating warming potential, we (1) derive a function linking carbon intensity to warming potential for each sector based on literature such as the Emissions Gap Report published by United Nations Environment Programme (UNEP), (2) estimate the future carbon intensity of each company (Figure2-20), (3) calculate the warming potential for each company in the portfolio using the function derived in (1) and the carbon intensity of each company estimated in (2) (Figure2-21), and (4) calculate the weighted average warming potential of the portfolio using the portfolio weight of each company. Revenue from clean technologies expected to have the effect of preventing global warming is designated as "Cooling Potential," which pushes down overall warming potential. MSCI estimates the Cooling Potential per dollar of revenue for each company based on publications such as the Emissions Gap Report published by UNEP.

Last year's analysis only included scope 1 (direct) GHG emissions. This year's analysis includes scope 2 (indirect emissions) and scope 3 (indirect emissions), as well as the company's emissions reduction targets. Corporate emissions reduction targets may be based on carbon intensity or absolute emissions, and the boundary (scope) may vary from company to company, so data are standardized based on models when conducting analyses.

Overall Global Warming Potential of GPIF Portfolios

The results of the analysis showed that the warming potential of GPIF's portfolio as a whole was 3.40°C for domestic equities, 3.26°C for domestic bonds, 3.49°C for foreign equities, and 4.34°C for foreign bonds (Figures 2-22～25). In all asset classes, warming potential is well above 2°C. Looking at domestic and overseas trends, the warming potential for foreign companies was generally higher than that for domestic companies.

A breakdown of trends by sector reveals that warming potential tended to be high in the energy and materials sectors across all asset classes (Figures 2-22～25), while a comparison of the domestic and overseas portfolios shows that the warming potential of foreign companies is higher than that of

Japanese companies, particularly in the energy and materials sectors.

In all cases, warming potential is naturally lower when emission reduction targets are factored in than when they are not. To bring the global warming potential closer to 2°C, it is critical for companies to set reduction targets and take action to achieve them.

Figure 2-20 Conceptual Diagram of Global Warming Potential Calculation

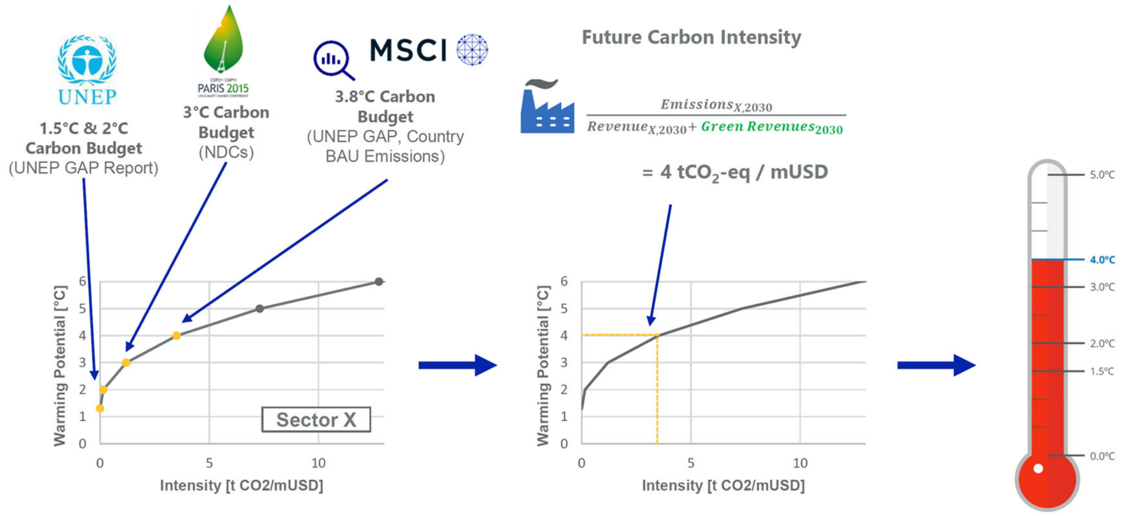


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Figure 2-21 Data Used in Global Warming Potential Calculation

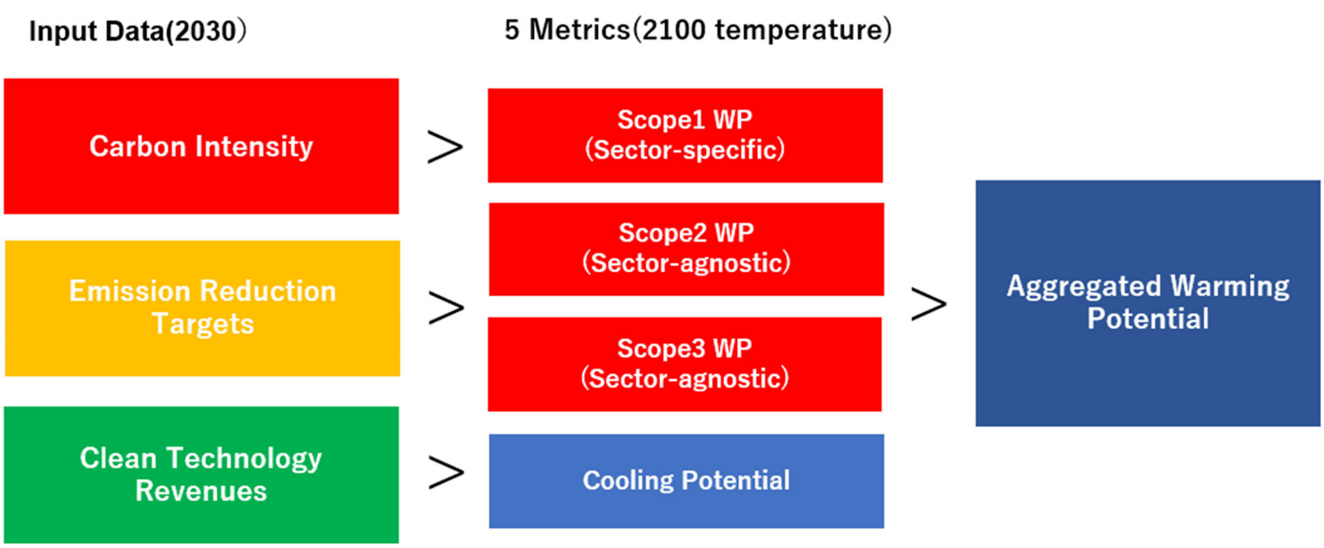

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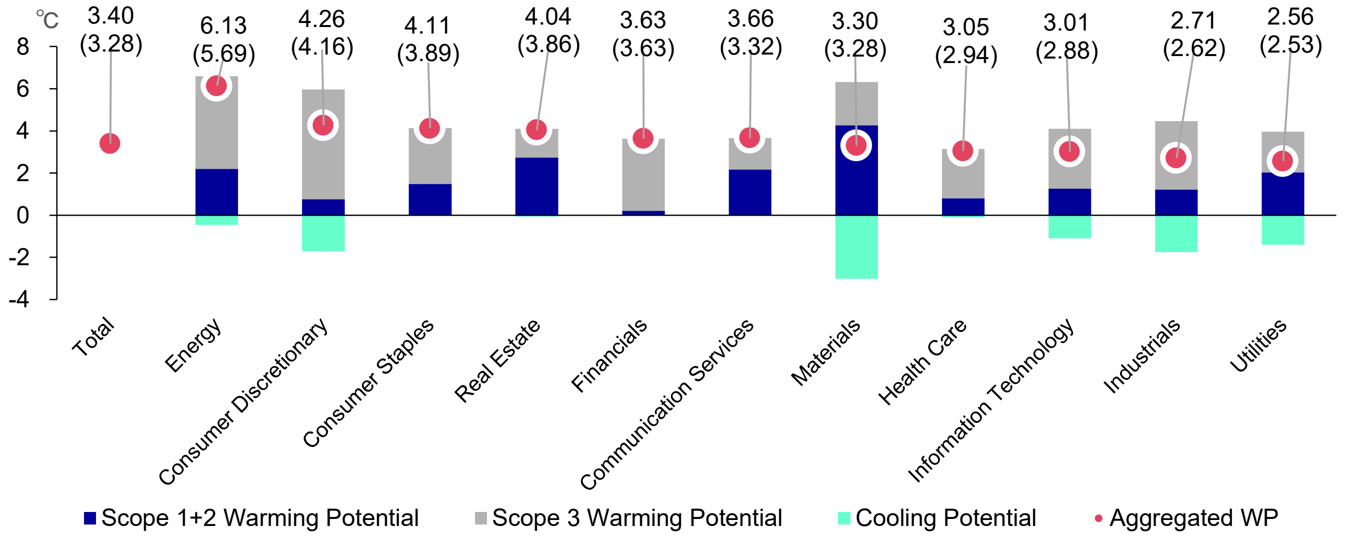
Figure 2-22 Global Warming Potential of GPIF's Domestic Equity Portfolio



Note: Global warming potential does not include reduction targets. Figures for global warming potential in consideration of reduction targets are shown in parentheses in the label.

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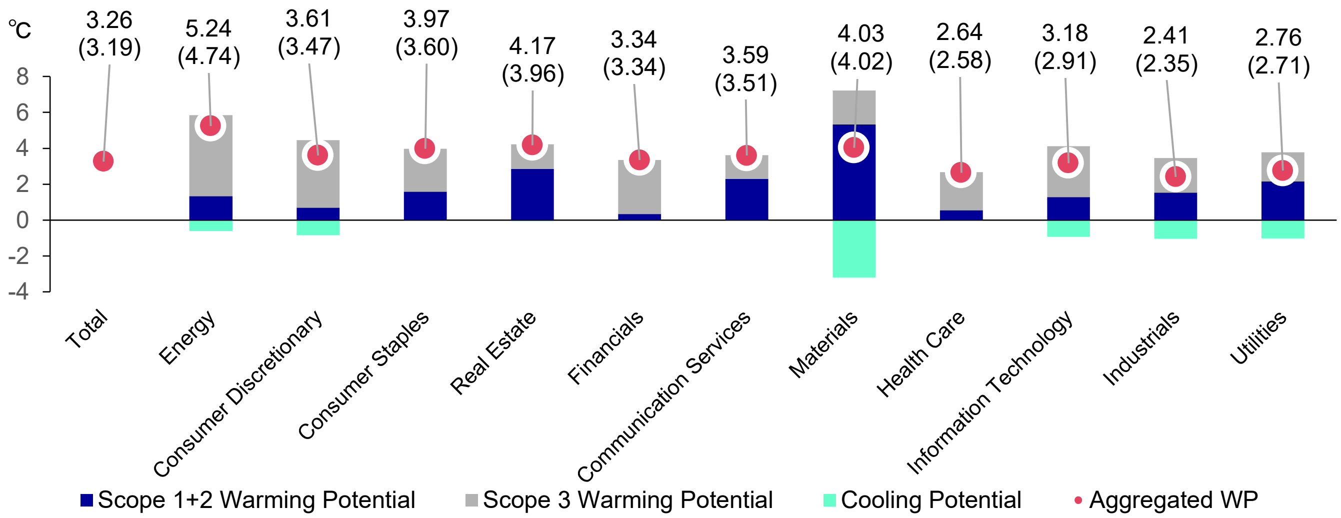
Figure 2-23 Global Warming Potential of GPIF’s Domestic Bond Portfolios



Note: Global warming potential does not include reduction targets. Figures for global warming potential in consideration of reduction targets are shown in parentheses in the label.

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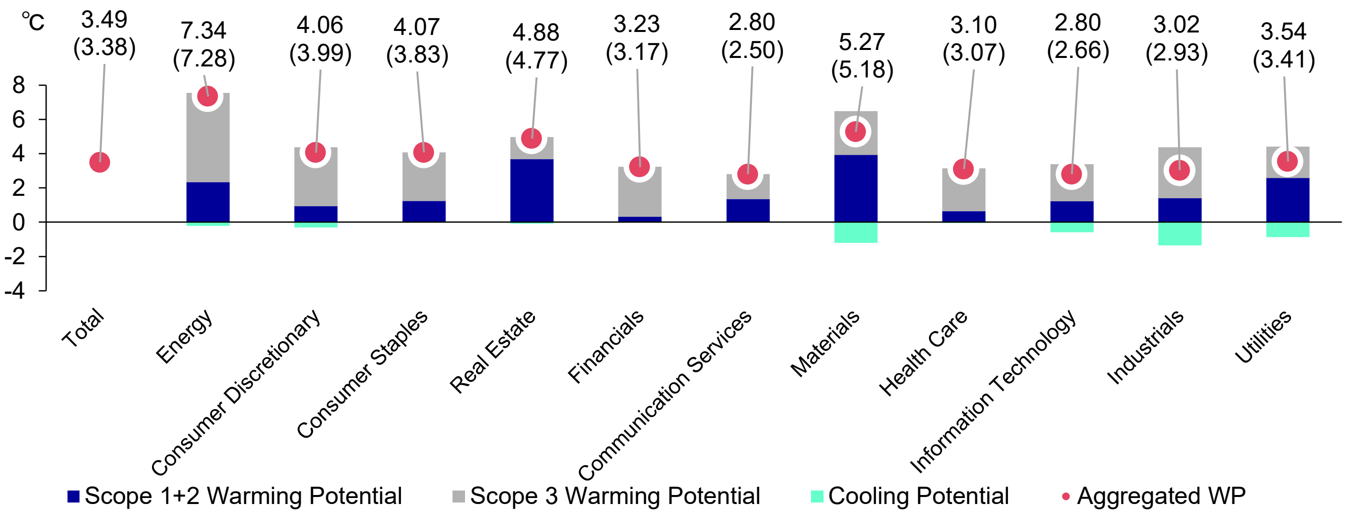
Figure 2-24 Global Warming Potential of GPIF's Foreign Equity Portfolios



Note: Global warming potential does not include reduction targets. Figures for global warming potential in consideration of reduction targets are shown in parentheses in the label.

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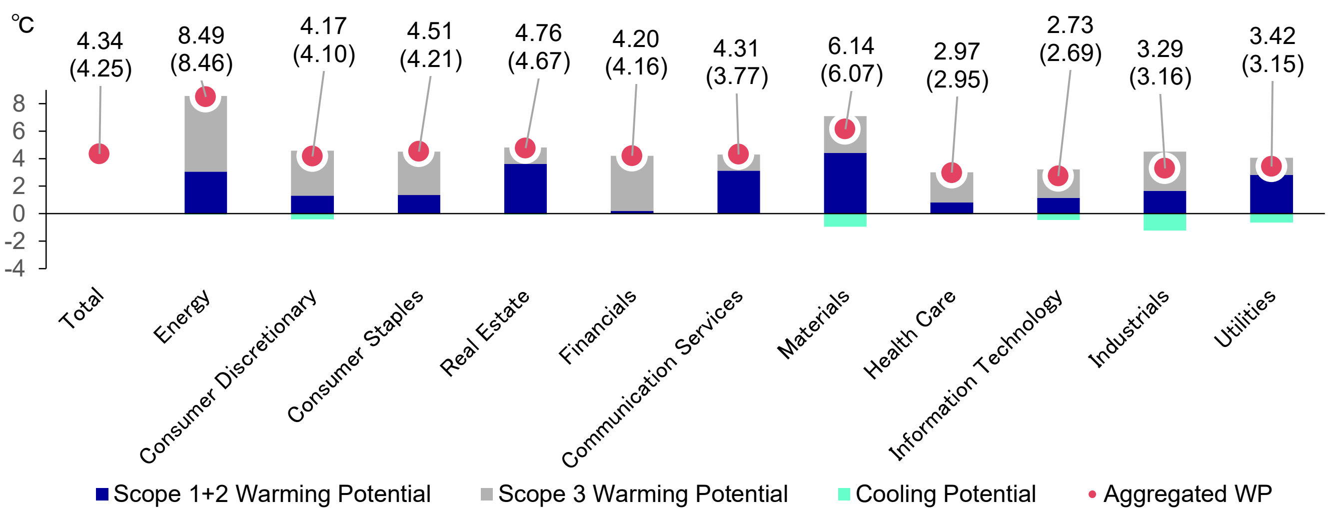
Figure 2-25 Global Warming Potential of GPIF's Foreign Bond Portfolio



Note: Global warming potential does not include reduction targets. Figures for global warming potential in consideration of reduction targets are shown in parentheses in the label.

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Analysis of Real Estate Portfolio Using Climate Value-at-Risk

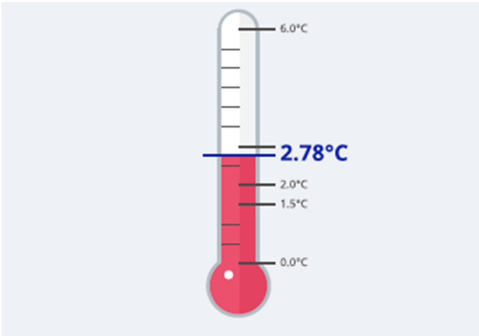
Climate Change Risk Analysis of Real Estate Portfolio

GPIF's portfolio includes traditional assets such as equities and bonds, as well as alternative assets such as infrastructure, private equity, and real estate. In this year's climate-related financial disclosures, we conducted a quantitative analysis of climate change risk for domestic real estate in which we invest through private equity funds. With regards to the weight based on total net assets (NAV) of the domestic real estate portfolio, industrial properties such as logistics facilities was largest at 60.8%, followed by residential housing (15.1%), retail (12.3%), and offices (10%). For this property portfolio, we analyzed (1) physical risks, (2) policy risks, and (3) warming potential as climate change risks (Figure 2-26)[20]。

Figure 2-26　Overview of Climate Change Risk Analysis of Real Estate Portfolio

Category	% Value	
	Physical Risk	Regulatory Risk
Very High	0	0
High	4	0
Medium	24	23
Low	4	14
Very Low	68	22
No Risk	0	41

Warming Potential



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[20] Please refer to P.58-65 for details of the analysis methodology

Physical Risks

The physical risk analysis predicts the building damage and the risk of heating/cooling cost increases caused by climate change. We assessed the risks of (1) coastal flooding, (2) fluvial flooding, (3) tropical cyclones, (4) extreme heat, and (5) extreme cold, as well as comprehensive physical risks covering all of those risks by sector. If available, information on countermeasures against physical risks for each property is partially included in the analysis, but in general, we use methods that emphasize data on the location and topography of the property.

Physical risk is analyzed at each facility level based on three factors: "exposure (assessment based on the location, size, type, and value of assets held by the company)", "hazard (probability and severity of occurrence of extreme weather events)", and "vulnerability (the propensity or predisposition of an asset to be affected)", and is assessed in six levels : "very high", "high", "medium", "low", "very low", and "no risk". The results of the analysis (Figure 2-27) indicate a high risk from (3) tropical cyclones across all sectors. Risks from (4) extreme heat were relatively high as well, except for rental housing. On the other hand, risks posed to the overall portfolio by (1) coastal flooding and (2) fluvial flooding, which are of particular concern in Japan, are low despite the inclusion of a very small number of properties with a particularly high risk of coastal and other flooding (Figure 2-28). As a result, comprehensive physical risks covering (1) to (5) are generally “low” or “very low” in each sector.

Figure 2-27 Physical Risks by Sector

	Coastal Flooding	Fluvial Flooding	Tropical Cyclones	Extreme Heat	Intense Cold	Aggregate Physical Risks
Industrial	Very Low	Low	High	High	No Risk	Low
Offices	Very Low	No Risk	High	High	No Risk	Very Low
Rental Housing	Very Low	No Risk	High	No Risk	No Risk	Low
Retail	No Risk	No Risk	High	High	No Risk	Very Low
Others	No Risk	No Risk	High	High	No Risk	Very Low

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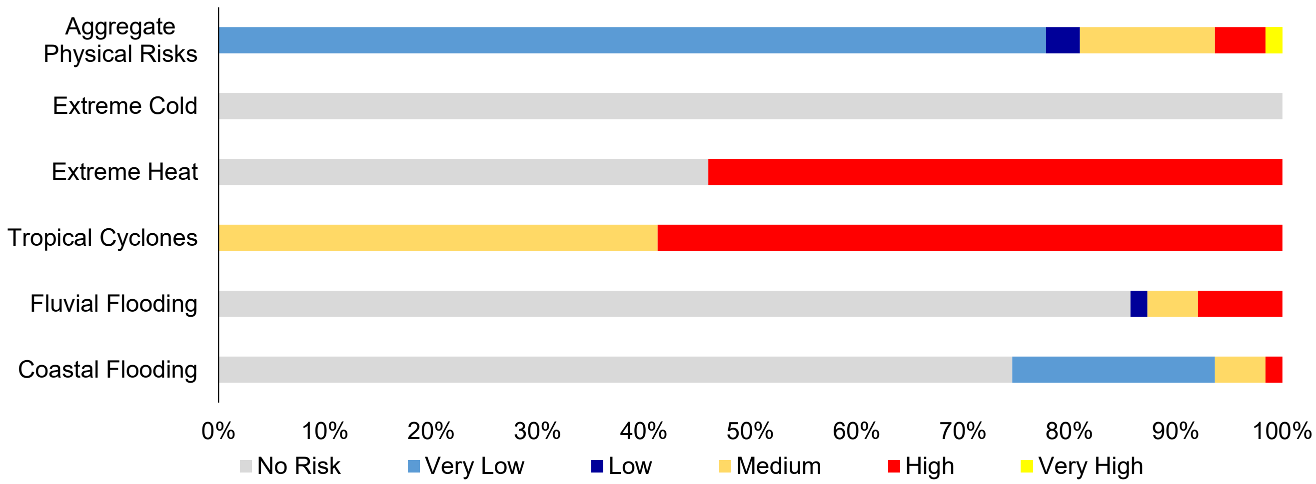
Figure 2-28 Distribution of Properties by Physical Risk



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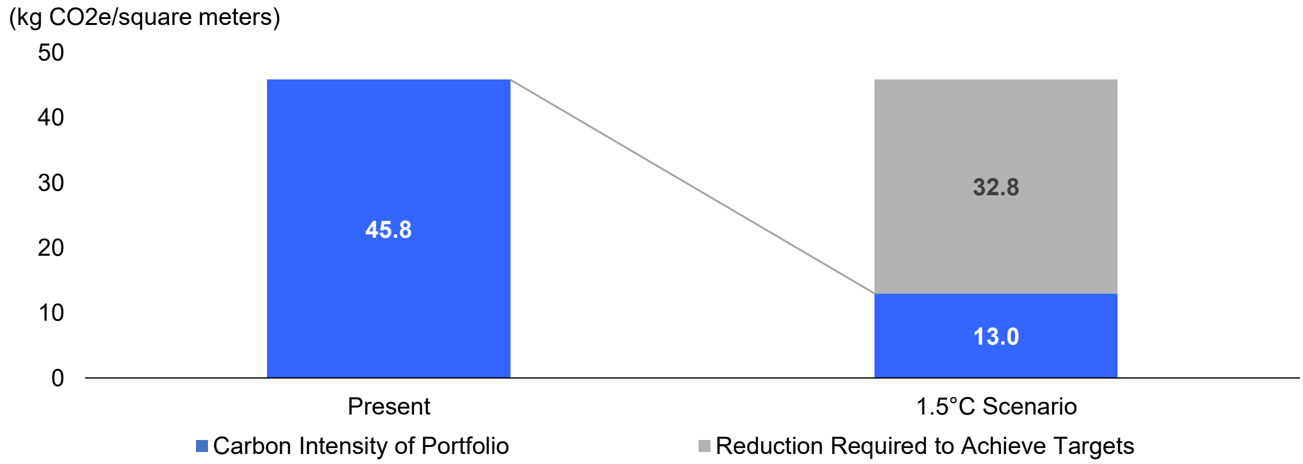
Policy Risk

In the analysis of transition pathways, we measured the carbon intensity (greenhouse gas emissions per area) of each property and estimated the required reduction in carbon intensity by 2034 (14 years from the end of 2020, which is the base year) needed to reach the 1.5°C, 2°C, and 3°C targets. Data on environmental performance and the energy usage for each property is included in the analysis if available, but in general, we use methods that uses the average data of the sector of the property if such information has not been disclosed. The analysis results showed that portfolio emissions need to decline by a total of 32.8 CO2-equivalent kg per square meter over the next ten years or so in order to achieve the 1.5°C target (Figure 2-29).

Figure 2-29 Reduction in GHG Emissions Required to Achieve 1.5°C Scenario



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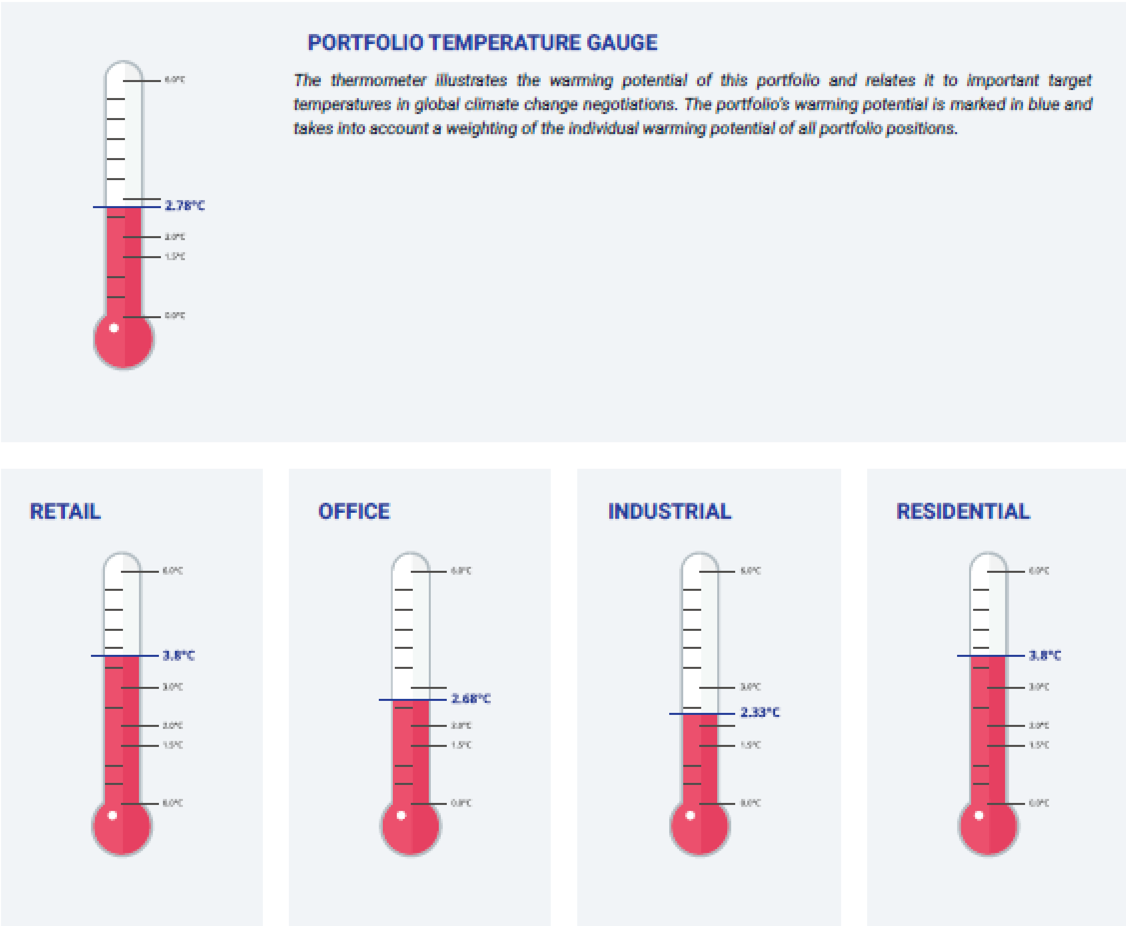
Global Warming Potential and Transition Risks

Finally, this analysis also confirmed that the warming potential of the entire portfolio. By sector, the global warming potential was 3.8°C for retail, 2.68°C for office, 2.33°C for industrial, and 3.8°C for residential. The overall portfolio’s warming potential was 2.78°C (Figure 2-30) which is higher than the 2°C and 1.5°C targets set by the Paris Agreement (Figure 2-30).

As described above, by analyzing climate-related financial information on the real estate portfolio using CVaR, we were able to evaluate physical risks from natural disasters, global warming potential, and the distance to the achievement of the 1.5°C target. However, unlike climate-related risk and opportunity analysis for traditional asset classes, there is still a great deal of room for further development in the analysis for alternative assets. There are several reasons for this, such as data limitations that restrict the scope of analysis for alternative assets, and the fact that results differ at the portfolio level depending on whether the weighted average is calculated using gross floor area or asset price.

Figure 2-30 Global Warming Potential of the Domestic Real Estate Portfolio



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(Appendix) CVaR: Methodology Descriptions

Characteristics of CvaR

MSCI's Climate Value-at-Risk (CVaR) is a valuation model that measures the potential impact of climate change on corporate and security values. CVaR measures the impact of future climate-related costs and revenue opportunities from low-carbon technologies on the value of a company and the securities it issues. Although there is still room for improvement in measurement methods, CVaR is an extremely innovative analytical method in that it can comprehensively assess the costs and opportunities of climate change in terms of its impact on corporate and security values based on financial theory. The following four steps are taken to measure the impact of climate change-related costs and revenue opportunities from low-carbon technologies on corporate equities and bonds:

Step 1: Estimate future climate change-related costs and profits
Step 2: Discount future climate change-related costs and profits to present value
Step 3: Estimate the impact on present corporate value (EV: Enterprise Value)
Step 4: Apportion the impact into impacts on equity and debt securities

CVaR has three main components: (1) Policy risk, (2) Technology opportunities, and (3) Physical risk[21]、which are combined into aggregated CVaR (Figure 2-31). (1) and (2) together are categorized as "transition risks and opportunities," and can be evaluated as a whole with (3) physical risks. The following sections provide details on calculating CVaR for (1), (2) and (3) above.

Figure 2-31 Composition of Aggregated CVaR and Scenario Analysis Assumptions

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[21] "Physical Risks and Opportunities" in the last fiscal year's ESG REPORT and in the supplementary guide to the ESG REPORT are referred to as "Physical Risks" in this fiscal year. However, as described in the main text, this is the same as last fiscal year in that the positive and negative impacts on corporate earnings are netted.

Climate Change Policy CvaR

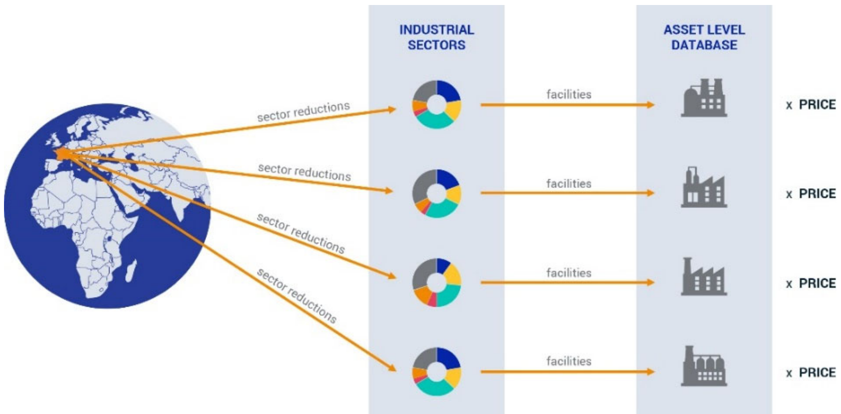
Policy CVaR estimates a company's costs associated with reaching emissions reduction targets under future climate change policies through the end of the 21st century. The Policy CVaR model analyzes the downside risk of climate policy to a company and its securities by estimating the future cost to that company of reducing emissions required to comply with these policies.

First, Policy CVaR analyzes the impact of national emissions reduction targets (Nationally Determined Contributions, commonly called NDCs) submitted under the Paris Agreement and recent national climate change-related regulations. These targets and regulations include Scope 1 GHG emissions, which are directly emitted from business activities, and Scopes 2 and 3 GHG emissions, which are indirectly emitted. The Scope 1 emissions analysis involves setting GHG emissions reduction targets at the national and sector level based on the country's NDC, and assigning emissions reduction requirements to companies operating in those sectors. The allocation is based on the "fair share" principle – i.e. each company is allocated a portion of the total required country and sector Scope 1 emission reduction according to the company's level of emissions. In other words, companies with a greater percentage of total emissions levels in their sector are required to reduce GHG emissions by a proportionally higher percentage.

In addition, company asset data is used to assign sector emission reduction targets to each company's facility level. This allows us to calculate emissions reduction requirements for facilities owned and operated by companies worldwide. By multiplying each company's demand for emission reductions by the future carbon price, we calculate the climate change policy cost that each company would have to pay to achieve its emission reduction target (reduction requirement) (Figure 2-32).

A portion of this climate change policy cost is modeled to pass through to customers and suppliers within a company's value chain as discussed below. Incidentally, the carbon price is determined using the integrated assessment model and depends on the selected policy scenario (1.5℃, 2℃, 3℃).

Figure 2-32 Image of Scope-1 Emissions Analytical Models for Policy CVaR



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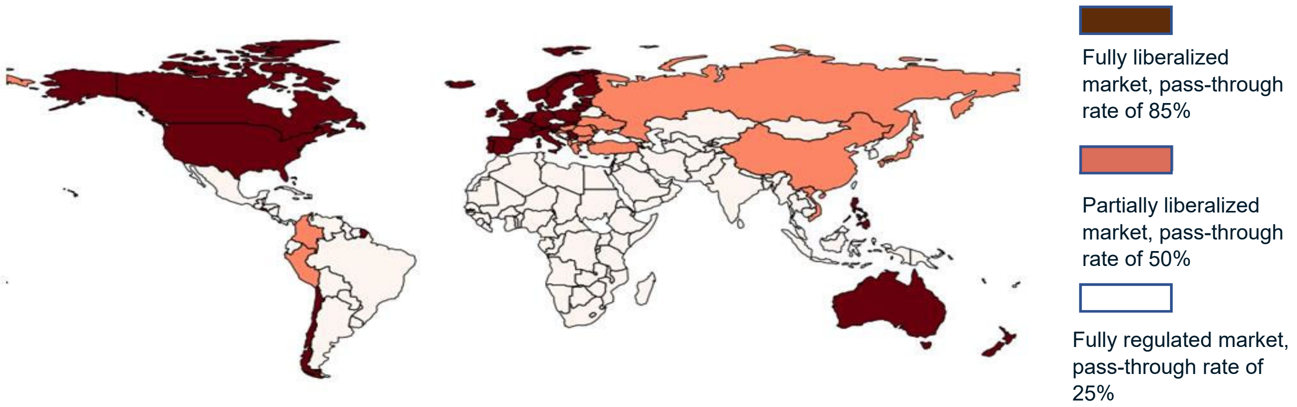
The scope 2 emissions analysis calculates the costs incurred by power producers that are passed on to consumers. The transition to a low-carbon economy requires switching electricity sources from coal and natural gas to lower carbon or GHG emissions-free sources. However, this transition can be costly. For electric power companies, phasing out fossil-fuel-based thermal power plants and shifting to low-carbon power sources leads to increased capital expenditures. These include decommissioning aging power plants, introducing new technologies, and upgrading power grids to ensure supply from new power sources. Electric power companies do not bear all these costs – some are passed on to electricity consumers. The potential cost associated with electricity consumption for each transition scenario is calculated from data on electricity production and consumption generated by the Integrated Assessment Model and estimates of cost passthrough rates to consumers. For example, in regions where the electricity market is fully liberalized, power producers are expected to pass on 85% of their costs to end consumers. We assume a pass-through rate of 50% for partially liberalized regions and 25% for fully regulated regions.

Figure 2-33 Pass through rates of Scope 2 Emissions from the Policy CVaR



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The Scope 3 emissions analysis examines each company’s potential carbon-related costs within the value chain, as determined by the size of the company's Scope 3 emissions. By combining Scope 3 carbon-related costs with assumed burden rates, we estimate the impact on the costs that companies will incur from GHG emissions occurring in the value chain. The assumed burden rate represents the level of costs that a company may bear depending on the amount of GHGs emitted from the value chain, which stem from 15 upstream and downstream categories as defined by the GHG protocol.[22] The CVaR analyses also distinguish between upstream and downstream categories. For example, by analyzing upstream GHG emissions, we assess the risk that companies' procurement

[22] International standards for the calculation and reporting of greenhouse gas emissions. The World Resources Institute and WBCSD operate in cooperation with governments, companies, and NGOs, and publicize the definitions of Scopes 1, 2, and 3. GHG Protocol https://ghgprotocol.org/

costs for materials and other items will increase. The downstream GHG emissions analysis, on the other hand, examines the risk that a company's market share will be lost due to changes in demand. By evaluating upstream and downstream GHG emissions independently, we calculate a company's "value chain (scope 3) CVaR" and included this in the company's policy risk evaluation. The assumed burden rates applied to distinguish the upstream and downstream impacts of the value chain are as follows (Figure 2-34).

Scope 3 Upstream Burden Rate: Upstream Burden Rate represents the percentage of costs that are passed through from companies upstream in the value chain to companies being evaluated. If countries implement climate change policies aimed at reducing GHG emissions, companies may need to shift to less-emitting production technologies and product development, and if this is not possible, they may face the risk of paying fines and taxes. This could lead to increased capital and operating expenditures to comply with climate change policies, which in turn could increase a company's marginal cost of production. Competitiveness in a company's product markets and how efficiently a company can internalize its costs affect analysis of how much the company can pass on its climate costs to its customers.

Scope 3 Downstream Burden Rate: Downstream Burden Rate is the percentage of costs that a company must absorb as market demand for its products has been affected. In a low carbon economy transition scenario, it is anticipated that the implementation of regulations aimed at reducing GHG emissions will result in weak market demand for high GHG emission products and a shift in market demand from low carbon products to zero emission products. This means that demand for its products may decline sharply in a particular sector. The assumed burden ratio varies depending on the price elasticity of demand and the substitutability of the product.

Figure 2-34 Examples of Scope 3 Emissions burden rates in the Policy CVaR

Scope 3 Category		Assumed Burden Rate	Rationale	Supporting Research
Default Burden Rate		45%	Research suggests an overall low burden rate for industry.	Nuehoff & Ritz (2019) MSCI ESG Research estimate
4 + 9	Upstream and downstream transportation	100%	High burden rate as extra costs from transportation are typically passed on to a high degree because of low profit margins.	MSCI ESG Research estimate
6	Business travel	78%	Research suggests a rather high burden rate for some of the major business transportation means such as air travel.	Grey & Ritz (2018)
7	Employee commuting	0%	No burden on companies, assumes costs are absorbed by employees.	MSCI ESG Research estimate
11	Use of sold products	Sector specific	Burden rates depend on several sector specific factors such as: • Price elasticities of demand • Depth of supply chain • Sector competitivity	Droege (2013) Ganapati et al. (2019) MSCI ESG Research estimate
	• Consumer Discretionary	60%		
	• Energy	55%		
	• Materials	10%		
15	Investments	5%	Weak impact of investor costs on market capitalization leads to a low burden rate.	MSCI ESG Research estimate

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Measures Against Double Counting

Given that GHG emissions from Scope 3 are an important factor in institutional investors' climate risk management, we need to consider the issue of double counting of GHG emissions. Double counting for GHG emissions refers to counting the same emissions more than once. For example, the Scope 1 GHG emissions for one company can be counted as another company's Scope 3 emissions. This occurs primarily when a company's comprehensive carbon footprint (scopes 1, 2, and 3) is aggregated within its investment portfolio. Even if companies in the same value chain calculate and report the same emissions, the reasons for double counting differ. For example, oil mining companies should report GHG emissions generated when fuel products sold are burned, while car companies should include emissions from the combustion of the same fuel in reporting GHG emissions generated when vehicles sold are used. Some fossil fuel refining companies also perform similar calculations and reports. In most cases, model estimates are available without problems, but the inclusion of double counting may be a barrier. We recognize that it is not possible to completely eliminate duplication from scope 3 emissions even in CVaR analyses. The most difficult issue is that individual companies may have significantly different levels of double counting.

Despite these barriers of double counting, pressure is increasing to fully understand the upstream and downstream climate risks of the investment portfolio. In CVaR analyses, we use deduplication factors to reduce the impact of double counting. With regard to the calculation of the deduplication factors, at first, in order to determine the double counting at the macro level, we calculated the total GHG emissions of the largest group of enterprises (10,000 or more enterprises) with both Scope 1 GHG emissions and Scope 3 GHG emissions data points for each scope and determined their relationship. Assuming that the GHG emissions for these two data sets are within a limited closed environment, the relationship between the data points can be regarded as an approximation of the double counting that occurred. All Scope 3 emissions at any point in time are considered to have been Scope 1 emissions by other companies. CVaR models calculate deduplication factors from these relationships and apply them to the analyses.

Figure 2-35 Estimated Burden Rate of Scope 3 Emissions from the Climate-Change Policy-Risk CVaR

Number of companies	10,881
Sum of Scope 1 total emissions	15,028 MtCO2 / year
Sum of Scope 3 total emissions	68,080 MtCO2 / year
Deduplication Factor	～0.22

Note: This deduplication factor is illustrative and may not be the actual factor used to compute CVaR.

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Low-carbon Technology Opportunity CvaR

The Low Carbon Technology Opportunity CVaR calculates the profits a company generates in the future from low carbon technologies based on an assessment of the status of companies' acquisitions of low carbon technology patents and current low carbon technology-related revenues. This patent analysis covers approximately 100 million corporate patent data from more than 70 patent authorities worldwide. Assessing the quality of low-carbon patents classified in more than 400 groups and using that assessment as an alternative indicator of an enterprise's innovative capacity, this model aims to analyze which companies are likely to generate profits and gain growth opportunities from low-carbon technologies when policies related to climate change are implemented globally at the 3°C, 2°C, or 1.5°C levels. This low-carbon technological opportunity CVaR works to boost corporate value and security value as a factor in contrast to the impact of the costs of climate change policies (the cost of reducing carbon emissions) that arise as a result of the transition to a low-carbon society.

Because not all patents have equal value, the number of patents alone cannot predict a company's innovative capabilities or future market growth potential. The Low-Carbon Technology Opportunities CVaR calculates patent scores based on four statistical measures established in academic literature and by practitioners (Figure 2-36).

Profits from each company's environmental technologies are calculated by allocating future environmental revenues for each sector by the share of patent scores within the sector, and multiplying the allocated revenues by the sector average profit margin. At this time, we assume that the size of the sector's future revenues from environmental technologies is equal to the sector-level climate change policy costs (the cost of reducing carbon emissions) calculated under the Climate Change Policy Risk CVaR. This is because we assume that if the cost of reducing carbon emissions is incurred, the potential revenues from selling low-carbon technologies are equal.

Figure 2-36 Four statistical measures in the calculation of patent scores

Forward citations	The number of references to the patent in other patent applications. This is a measure of the widespread acceptance of the value or significance of a patent. If a patent is frequently cited by other patent applications, the patents frequently cited are likely to be fundamental technologies or important technology patents.
Backward citations	The number of patents of others cited at the time of filing of the patent application. A larger number of backward citations reduces the patent value because it is likely to be older and based on more established technology.
Market Coverage	The total GDP of the country in which the patent to be evaluated was filed. The higher the market coverage, the higher the patent score.
CPC coverage	Number of tagged CPC patent groups. Cooperative Patent Classification (CPC) evaluates the relevance of patents to patent groups based on the International Patent Classification. The more groups tagged in this relevance assessment, the higher the patent score.

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Physical Risks CvaR

The Physical Risks CVaR analyzes the financial impacts of acute and chronic extreme weather that is expected to occur over the next 15 years, based on abnormal weather patterns observed over the last 40 years. The impact of physical risk is calculated at the region, sector, and enterprise levels.

The Physical Risk CVaR estimates the physical risk at the company's facility level under selected scenario conditions (average or aggressive scenario) for three factors: "exposure (assessment based on the location, size, type, and value of the enterprise's assets)", "hazards (probabilities and severity of abnormal weather events)", and "vulnerability (the propensity or predisposition of an asset to be affected)".

The physical risk CVaR is currently classified into two types of risk (chronic risk and acute risk). The following eight types of extreme weather events are the scope of the Physical Risk CVaR Analysis, with the addition of the Fluvial Flooding in this fiscal year (Fig. 2-37).

New natural disaster: Fluvial Flooding

The regions affected by flooding are usually relatively limited on coastlines, but those regions are exposed to potential significant risks because of the concentration of economic activity and assets in these regions. The Physical Risks CVaR assesses the impact of river flooding and coastal flooding on investment portfolios based on an extensive hazard data set, data on regional flood control, and characteristics of sector vulnerabilities. Specifically, we estimate the full range of impacts that could have a financial impact on the business activities, including the costs of repairing or replacing affected assets and restoring operations, as well as the impact of disruptions in operations.

Figure 2-37 Natural Disasters Subject to Analysis of Physical Risks CVaR

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Financial Models that Reflect Climate Change Risks and Opportunities in Security Values

As noted earlier, CVaR estimates follow four steps. In Step 1, we estimate future climate-related costs and profits, and the analyses will take a different approach over the next 15 years and beyond. For the first 15 years, we estimate in detail climate change policy risks, profits from low carbon technologies, business losses and facility damage due to extreme weather. From the 16th year onward, we estimate costs through 2080 using the model.

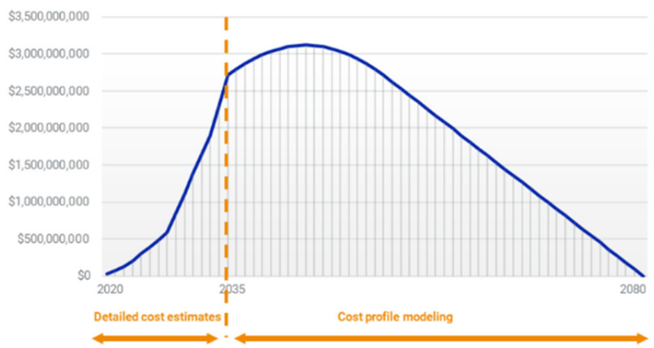
The model estimates that climate change policy costs and profits from low-carbon technologies will peak in the next 25 years and then decrease linearly to 0 by 2080 (Figure 2-38). On the other hand, actual climate change, such as global warming, is expected to have a longer-term impact. For physical risks, the annual growth rate is set at 3%, and it is assumed that this will continue until 2080.

Step 2 is to discount costs and profits calculated under Step 1 using the weighted-average cost of capital (WACC). The model assumes that the discount rate used for the first year is equal to a company's WACC and over time the rate converges to the sector average WACC by 2080.

Step 3 calculates CVaR of the company, which is the present value of the costs and profits calculated in previous step divided by the enterprise value (EV:). The value implies the impact of climate change-related costs and profits on enterprise value[23].

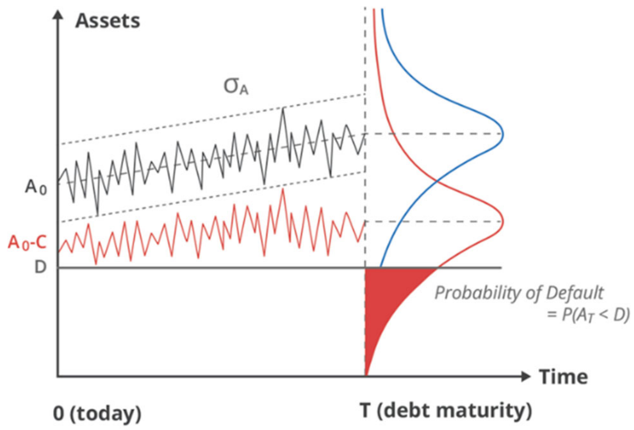
Finally, Step 4 divides the company-level CVaR into its equity and debt securities. In this step, CVaR for debt securities is determined by the Merton model to estimate the change in the probability of the company's default resulting from climate-change-related costs and profits (Figure 2-39). Equity CVaR is then calculated using the company's aggregated CVaR and CVaR for debt securities.

Figure 2-38 Estimation Methods and Image of Climate Change Policy Costs and Low-Carbon Technologies Profits



Source: Reproduced by permission of MSCI ESG Research LLC©2021

Figure 2-39 Image of the Merton Model



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[23] It is assumed that the current enterprise value does not incorporate the climate change-related costs and benefits that are being analyzed.

Chapter 3: Analysis of Inter-Industry Transfer of Transition Risks and Opportunities

Analysis Purpose and Process

The analyses presented in previous sections of this report adopt a bottom-up approach to explore the impact of climate risks on GPIF's portfolio. This approach begins by measuring and analyzing the carbon footprint, CVaR, and other factors of individual companies and securities, then aggregating the results across all of GPIF's equity and bond holdings.

This section departs from the perspective of the direct impact on GPIF's portfolio to examine how climate change-related risks and opportunities will shift between industries over the long term to 2030 and 2050, according to an analysis performed by Astamuse. Specifically, this analysis uses data on industry-level required greenhouse gas (GHG) reductions, expected GHG reduction contributions of individual decarbonization technologies, and projections for the rate at which they will be implemented in society. As opposed to the CVaR analysis, which assumes that the transfer of risks and opportunities occur within the same industry, the purpose of this analysis is to focus more on the opportunities inherent in decarbonization and appraise different GHG reduction technologies by understanding the transfer of risks and opportunities that occur between industries. We reveal the potential for certain industries to boost growth by turning risks for other industries into opportunities for themselves.

Figure 3-1 Inter-Industry Risk and Opportunity Transfer Visualization Process

Step1: Risk Analysis

Estimate Required GHG reductions by industry for 2030/2050.

＊The Sustainable Development Scenario (SDS) developed by the International Energy Agency (IEA) is used to estimate required GHG reduction rates for 2030/2050 for each industry.

Step:2 Opportunity Analysis

Identify technologies with the potential to contribute to GHG reductions by industry and estimate GHG reduction contributions (= current GHG emissions × GHG reduction rate × implementation rate) in 2030/2050 for individual decarbonization technologies.

Step:3 Risk and Opportunity Transfer Visualization

Net GHG reduction opportunities = GHG reduction contributions – required GHG reductions

＊GHG reduction contributions = GHG reduction potential x adjustment factor

The adjustment factor is a value that balances total required GHG reductions for all industries with total GHG reduction contributions

Source: Prepared by GPIF based on Astamuse analysis

Risk Analysis

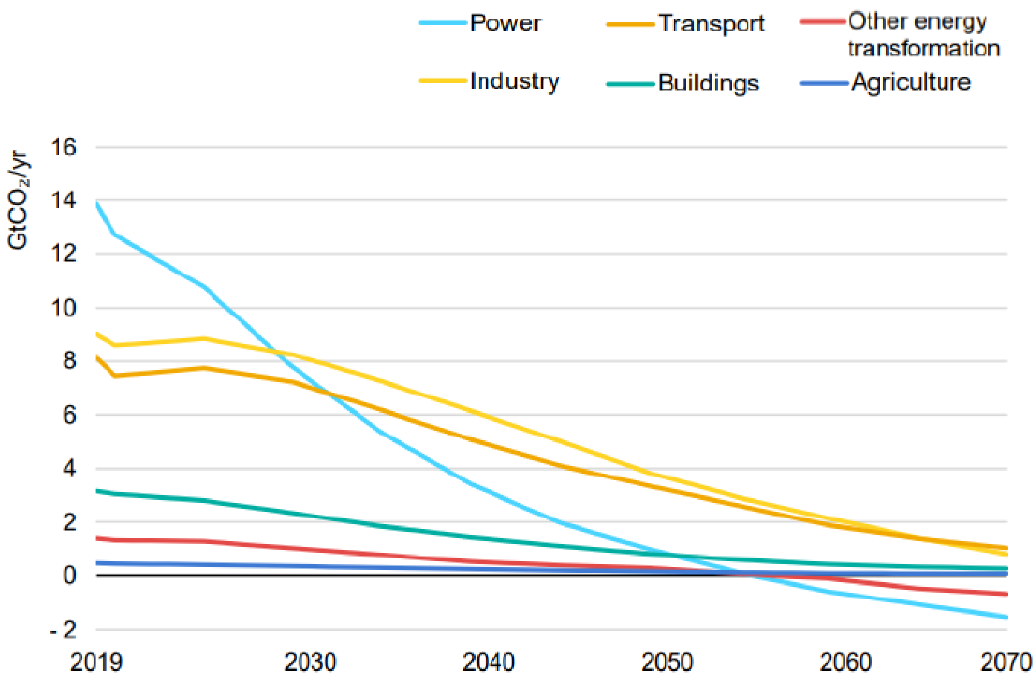
The first step in this analysis is to identify the emissions reductions required in each industry by 2030 and 2050 to achieve the target of limiting global warming to “well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels” (Step 1 of Figure 1) as agreed in the Paris Agreement. Here, we use the Sustainable Development Scenario (SDS) compiled by the International Energy Agency (IEA) to calculate the emissions reductions required to achieve the goals of the Paris Agreement. The SDS outlines CO_2 emission reduction paths for a number of different industries from 2019 to 2070 that would meet these goals (Figure 3-2). Based on these paths, we derive the GHG reduction targets for each industry for 2030 and 2050 as a percentage of 2019 emissions. The industries included in the IEA analysis are “Power,” “Industry,” “Transportation,” “Buildings,” “Agriculture,” and “Other Energy Transformation,” which Astamuse reorganizes into 13 different industries based on decarbonizing/carbon reducing technologies for the purposes of this analysis (Figure 3-3).

For each of these 13 industries, we aggregate GHG emissions data based on public information for the top 40 companies in the world by revenue. Emissions for companies with no or partial GHG disclosures are estimated based on financial data and emissions information disclosed by similar companies. The total emissions for the top 40 companies in the industry are then divided by the total revenue share of these companies as a percentage of total industry revenue to derive the estimated GHG emissions of the entire industry. The total GHG emissions for each industry in 2020 ((a)), GHG reduction target rates for 2030 and 2050 ((b), (c)) and required reduction amounts ((a) x (b), (a) x (c)) are shown in Figure 3-4. Additionally, we calculate emissions generated for each segment in the supply chain for each industry. Using the GHG Protocol[24] definition of Scope 1 to Scope 3 emissions and Categories 1 to 15, which separate the supply chain into upstream portions (purchased goods/services, etc.) and downstream portions (processing, usage and disposal of sold goods, etc.), we break down the supply chain into four broad segments: “raw materials” (Scope 3 categories 1-3 and 5-8), “production” (Scope 1, Scope 2), “use/disposal” (Scope 3 categories 10-15) and “transportation” (Scope 3 categories 4 and 9) (Figure 3-5).

The results of the above analysis indicate that “Construction, Civil Engineering and Construction-Related Products”, “Energy,” and “Metals, Mining and Paper Products” are predicted to have the highest level of required GHG emission reductions (i.e. high risk). Looking at the supply chain of the Construction, Civil Engineering and Construction-Related Products industry, we can see that most of emissions are generated in the “raw materials” (i.e. cement and steel-related GHG emissions) and “use/disposal” (i.e. GHG emitted when buildings are used) segments.

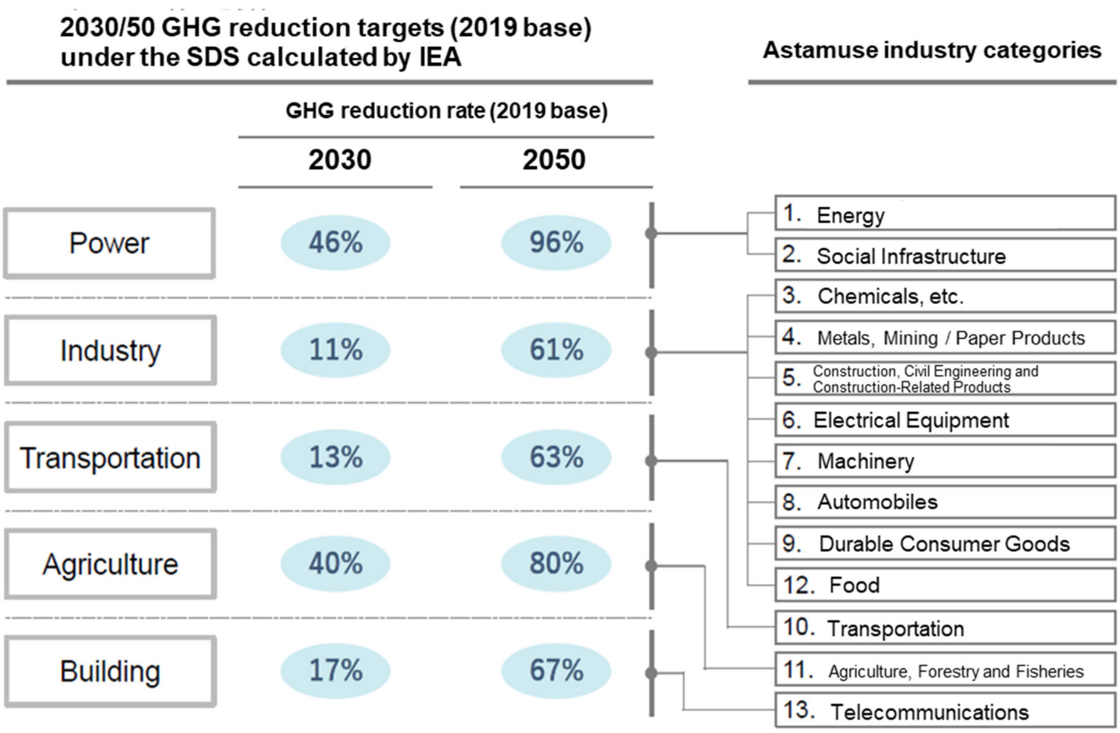
[24] GHG emission calculation and reporting standards developed by the GHG Protocol initiative

Figure 3-2　CO2 Emission Trends by Industry from 2019 to 2070 Under the SDS



Source: Prepared by GPIF based on IEA analysis

Figure 3-3　IEA-Calculated 2030/50 GHG Reduction Target Rates (2019 base) Under the SDS and Project Industry Classification



Source: Prepared by GPIF based on Astamuse analysis

Figure 3-4 2020 Total GHG Emissions and GHG Reduction Target Rates/Required Reduction Volumes for 2030/50

Industry	Total emissions (as of 2020): Total GHG emissions (a)	2030: Reduction target (b)	2030: Required reductions (a x b)	2050: Reduction target (c)	2050: Required reductions (a x c)
	bn. tons	%	bn. tons	%	bn. tons
Energy	8.30	46%	3.8	96%	7.97
Social Infrastructure	0.56	46%	0.3	96%	0.54
Chemicals, etc.	4.83	11%	0.5	61%	2.95
Metals, Mining / Paper Products	5.86	11%	0.6	61%	3.57
Construction, Civil Engineering and Construction-Related Products	13.55	11%	1.5	61%	8.27
Electrical Equipment	0.13	11%	0.0	61%	0.08
Machinery	1.03	11%	0.1	61%	0.63
Automobiles	1.50	11%	0.2	61%	0.92
Durable Consumer Goods	0.80	11%	0.1	61%	0.49
Transportation	1.51	13%	0.2	63%	0.95
Agriculture, Forestry and Fisheries	3.47	40%	1.4	80%	2.77
Food	1.75	11%	0.2	61%	1.07
Telecommunications	2.01	17%	0.3	67%	1.34
Total	45.29		9.2		31.54

Source: Prepared by GPIF based on Astamuse analysis

Figure 3-5 Supply Chain Segment Emissions by Industry

Industry	Supply Chain: Raw Materials	Supply Chain: Production	Supply Chain: Use/Disposal	Supply Chain: Transportation	Total emissions: Subtotal
	bn. tons	bn. tons	bn. tons	bn. tons	bn. tons
Energy	0.36	1.67	6.05	0.22	8.30
Social Infrastructure	0.02	0.47	0.07	0.00	0.56
Chemicals, etc.	1.67	1.84	1.18	0.14	4.83
Metals, Mining / Paper Products	0.24	4.28	1.22	0.11	5.86
Construction, Civil Engineering and Construction-Related Products	3.66	2.58	6.78	0.54	13.55
Electrical Equipment	0.02	0.02	0.08	0.00	0.13
Machinery	0.01	0.01	1.01	0.00	1.03
Automobiles	0.33	0.05	1.09	0.03	1.50
Durable Consumer Goods	0.20	0.18	0.40	0.01	0.80
Transportation	0.38	0.85	0.00	0.27	1.51
Agriculture, Forestry and Fisheries	1.53	1.41	0.27	0.26	3.47
Food	0.97	0.36	0.12	0.30	1.75
Telecommunications	0.36	0.49	1.11	0.04	2.01
Total					45.29

Source: Prepared by GPIF based on Astamuse analysis

Opportunities Analysis

Next, we identified the technologies that contribute to the reduction of GHG, estimated emissions reduction rates for each technology compared with existing technologies, and forecast the implementation of each in 2030 and 2050. We then use these figures to calculate the GHG reduction contributions (opportunities) of individual technology fields (Step 2 of Figure 3-1). In this step, Astamuse utilized their proprietary database, which includes data on various technologies, research themes, research papers and new business enterprises, along with technology analyst insight to comprehensively identify 40 technology fields likely to contribute to greenhouse gas reduction (Figure 3-6). This is done by using machine learning to perform a cluster analysis of 10s of millions of innovation-producing ideas (new products, businesses and technologies) and experts with sophisticated technical knowledge to identify where innovators and innovation capital is flowing.

Figure 3-6 40 Technology Fields Contributing to GHG Reduction

Industry	Technology Fields
Energy	Bioenergy (generation, fuel)
	Hydropower energy, small and medium hydroelectric power generation
	Smart grid / smart city
	Hydrogen/ammonia power generation
	Hydrogen systems and infrastructure
	Green hydrogen
	Hydrogen storage/transport
	Photovoltaic power generation, solar batteries, solar thermal power generation
	Wind Power
	Marine energy
	High-efficiency thermal power generation (coal, natural gas, methane capture from oil fields)
	High-efficiency thermal power generation
	High-efficiency LNG power generation
	Geothermal power
	Nuclear power, nuclear fusion
Social Infrastructure	Underground and submarine carbon storage (phytoplankton solidification, upwelling/sinking current promotion (synthetic submarine mountain ranges), etc.)
	Underground carbon storage
	Submarine carbon storage
	Underground injection, submarine storage
	Waste and sewage sludge treatment (energy capture from hydrogen/methane/BFC)
	Power generation from anaerobic digestion of biomass waste
	Usage of waste materials in production of biomass
Metal, Mining, and Paper Products	Low-carbon steelmaking
	Ferro coke
	Reduced iron
	Hydrogen direct reduction steelmaking
Construction, Civil Engineering and Construction-Related Products	Energy-efficient housing (insulation, HEMS/BEMS/ZEH/ZEB)

Continued on following page

Figure 3-6 40 Technology Fields Contributing to GHG Reduction

Industry	Technology Fields
Chemicals	Bio materials (concrete/biomass-based plastics)
	Materials capable of CO_2 absorption/adherence/separation/condensation/long-term storage (membranes, filters, polymers, chemicals) (including DAC, carbon-absorbing concrete)
	CCS from high emission sources
	DAC
	Carbon absorbing concrete
	Fuel cells
	Batteries
	Fully solid batteries
	Next-generation capacitors
	Air cells
	Reduction of CFC emissions, green refrigerants
	Carbon reuse (usage of captured CO_2 in production, fuel, concrete, etc.)
	Methanol production
	Polymer production
	Concrete/cement production
Electrical equipment	Electrification of industrial equipment (heating/drying, etc.), energy management (FEMS, etc.)
	Industrial heat pumps
	Sensing networks
	Energy harvesting
	Reducing losses in power transmission
Machinery	Electric drive, power supply equipment (ships/aircraft (incl. drone-based transport), farm equipment, construction equipment) excl. automobiles
	Hybrid aircraft
	Electric ships
	Electric farm equipment/construction equipment
	Ammonia drive (automobiles/ships)
	Heat storage, heat transport technology, heat pumps
Automobiles	Hydrogen/fuel cell vehicles
	Clean energy vehicles (engine efficiency, usage reduction through smaller vehicles, lightweight chassis)
	Electric Vehicles
	Hybrid automobiles
	Electric vehicles (BEV)
Durable Consumer Goods	Energy-efficient home appliances and lighting
	Power semiconductors
	Auto-control of appliances/lighting using AI
Transportation	Smart transport, MaaS (ship operation/docking efficiency, sophistication of air traffic control systems using satellites, etc.)
	Modal shift (public transport, community busses, on-demand transport, shift from trucking to rail/ship)
Agriculture, Forestry and Fisheries	Advanced uses of wood (construction material, charcoal, modified lignin, cellulose nanofibers, etc.), substitution of plastic/metal materials with wood/paper
	Smart agriculture (fertilizer/water absorption/feeding efficiency, improvements in feed stock efficiency, reduction in methane emissions, use of CO_2 in horticulture/greenhouses
	Cultured meat/meat substitutes/dairy substitutes (reducing livestock methane)
	Afforestation, desert greening (incl. breed improvement/elite trees, etc.)
Food	Reducing byproducts and food waste in manufacture of food products
	Innovative extension of storage periods
	Food waste utilization
Telecommunications	Power semiconductors

Source: Prepared by GPIF based on Astamuse analysis

Next, we project the GHG reduction rate and market implementation rate in 2030 and 2050 for these 40 technology fields. For the GHG reduction rate, Astamuse analysts review a broad array of reports and publications by governments, international institutions and think tanks to identify the current technologies that can be substituted by GHG reducing technologies, and estimate the degree to which they can be substituted by 2030 and 2050. Taking the bioenergy field as an example, the CO2 reduction rate for liquid biofuels used in transportation is around 55% as compared to gasoline according to the Japanese government's Energy Supply Structure Enhancement Act, so gasoline is specified as the replaced technology for bioenergy, and the GHG reduction rate is set at 55% for 2030 and 2050.

For the implementation rate estimate, Astamuse analysts first perform a qualitative assessment of key technologies based on academic papers and other leading research to identify hurdles to the widespread adoption of each technology field and the milestone technologies vital to overcoming these issues. Based on who is the main party involved in developing the technology (business and/or academia), the current state of research and development and other factors, analysts then select the most appropriate data source (patents, research papers or grants) to use in determining the current implementation phase (R&D, Verification, Introduction, Spread, or Expansion) for each milestone technology. Then, using this data source, analysts study technological development trends over the past 20 years to estimate the life cycle and current implementation phase for each technology. In the bioenergy example, production of biofuels based on inedible and organic waste and algae-based fuels is expected to grow in the future, and as such, 1) cellulose-based fuels, 2) waste product biomass fuels and 3) algae-based fuels are designated as milestone technologies. For each of these, research papers are used to determine the future implementation phase and therefore the implementation rates for each milestone technology in 2030 and 2050 (Figure 3-7).

Figure 3-7　GHG Reduction Rates and Implementation Rates for Bioenergy Milestone Technologies

Chronological trends in patents/research papers/research themes (grants) related to bioenergy

Patent application trends

Forward-looking technology	Total	2000–2019
Cellulose-based fuels	5458	
Waste product biomass fuels	757	
Algae-based fuels	3162	

Research paper trends

Forward-looking technology	Total	2000–2019
Cellulose-based fuels	1167	
Waste product biomass fuels	8908	
Algae-based fuels	9213	

Grant number trends

Forward-looking technology	Total	2000–2019
Cellulose-based fuels	718	
Waste product biomass fuels	817	
Algae-based fuels	631	

Milestone technology implementation rate

		Chronological trend 2020	2030	2050
Cellulose-based fuels	Current technology replacement rate	55%	55%	55%
	Development phase	Development	Verification	Spread
Waste product biomass fuels	Current technology replacement rate	55%	55%	55%
	Development phase	Verification	Introduction	Expansion
Algae-based fuels	Current technology replacement rate	55%	55%	55%
	Development phase	Development	Development	Introduction

Source: Prepared by GPIF based on Astamuse analysis

Next, Astamuse analysts evaluate each technology field based on replaced technologies and other factors. For each industry’s estimated supply chain segment emissions shown in Figure 3-5, they identify which technology can contribute to GHG reductions in which supply chain segment of which industry, and by how much. These values are then aggregated for each technology across industries to obtain the total emissions for all target segments to which the technology can contribute to GHG reductions. In the case of bioenergy, gasoline is identified as the replaced technology. As a result, bioenergy is anticipated to contribute to the manufacturing and transportation segments across a broad swath of industries, resulting in an estimated target segment emission total of 11.48 billion tons (Figure 3-8).

Multiplying total target segment GHG emissions by the GHG reduction rate and implementation rate for each technology field as derived above yields the potential GHG reduction contribution thereof. Figure 3-10 gives the 10 technological fields with the highest potential GHG reduction contributions. The energy field in particular has many technologies that have significant potential to contribute to lower greenhouse gases, owing to the high emissions that occur along the supply chains in the industries for which these technologies can contribute, among other factors. One somewhat unexpected finding is that “hydropower energy and small and medium hydroelectric power generation” is shown to have the largest opportunity out of all technologies. On a global level, however, the technological potential of hydroelectric power as a whole is estimated to be approximately 15,000 TWh, or about 65% of global power consumption (approx. 23,000 TWh)[25]. Additionally, looking at global demand trends, countries that have rivers with large watersheds such as China are expected to substantially expand hydroelectric power generation. Furthermore, as fossil fuel-based power decreases, enhanced hydropower generation management made possible by improvements in weather, precipitation and flow forecasting will help maximize dam performance for existing and future stock, thereby dramatically contributing to reduced emissions.

Figure 3-8 GHG Emission Reduction Target Sectors (Bioenergy)

Industry	Supply Chain				Subtotal
	Raw materials	Production	Use/Disposal	Transportation	
Construction, Civil Engineering and Construction-Related Products	0	3.87	0	0.21	4.08
Energy	0	1.59	0	0.18	1.76
Metals, Mining / Paper Products	0	2.14	0	0.09	2.23
Chemicals, etc.	0	0.92	0	0.11	1.03
Agriculture, Forestry and Fisheries	0	0.70	0	0.21	0.91
Telecommunications	0	0	0	0	0
Food	0	0.18	0	0.24	0.42
Transportation	0	0.43	0	0.22	0.64
Automobiles	0	0.03	0	0.02	0.05
Machinery	0	0.01	0	0.00	0.01
Durable Consumer Goods	0	0.09	0	0.01	0.10
Social Infrastructure	0	0.24	0	0	0.24
Electrical Equipment	0	0.01	0	0	0.01
Total					11.48

Note: Values are in billions of tons.

Source: Prepared by GPIF based on Astamuse analysis

[25] *Technology Roadmap: Hydropower* (IEA) https://iea.blob.core.windows.net/assets/8b1f76a8-f48a-46bf-ab5e-f91695011a85/2012_Hydropower_Roadmap.pdf

Figure 3-9 Top 10 Technology Fields With Largest GHG Reduction Potential

Industries	Technology Fields	Present	2030			2050		
		GHG Emissions of Target Segment (a)	GHG Reduction Rate (b)	Implementation Rate (c)	GHG Reduction Contributions (a × b × c)	GHG Reduction Rate (d)	Implementation Rate (e)	GHG Reduction Contributions (a × d × e)
		bn. tons	%	%	bn. tons	%	%	bn. tons
Energy	Hydropower energy, small and medium hydroelectric power generation	10.02	100%	65%	6.51	100%	65%	6.51
Chemicals	CCS from large emitters	8.00	90%	5%	0.36	90%	85%	6.12
Energy	Marine energy	6.64	100%	15%	1.00	100%	85%	5.65
Energy	Solar power generation, solar cells, solar thermal power generation	6.64	99%	50%	3.29	99%	85%	5.59
Energy	Bioenergy (power generation, fuel)	11.48	55%	15%	0.95	55%	85%	5.37
Telecommunications	Power semiconductors	7.27	71%	50%	2.58	71%	100%	5.16
Chemicals	Methanol production	8.83	65%	15%	0.86	65%	85%	4.88
Social Infrastructure	Power generation by anaerobic digestion of waste biomass	6.64	15%	15%	0.15	85%	85%	4.80
Energy	Green hydrogen	8.43	100%	0%	0.00	100%	50%	4.21
Energy	Hydrogen/ammonia power generation	10.02	79%	5%	0.40	79%	50%	3.96

Source: Prepared by GPIF based on Astamuse analysis

Inter-Industry Risk and Opportunity Shift Potential

The last step in the process is to reveal how risks and opportunities may potentially shift between industries. To do this, we aggregate the GHG reduction potential of all technology fields by industry, then multiply each by an adjustment factor to obtain each industry's GHG reduction potential. From this, we subtract the required GHG emission reductions for that industry. The adjustment factor is included in the calculation to reflect the fact that in reality, amongst the many competing GHG reduction technologies, those that are most effective and efficient at cutting emissions will be used most widely. As a result, total GHG reduction contributions far surpassing total required GHG reductions is not a very realistic outcome. An adjustment factor is therefore applied to balance total required GHG reductions and total potential GHG reduction contributions. In other words, GHG reduction contributions is defined as potential GHG reduction contributions multiplied by the adjustment factor.[26]

If GHG reduction contributions are larger than required reductions, the industry has a "net opportunity." Conversely, if required reductions outweigh potential contributions, the industry is deemed to have a "net risk." (Figure 3-1 Step 3, Figure 3-10). The risk and opportunity profile for each industry in 2030 and 2050 as determined by the above process is shown in Figure 3-11. In 2050, opportunities will outweigh risks in seven industries, including energy, chemicals, and social infrastructure, while risks will outweigh opportunities in six industries, including construction, civil

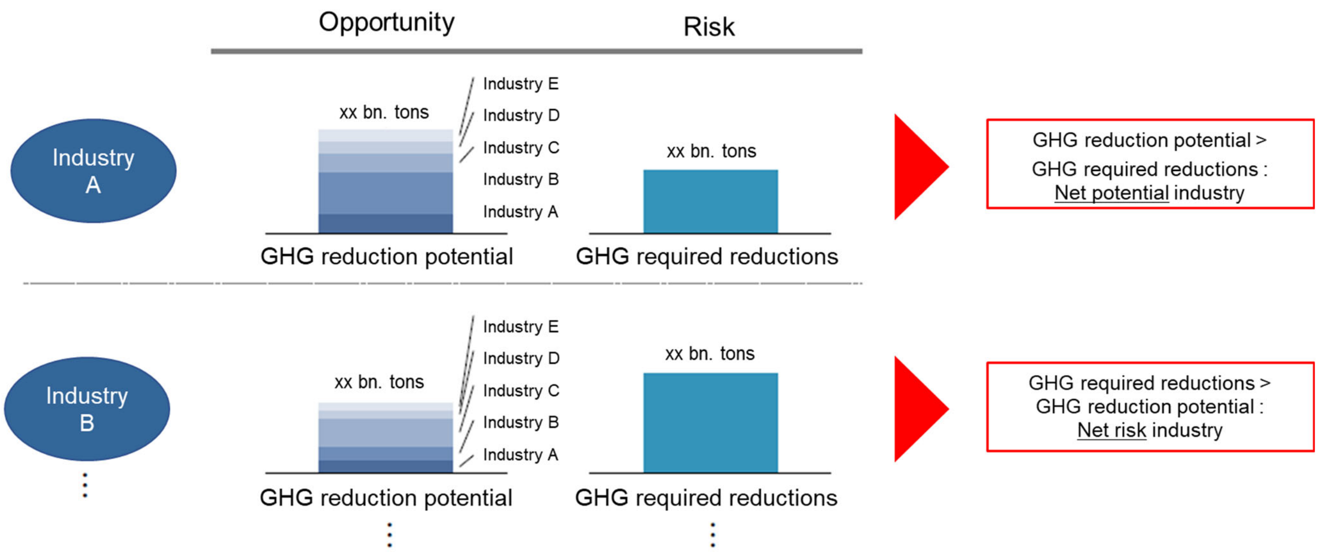
[26] This is a revision made to the model after the publication of the ESG Report 2020. While the term "GHG reduction contribution" is used in the ESG Report, the definition is different than in this report as it does not include the adjustment factor.

engineering, and construction-related products. The energy industry, which is considered to have the greatest net opportunities in 2030 and 2050, is also the industry required to reduce GHG emissions the most in both target years. On the other hand, this industry is expected to contribute greatly to decarbonization in other industries through a wide range of technologies, including hydrogen systems and infrastructure, hydropower energy and small and medium hydroelectric power generation (proliferation of small and medium hydroelectric power generation, optimization of weather forecasting and power generation, and improvement of flow control), and solar power generation and solar cells (weight reduction and cost reduction through the use of new materials). These GHG reduction contributions are expected to far exceed the level of reductions required for the industry.

For chemicals, although decarbonization opportunities in 2030 are not as great, from 2030 to 2050, technological developments in Carbon Capture and Storage (CCS) from large-scale sources of CO2 emissions and Direct Air Capture (DAC) are forecast to accelerate, and, as costs come down and efficiency improves, these technologies are expected to be more widely adopted. In the social infrastructure industry, progress in the utilization of useful biogases through the treatment of waste and sewage sludge and the implementation of underground and submarine carbon storage will lead the reduction of GHG emissions in a variety of different sectors, including agriculture, forestry and fisheries.

On the other hand, the construction, civil engineering, and construction-related products industry is expected to have negative net opportunities in both 2030 and 2050. While the required GHG reduction in this sector is just as high as that of the energy sector, unlike that and other industries, the technologies in construction and civil engineering, such as low-energy housing, are seen as making limited GHG reduction contributions to other industries.

Figure 3-10 Analysis of GHG Reduction Contributions and Required Reductions by Industry



Source: Prepared by GPIF based on Astamuse analysis

Figure 3-11 Transfer of Risks and Opportunities by Industry in 2030 and 2050

Industries	2030				2050			
	Reduction Contributions (a)	Required Reduction (b)	GHG Reduction Net Opportunity		Reduction Contributions (a)	Required Reduction (b)	GHG Reduction Net Opportunity	
			Volume (a - b)	(Reference) Monetary Amount			Volume (a - b)	(Reference) Monetary Amount
	bn. tons	bn. tons	bn. tons	US $bn.	bn. tons	bn. tons	bn. tons	US $bn.
Energy	4.8	3.8	1.0	108.1	13.5	8.0	5.5	998.4
Social Infrastructure	0.5	0.3	0.2	23.4	3.9	0.5	3.4	606.1
Chemicals, etc.	0.7	0.5	0.1	13.4	4.7	2.9	1.8	318.6
Electrical Equipment	0.7	0.0	0.7	75.5	1.7	0.1	1.6	284.4
Machinery	0.2	0.1	0.1	11.7	1.6	0.6	1.0	184.1
Automobiles	0.7	0.2	0.5	51.2	1.8	0.9	0.9	162.1
Telecommunications	0.8	0.3	0.4	45.2	1.6	1.3	0.3	51.9
Durable Consumer Goods	0.2	0.1	0.1	9.8	0.3	0.5	-0.2	-38.2
Transportation	0.1	0.2	-0.1	-13.1	0.6	1.0	-0.3	-58.9
Food	0.0	0.2	-0.2	-19.0	0.1	1.1	-1.0	-171.8
Agriculture, Forestry and Fisheri	0.1	1.4	-1.3	-135.7	0.6	2.8	-2.2	-394.1
Metals, Mining / Paper Products	0.5	0.6	-0.2	-20.1	0.8	3.6	-2.8	-502.1
Construction, Civil Engineering and Construction-Related Products	0.1	1.5	-1.4	-150.4	0.3	8.3	-8.0	-1440.7

Note: Monetary amounts above were converted using a carbon price of USD$105/ton in 2030 and USD$180/ton in 2050 as a reference.
The carbon price above is based on the scenario of keeping the rise in global mean temperature to within 2°C in 2100 with a probability of 66%, which was proposed by the International Energy Agency and International Renewable Energy Agency

Source: Prepared by GPIF based on Astamuse analysis

Analysis of Patent Competitiveness of Decarbonization Technologies by Country/Region

This analysis also examined the patent competitiveness of decarbonizing and low-carbon technologies by country and region. In MSCI's CVaR analysis of low-carbon technologies, "forward citations," "backward citations," "market coverage," and "cooperative patent classification coverage" were factored into the estimation of patent value.[27] The analysis performed by Astamuse, on the other hand, assigns each patent a "Patent Impact Score," which evaluates the patent's impact in terms of its exclusivity rights, meaning the competitive threat posed to other companies (as determined by the number of patent rejections issued to other companies, invalidation trial requests, etc.) and the level of attention paid to the patent by other companies (e.g. number of views by other companies, number of times information is provided, etc.), among other factors. Each Patent Impact Score is then weighted by the geographical scope (countries of application, etc.) and remaining term of these rights, and aggregated by company to obtain the company's "Total Patent Assets." The competitiveness of each country's patents is measured using the Total Patent Asset indicator.

Figure 3-12 shows the relative competitiveness for five major countries and regions for all 40 technology fields. The results of this analysis indicate that Japan's technological competitiveness is particularly high in the energy technology field with respect to hydropower energy, small and medium hydroelectric power generation, hydrogen/ammonia power generation, photovoltaic power generation, solar batteries, and solar thermal power generation, among others. In the chemical technology field as well, Japan is 2nd in the world behind the U.S. in materials for carbon absorption, adherence, separation and storage, as well as carbon reuse. On the other hand, the analysis found that the U.S. is superior in bioenergy and marine energy within the energy technology field, in addition to underground/submarine carbon storage and waste/sewage sludge treatment within the social infrastructure technology field (Figure 4), with the E.U.(Germany, France, Switzerland), the U.K. and South Korea also being highly competitive.

This analysis shows that socioeconomic trends and the evolution of technologies toward net-zero will bring about a shift in supply and demand among industries and among countries, and that many companies in Japan have the potential to benefit from this shift.

[27] Please refer to page 63

Figure 3-12 Comparison of Total Patent Assets of Decarbonization Technologies by Country/Region

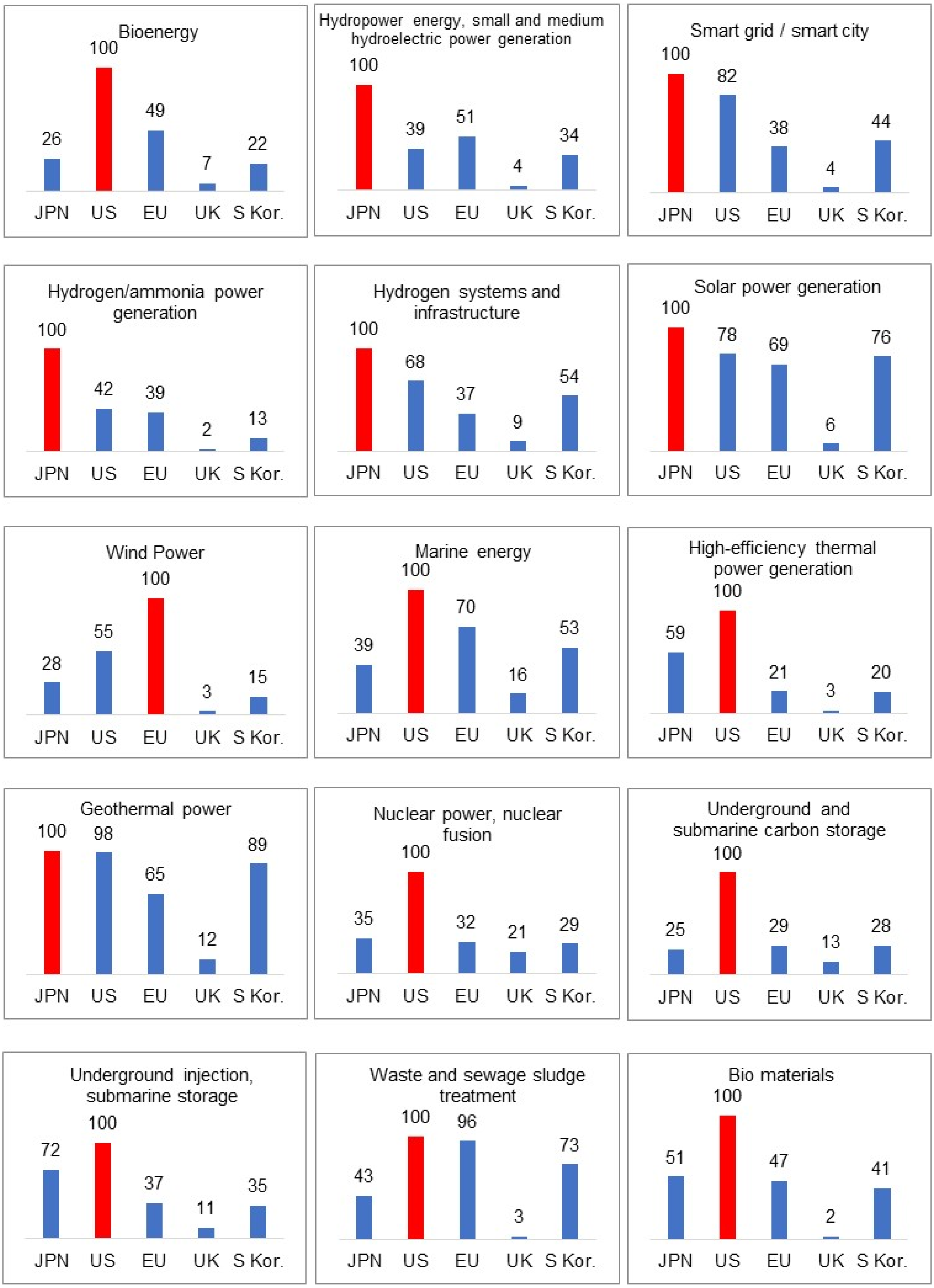


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Figure 3-12 Comparison of Total Patent Assets of Decarbonization Technologies by Country/Region

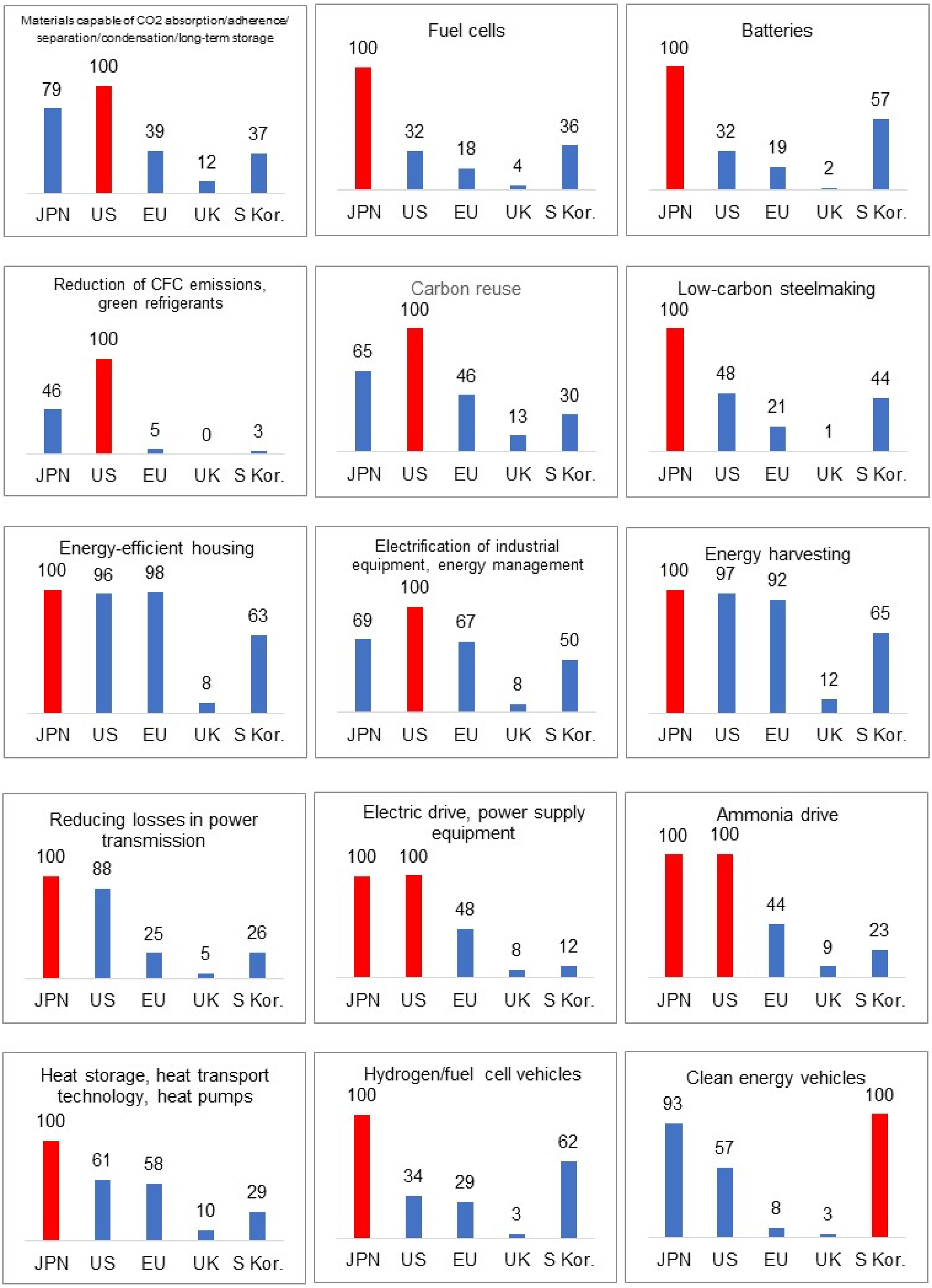

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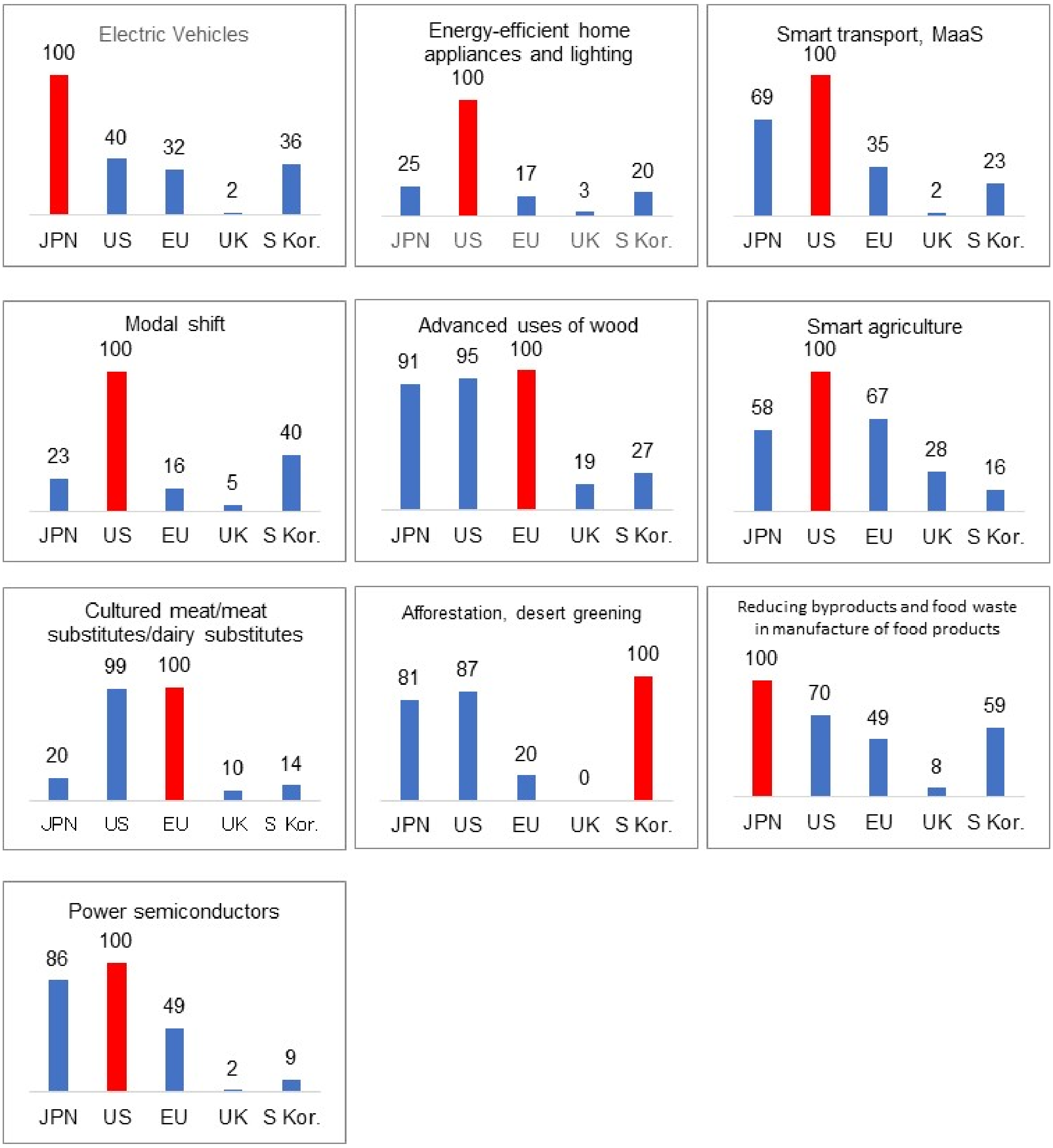
Figure 3-12 Comparison of Total Patent Assets of Decarbonization Technologies by Country/Region



Notes:

1. Indexed with the country with the highest total patent asset score in each technology domain, assigned a score of 100.

2. “EU” refers to EU member countries.

3. Chinese patents are not included in the analysis because it is difficult to compare them with patents from other countries from a quality perspective.

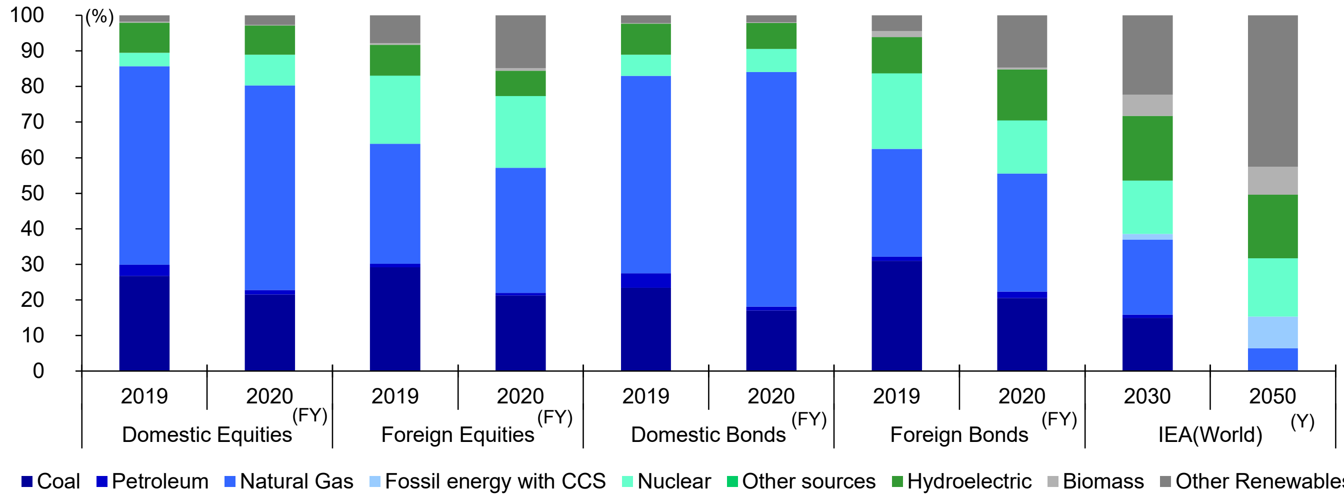
Source: Prepared by GPIF based on Astamuse analysis

Chapter 4: Other Analysis

Energy Mix

This section reviews company disclosed data to analyze the physical units of power generated by energy companies to calculate the corresponding energy mix. The energy mix is then compared to the 2-degree aligned energy mix requirements for 2030- and 2050-time horizons, as estimated by the International Energy Agency (IEA) (Figure 4-1). The energy mix of the portfolio is the weighted average[28] of the power supply composition of the portfolio's energy companies, based on their disclosures. As a result, compared to the power supply composition in 2030 and 2050, which is assumed in the IEA's 2-degree Scenario,[29] the share of fossil fuel (coal, oil, and natural gas) power generation is higher across all portfolios. Also, the share of renewable energy (hydro, biomass, and other renewable energy) is lower in all portfolios. Compared with fiscal 2019, fiscal 2020 saw an increase in the share of natural gas generation across all portfolios. In foreign equities and bonds, the share of renewable energy grew significantly from fiscal 2019 to fiscal 2020, accounting for about 20% of generation. On the other hand, domestic equities and bonds have reflected a slower growth in renewable energy, so there are expectations for this to grow in the future.

Figure 4-1 2-degree Alignment: Energy Mix



Source: S&P Trucost Limited© Trucost 2021

[28] The percentage (%) is obtained by multiplying the amount of electricity generated by energy by its portfolio weight and dividing that figure by the total electricity generated, weighted by the portfolio weight.
[29] Based on data presented by the 2°C Scenario (2DS) developed by the IEA ©OECD IEA 2017.

EU Taxonomy Analysis

Background and Overview

In March 2018, as part of its Action Plan for Sustainable Finance, the European Commission adopted a strategy to incorporate Environmental, Social and Governance (ESG) considerations into Europe's finance-related policy framework to promote sustainable economic growth from finance. In May 2018, the Commission published the first batch of legislation based on this plan. In June 2019, the draft taxonomy was published. The final report, with recommendations including the design of the EU Taxonomy and implementation guidance, was published in March 2020.

The EU Taxonomy addresses six key environmental objectives: climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and the protection and restoration of biodiversity and ecosystems. The taxonomy considers economic activities that meet the following three conditions to be environmentally sustainable: (1) make a substantive contribution to one of six environmental objectives (meet the thresholds set by the taxonomy); (2) do no significant harm (DNSH) to the other five, where relevant; and (3) meet minimum safeguards such as the Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises and the United Nations Guiding Principles on Business and Human Rights. Institutional investors, major listed companies and others must make their first disclosures that take climate change mitigation and adaptation into account by the end of 2022.

Economic activities covered by the taxonomy will be designated as either (1) low-carbon activities; (2) transitional activities; or (3) enabling activities. Low-carbon activities are those that do not already emit GHGs (e.g., wind power generation, electric transportation, etc.); transitional activities are those that currently have a high carbon intensity but have room for significant reduction (e.g., natural gas power generation, gasoline-powered transportation, etc.); and enabling activities are those that enable the transition to a low-carbon society (e.g., the production of wind power and electric vehicles).

This analysis is based on Trucost's methodology to determine what percentage of the portfolio, in terms of revenue, is potentially aligned with the EU taxonomy. Due to data and methodology limitations, the analysis will not consider the performance threshold for substantial contribution described above; it will only examine whether a business falls under the transitional activity or enabling activity categories described above.

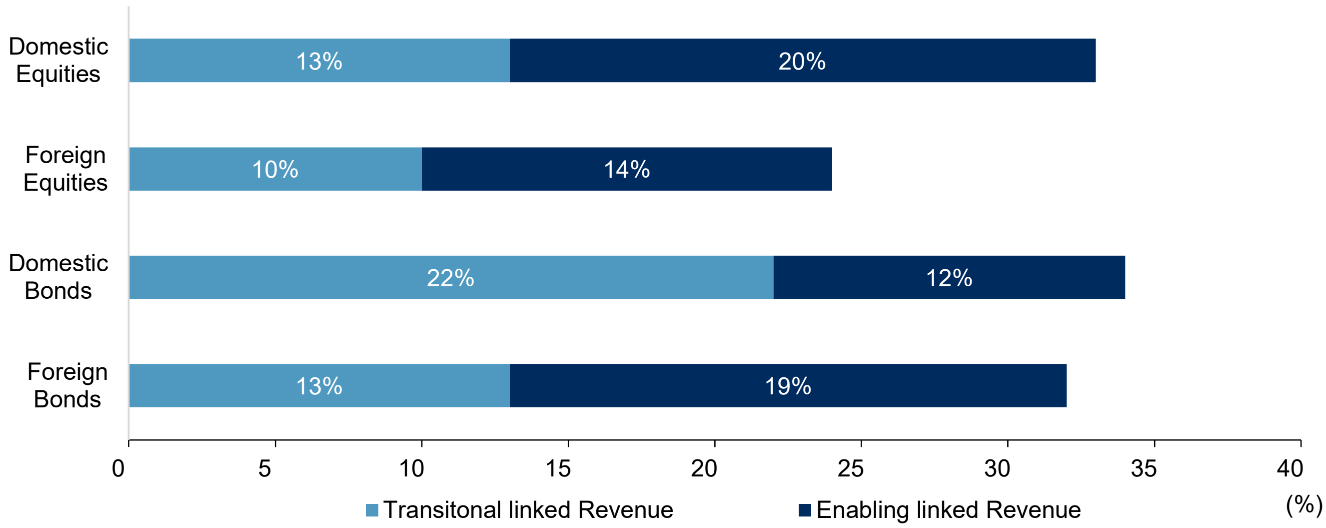
Analysis Methodology and Results

In the EU Taxonomy, 67 climate change mitigation activities are mapped to the seven macro-sectors of the European industry-standard economic activity classification system (NACE[30]). This analysis begins by mapping the 464 business activities in Trucost's classification system to the NACE macro sectors to identify those businesses that fall within the 67 activities identified in the EU Taxonomy. Of the 464 business activities, 117 are mapped to the EU taxonomy. The percentage of revenue from each company from each of these 117 business activities is then calculated and weighted using the portfolio weights of those businesses to measure the EU taxonomy revenue share of the entire portfolio and the proportions of transitional and enabling businesses.

The results of the analysis of the GPIF portfolio by asset class are shown in Figure 4-2. We found that the EU taxonomy revenue share in the domestic equity portfolio exceeds that of the foreign equity portfolio, with both the transitional revenue (13%) and enabling revenue (20%) exceeding the proportion of foreign equity (10% and 14%). On the other hand, while the EU taxonomy revenue share for domestic bonds is higher than that for foreign bonds, the enabling revenue for foreign bonds (19%) is higher than that for domestic bonds (12%).

Note that this analysis does not consider the criteria (thresholds) for judging substantial contributions to climate change mitigation and climate change adaptation, but rather shows the percentage of potential revenue that could be considered environmentally sustainable economic activity. Therefore, the figures that consider the above criteria are expected to be lower than those shown in Figure 4-2.

Figure 4-2 Weighted Average EU Taxonomy Revenue Share



Note: Data is as of the end of March, 2021.
Source: GPIF, S&P Trucost Limited©Trucost 2021

[30] Nomenclature des Activités Économiques dans la Communauté Européenne

Analysis by Sector

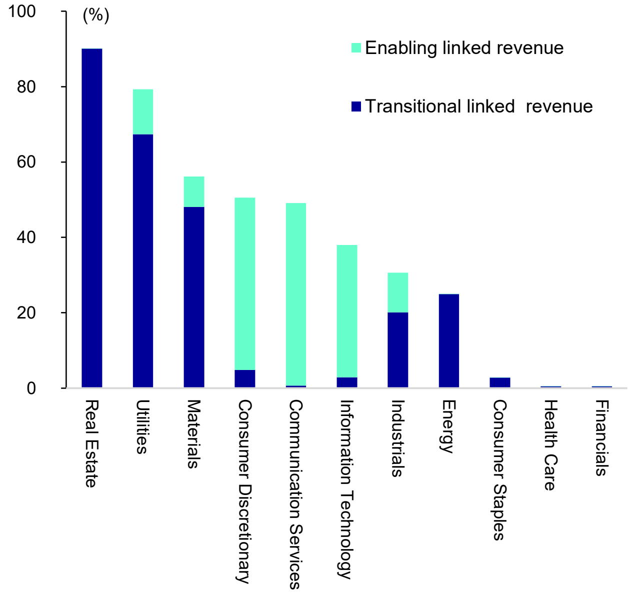
We will now look at the results of the analysis above by sector. As a trend across all portfolios, sectors such as Utilities, Materials, Industrials, and Energy have a high level of transitional revenue because their current emissions are high and can be significantly reduced through future technological innovation. On the other hand, electric vehicles and their components, energy-efficient communication networks such as 5G, and software used to improve resource efficiency in other industries are technologies expected to contribute to reducing GHG emissions in the future. For this reason, the Consumer Discretionary, Communication Services, and Information Technology sectors, which contain these technologies, have a high ratio of enabling revenue. In addition, since almost all businesses related to real estate are designated as transitional businesses in the EU taxonomy, the transitional revenue share of the Real Estate sector in each portfolio is exceptionally high.

Figures 4-3 and 4-4 show the results of our analysis of equity portfolios. The reason why the domestic equity portfolio has a relatively higher ratio of transitional revenue than the foreign equity portfolio is that domestic equity has a higher weight in Industrials. In addition, the Utilities and Materials sectors in the domestic equity portfolio have a larger revenue share from businesses that have more room for GHG reduction in the future than the same sectors in the foreign equity portfolio. Domestic equities had a higher enabling revenue share than foreign equities due to the relatively large share of revenue generated from businesses that will contribute to future GHG reductions in Consumer Discretionary and Communication Services.

The results for the bond portfolio are shown in Charts 4-5 and 4-6. The domestic bond portfolio has a higher share of transitional revenue than the foreign bond portfolio due to the high portfolio weighting of Utilities and the relatively large amount of revenue generated by businesses with considerable potential for future GHG reductions in this sector, as well as the Materials and Industrials sectors. Although the weight of the Utilities sector in the foreign bond portfolio is lower than that of domestic bonds, the share of the revenue from business lines that will contribute to future GHG reductions is high. In addition, unlike both the equity portfolios, the revenue share of enabling was higher than that of domestic bonds due to the significant revenue share of projects that contribute to emission reductions from Communication Services.

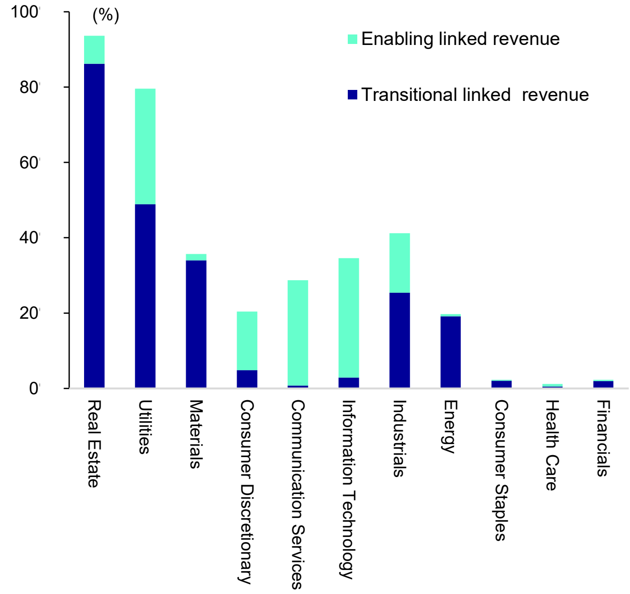
As noted above, the above results focus only on whether each business is eligible for the taxonomy framework and does not assess whether the three conditions described above (in particular, the achievement of the substantial contribution threshold) are met. Therefore, it should be noted that the revenue shares shown here may not technically be considered as revenue from sustainable economic activities under the EU taxonomy.

Figure 4-3 EU Taxonomy Revenue Share by GICS Sectors in Domestic Equities Portfolio



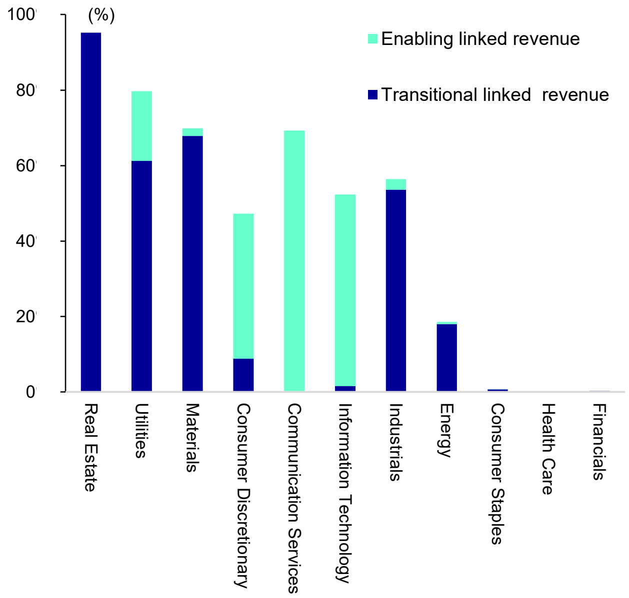
Source: GPIF, S&P Trucost Limited©Trucost 2021

Figure 4-4 EU Taxonomy Revenue Share by GICS Sectors in Foreign Equities Portfolio



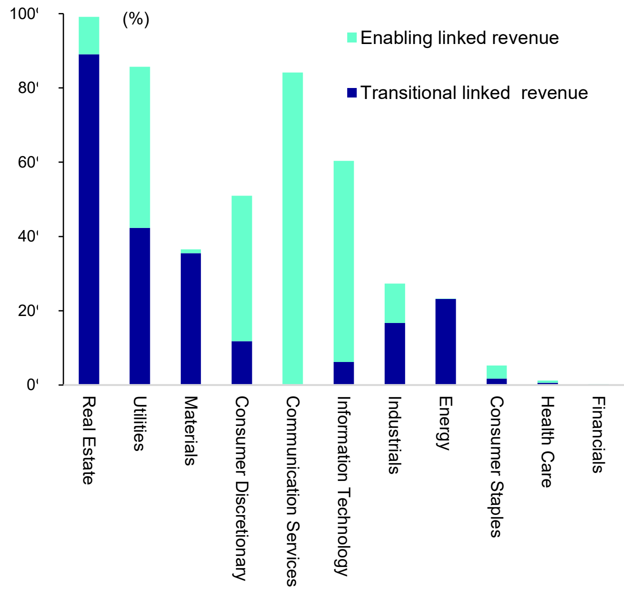
Source: GPIF, S&P Trucost Limited©Trucost 2021

Figure 4-5 EU Taxonomy Revenue Share by GICS Sectors in Domestic Bonds Portfolio



Source: GPIF, S&P Trucost Limited©Trucost 2021

Figure 4-6 EU Taxonomy Revenue Share by GICS Sectors in Foreign Bonds Portfolio



Source: GPIF, S&P Trucost Limited©Trucost 2021

Analysis of SDGs-Related Revenue Opportunities and Risks

SDGs Positive Impact Analysis

In previous sections, we analyzed the risks and opportunities in the context of climate change, but this section expands the discussion beyond climate change by presenting an analysis of the indirect contributions of GPIF's equities portfolio to the resolution of social issues identified in the Sustainable Development Goals (SDGs) defined by the United Nations.

In this analysis, we determined the percentage of total revenue generated by products and services that contribute to the SDGs for the companies in GPIF's equities portfolio, based on definitions by Trucost. We then measured the exposure of companies contributing to the SDGs by using portfolio holding weights to calculate the weighted average revenue exposure, or SDGs Positive Impact, of the portfolio.

In a comparison of the SDGs Positive Impact of GPIF's domestic and foreign equities portfolios for each SDGs, the foreign equities portfolio generally tends to have a greater positive impact. This result suggests that, from the perspective of contributing to the SDGs and securing profit opportunities thereby, Japanese companies have much room for growth (Figure 4-7).

SDGs Additionality Analysis

Each year, the Sustainable Development Solutions Network (SDSN), launched in 2012 by the UN Secretary-General, releases the Sustainable Development Report. The report includes the "SDGs Performance Gap," which estimates the distance to the achievement of each target of the SDGs. The gap for each country is expressed as the contribution rate of the country to the global gap (Figure 4-8).

To determine the SDGs performance gap, it is necessary to analyze the extent to which countries are currently achieving the SDGs targets. The SDSN has set numerical targets for each of the 169 targets of the SDGs. Specifically, if a target already has a numerical target, that number is applied (e.g., Target 3.1 is to reduce the global maternal mortality ratio to less than 70 per 100,000 by 2030). For those where no targets are given, targets will be set based on scientific knowledge or the performance of the top five countries that have already achieved their targets. Next, each country's progress is assessed against the indicators using official data from the OECD, the World Health Organization (WHO), United Nations Children's Fund (UNICEF), and other sources. The distance from the current progress to the target value is called the SDGs performance gap.

For SDG 1: No Poverty and SDG 4: Quality Education, for example, the G20 nations' total contribution to the gap is only around 30%, indicating that, if the SDGs are to be achieved, improvement will be needed in non-G20 countries, especially African nations. On the other hand, for SDG 13: Climate Action, the G20 nations' total contribution to the gap is over 80%, indicating that this is a challenge particularly for the developed nations and China.

In the SDGs Positive Impact Analysis mentioned above, we linked the SDGs targets with companies' products and services. Even if two companies provide the same products and services, their degree of contribution to the SDGs will increase if the products and services are provided in countries that are a long way from achieving the SDGs. For example, marketing a certain drug in emerging countries that have poor sanitation and high morbidity rates is likely to make a greater contribution to the SDGs than if the same drug were marketed in developed countries with low morbidity rates. From this perspective, the SDGs Additionality. Analysis uses the SDGs Performance Gap to examine which products and services marketed in which countries and regions are able to contribute to what extent to the achievement of the SDGs. These contributions are aggregated for each company according to the composition of their net sales to determine their SDGs Additionality.

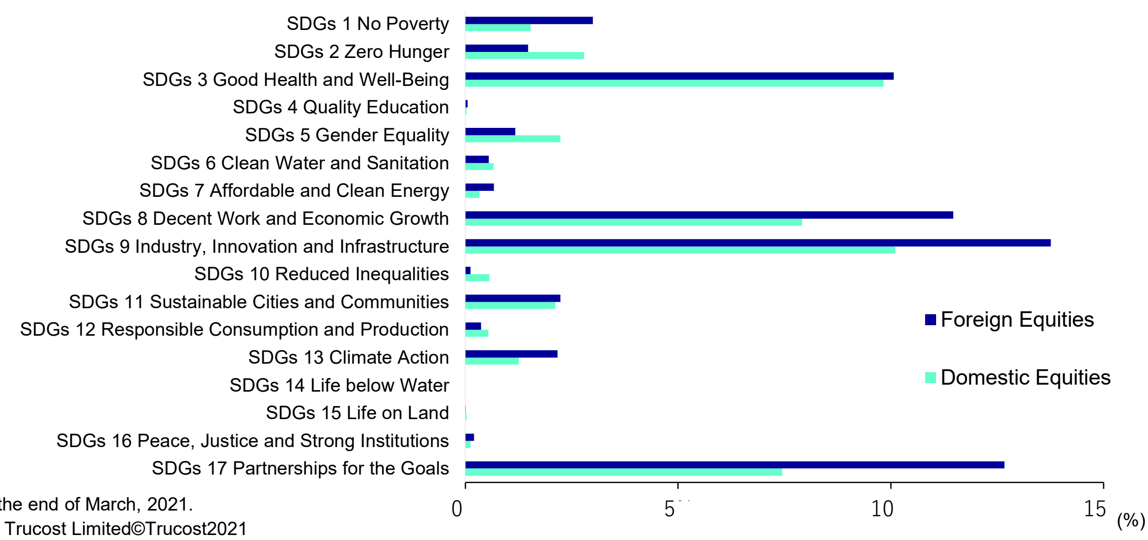
Comparing the weighted average SDGs additionality and the benchmark for GPIF's portfolio reveals that both domestic and foreign equities slightly exceeded the benchmark, showing that the portfolio makes a relatively large contribution to the SDGs (Figure 4-9). Among equities in major economies (top ten countries and regions by MSCI ACWI composition weight), we calculated the weighted average SDGs additionality by constituent country and ranked them by country and region. Taiwan came out on top, far ahead of the others, while Japan ranked seventh (Figure 4-10). In Taiwan, semiconductor-related companies, which have an extremely high weight in the index, are making significant contributions to SDG 9: Industry, Innovation and Infrastructure and SDG 17: Partnerships for the Goals, which seems to be largely attributable to individual company attributes.

SDGs Risk-Exposure Analysis

While the previous section examined the SDGs from a positive perspective, the SDGs Risk-Exposure Analysis is conducted from a risk perspective. In the SDGs Risk Exposure Analysis, the exposure to SDGs-related risks that directly or indirectly affect or are affected by the company in the value chain is represented by a score from 0 to 100, where 0 is the lowest risk, and 100 is the highest risk. These include the risks that a company directly or indirectly generates negative impacts, such as GHG emissions and the risks that a company relies on practices or activities that conflict with the SDGs, such as child labor and underpayment of wages. Exposure to these risks is assessed based on the geographic distribution of the sectors and supply chains in which the company operates. For example, air, land, and water pollution issues are more likely to involve companies in the heavy industry and energy sectors than companies in retail and services. Similarly, the risk of corruption and child labor may vary depending on the country in which a company has production activities. Since few companies disclose details such as the geographic distribution of their entire supply chain, we use Trucost's model for this analysis.

An analysis of the GPIF's domestic and foreign equity portfolios by sector reveals that while the high-risk SDGs items are similar for both domestic and foreign equities, foreign equities tend to have higher risk scores than domestic equities for many of the goals. In other words, foreign equities are more likely to have SDGs-related risks. This may be due to the geographical distribution of the supply chain affecting the evaluation, as foreign companies may be procuring products and services from countries with relatively higher risks. Reports released by the OECD[31] and other organizations have confirmed that Japanese companies have a low presence in global value chains. Where companies supply and procure goods and services across multiple countries to optimize their production processes, the supply chains of foreign companies tend to span more countries than those of Japanese companies. In all asset classes and sectors, the risks associated with SDG 17, "Achieve the Goals through Partnership," are high. One of the targets set in this goal is to "strengthen the mobilization of domestic resources, including international assistance to developing countries, to enhance taxation and tax collection capacity." This risk tends to be higher when companies based in tax havens are included in the supply chain. It should be noted that the SDGs Risk Exposure Analysis measures the exposure to risks defined by sector and supply chain and does not consider the actual activities that companies are undertaking to address SDGs-related risks.

Figure 4-7 SDGs Positive Impact by Individual Goal



Note: Data is as of the end of March, 2021.
Source: GPIF, S&P Trucost Limited©Trucost2021

[31] Global value chains: Efficiency and risks in the context of COVID-19©OECD 2021

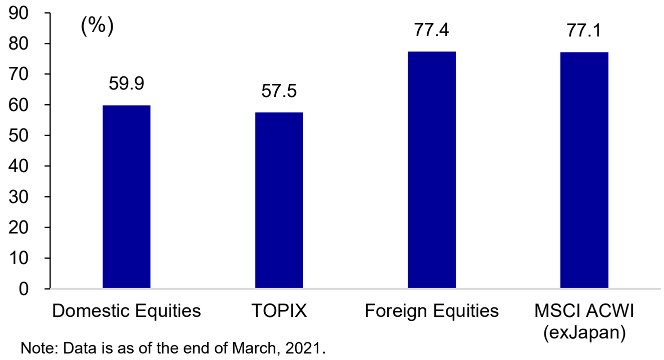
Figure 4-8 SDGs Performance Gap

	Japan	USA	EU	China	India	G20 Total
SDGs 1 No Poverty	0.1	0.2	0.3	1.8	21.8	33.3
SDGs 2 Zero Hunger	1.0	3.5	4.6	10.5	23.8	57.8
SDGs 3 Good Health and Well-Being	0.3	1.5	1.5	11.7	24.5	50.8
SDGs 4 Quality Education	0.0	0.1	1.1	5.4	17.3	30.2
SDGs 5 Gender Equality	1.6	2.6	3.1	10.7	29.2	58.7
SDGs 6 Clean Water and Sanitation	0.7	2.1	2.6	17.2	23.1	56.3
SDGs 7 Affordable and Clean Energy	0.4	1.0	1.4	20.1	19.7	49.7
SDGs 8 Decent Work and Economic Growth	0.9	2.8	4.7	10.3	14.0	49.2
SDGs 9 Industry, Innovation and Infrastructure	0.3	0.5	2.1	10.5	21.5	47.6
SDGs 10 Reduced Inequalities	0.8	5.0	3.1	16.0	17.6	62.4
SDGs 11 Sustainable Cities and Communities	1.2	1.4	2.7	13.5	27.2	56.8
SDGs 12 Responsible Consumption and Production	3.3	12.5	14.7	13.7	8.8	74.7
SDGs 13 Climate Action	4.7	16.3	14.6	17.2	5.2	81.9
SDGs 14 Life below Water	2.0	3.9	6.1	23.2	16.6	66.3
SDGs 15 Life on Land	1.4	4.3	2.9	18.7	22.0	66.3
SDGs 16 Peace, Justice and Strong Institutions	0.4	2.9	3.1	18.2	18.7	57.9
SDGs 17 Partnerships for the Goals	1.2	3.0	4.7	22.8	20.8	65.1

Note: Numbers in red are 10-20%, highlighted in yellow are +20%.

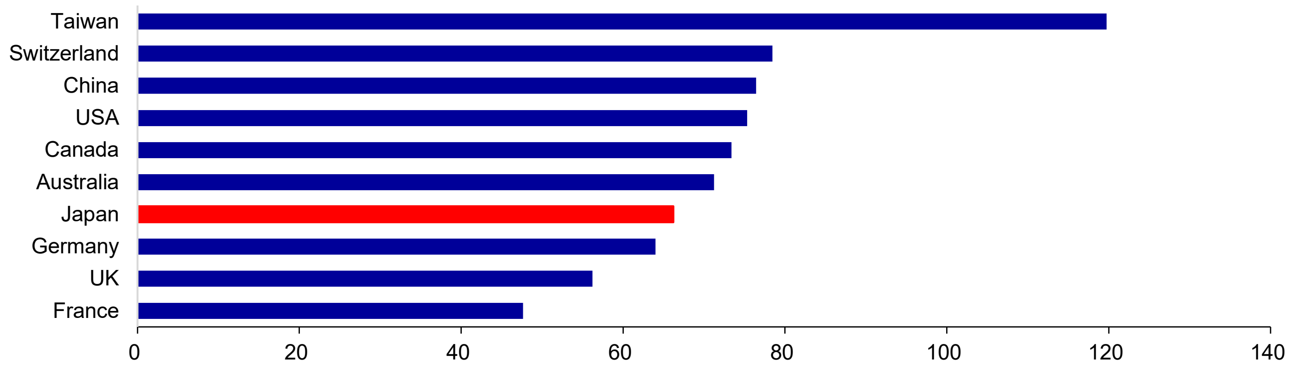
Source: Created by GPIF based on the Sustainable Development Report 2020.

Figure 4-9 GPIF Portfolio Weighted Average SDGs Additionality



Note: Data is as of the end of March, 2021.
Source: S&P Trucost Limited©Trucost2021

Figure 4-10 Comparison of Weighted Average SDGs Additionality by Major Countries and Regions



Note: Aggregated data is of MSCI ACWI constituents, Upper graph indicates the top 10 countries/regions with the most SDG Additionality among the 10 highest exposures in the index.
Source: MSCI, S&P Trucost Limited©Trucost2021

Introduction of Each Company

＜About MSCI Climate Risk Center＞

MSCI Climate Risk Center plays a central part in analyzing climate-change risks in MSCI. The Centre aims to use climate change science for financial risk analysis through partnerships with major academic institutions and research institutions built by Carbon Delta, which MSCI acquired in October 2019.

＜About Trucost＞

Established in 2000, Trucost is a pioneer in the field of carbon data and reporting and has compiled a comprehensive and growing dataset that includes over 15,000 companies. Acquired by S&P Global in October of 2016, Trucost is continuing to provide not only environmental data, but also essential ESG-related data on a global scale.

＜About Astamuse＞

Astamuse has built one of the world's largest intangible asset visualization databases with more than 700 million data points from193 countries and in 39 languages. We classify and analyze this data into uniquely defined "growth areas" and "social issues" that humanity needs to solve to achieve the SDGs.

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