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ENHANCING THE CREDIBILITY OF CORPORATE CLIMATE PLEDGES: BRINGING CLIMATE TRANSITION PLANS AND CLIMATE SCENARIO ANALYSIS INTO THE MAINSTREAM

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Abstract

In the face of the increasing frequency of climate change-related natural hazards and the resulting losses across the globe, companies are recognizing the importance of addressing climate-related risks and opportunities and taking timely actions to cope with them. While numerous large companies have committed to achieving net-zero greenhouse gas (GHG) emissions by 2050 or earlier, stakeholders are increasingly demanding greater transparency and credibility from these commitments. In response to a growing call for standardized, consistent disclosures that are essential for assessing corporate exposure to, and preparation for, climate change, the International Sustainability Standards Board (ISSB) released Climate-Related Disclosures in June 2023, based on well-established recommendations from the Task Force on Climate-related Financial Disclosures (TCFD). The ISSB's Standards are expected to be adopted by many countries as mandatory requirements for large companies. Specifically, disclosing GHG emissions data, including Scope 3 emissions in absolute amounts (excluding carbon credits), along with emissions reduction targets and a credible climate transition plan (roadmap), will become a crucial step for companies in demonstrating their unwavering commitment to their pledges. Additionally, conducting resilience assessments through climate scenario analysis is an essential component of corporate strategy. Corporate climate-related disclosures are evolving into an integral part of business strategies aimed at enhancing corporate value and gaining a competitive edge. This paper sheds light on identifying climate risks and opportunities and assessing their impacts, developing climate transition plans, and conducting climate scenario analyses.

Keywords: corporate disclosure, climate transition plan, climate scenario analysis

JEL Classification: K22, M41, Q54

Contents

1. INTRODUCTION

Many countries have made commitments aligned with the 2015 Paris Agreement, aiming to limit the global average temperature increase to well below 2°C, and striving to approach 1.5°C by the end of this century (2100) compared to pre-industrial levels. To fulfill these goals, these countries have submitted their Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change, which outline targets for reducing GHG emissions by approximately 2030. In addition, many countries have announced the long-term goal of achieving net-zero GHG emissions (or carbon neutrality) by around 2050. However, the prospect of attaining the Paris Agreement goals is becoming increasingly challenging, despite the escalating occurrence of climate change-induced natural hazards worldwide. Governments in these committed countries are expected to expedite the implementation of comprehensive climate policy measures. These include measures like carbon pricing, emissions regulations, subsidies for research and development (R&D) to promote decarbonization technology, and public investments promoting low-carbon transportation and a renewable energy supply. These efforts are critical for facilitating the transformation of their economies, industries, and businesses towards carbon neutrality. To make a substantial emissions reduction, it is essential to reduce emissions from energy systems (such as electricity and heat generation, transportation, and manufacturing), which account for approximately 75% of all emissions.

An increasing number of multinational corporations worldwide have voluntarily committed to achieving a net-zero greenhouse gas (GHG) emissions target, or carbon neutrality, by no later than 2050. However, a substantial proportion of these companies have yet to establish credible climate transition plans and actions that align with this ambitious target. Companies are now under increasing pressure to provide comprehensive disclosures, encompassing long-term net-zero targets, alongside coherent short- and medium-term targets, as well as historical GHG emissions data that include emissions throughout the entire value chain. To drive companies towards expeditious emissions reduction actions, it is important to significantly enhance their understanding of climate-related risks and opportunities. This can be achieved through mandatory disclosures in accordance with global standards. Internationally, it is widely acknowledged that climate-related disclosures should adhere to the recommendations set out by the TCFD, initially published in 2017 and revised in 2021 (TCFD 2017, 2021). Building upon the TCFD recommendations and the GHG Protocol, the ISSB has further refined disclosure requirements and carbon accounting standards by publishing the Climate-Related Disclosures (IFRS S2), in conjunction with the General Requirement for Disclosure of Sustainability-Related Financial Information (IFRS S1) (ISSB 2023b, 2023c). IFRS Standards are set to become effective for annual reporting periods commencing in January 2024, with reporting to commence in the subsequent year.

In alignment with the four-pillar framework outlined in the TCFD recommendations, the GHG Protocol, and some existing standards, the ISSB not only mandates the inclusion of data on Scope 1 emissions (direct emissions from a company's operations) and Scope 2 emissions (indirect emissions from purchased energy sources) but also requires the disclosure of Scope 3 GHG emissions data (emissions generated by suppliers and users), with a permissible one-year delay. Companies are required to provide information about carbon credits if they are used to derive net GHG emissions data. Disclosing Scope 3 emissions data presents a formidable challenge, yet it serves as a litmus test of a company's genuine commitment and credibility in addressing climate-related risks. To attain their emissions reduction targets and foster

sustainability in their operations, companies must first identify significant climate-related risks and opportunities. They also need to assess the actual and potential impact of these factors on both current and future business operations and financial performance. To translate these targets into actionable strategies, timely disclosure of a climate transition plan becomes imperative to enhance transparency and credibility. Furthermore, companies should gauge the resilience of their businesses against conceivable climate risks through the execution of climate scenario analysis.

The disclosure of this quantitative and qualitative information is highly appreciated by investors, financial institutions, and other stakeholders, thereby helping companies to secure the necessary funding at a reasonable cost of capital to achieve GHG emissions reduction objectives in line with the plan. In essence, climate-related disclosure and reporting not only assist companies in enhancing the sustainability of their business activities but they also enhance their risk management practices, enabling them to formulate transition strategies to seize opportunities and initiate concrete actions. A more informed engagement with stakeholders further facilitates progress towards sustainable climate objectives across companies. The ISSB Standards have garnered widespread global endorsement from governments, investors, and other stakeholders and will help to enhance the comparability of disclosures on a truly global scale. Although companies need to bear the cost of enhanced and more robust disclosure practices, the benefits of achieving compliance with these global standards far outweigh the expenses incurred.

This paper primarily focuses on the Strategy Pillar of the TCFD recommendations and the ISSB Climate-related Standards—especially with regard to the identification of risks and opportunities and the associated climate transition plan and climate scenario analysis. A credible climate transition plan describes a company's comprehensive, reliable business strategy to achieve GHG emissions short-, medium-, and long-term reduction targets. Moreover, climate scenario analysis is gaining prominence as a forward-looking exercise, spanning a time horizon from the short to the longer term, potentially extending up to 2050. It aims to assess the exposure and resilience of business models to climate risks within the context of plausible future climate developments, using a range of climate scenarios. Climate scenario analysis has also evolved into a crucial tool for financial authorities in conducting climate-related prudential policies towards financial institutions such as commercial banks.

Promoting climate-related corporate disclosure stands as an essential and pivotal step in making financial institutions' climate-related financial risk management and climate scenario analysis more effective. This is why promoting corporate-level disclosure is recognized as a crucial step in the Roadmap compiled by the Financial Stability Board (FSB) in 2021 in promoting coordinated international supervisory and regulatory efforts to improve climate-related financial stability (FSB 2021; Shirai 2023b). These practices also play a pivotal role in fostering sustainable finance, ultimately channeling more capital towards decarbonization and low-carbon activities. Section 2 delves into the identification of major climate-related risks and opportunities, which forms a critical foundation for the development of a robust climate transition plan. Section 3 provides an overview of corporate-level climate scenario analysis, highlighting the key scenarios commonly utilized by companies. In Section 4, the focus shifts to disclosures for financial institutions. Section 5 offers concluding remarks.

2. CLIMATE-RELATED RISKS AND OPPORTUNITIES AND CLIMATE TRANSITION PLANS

The TCFD, established in 2015 by the FSB under the auspices of the G20, issued its initial recommendations on forward-looking information disclosure by companies in 2017, followed by revised recommendations in 2021. This disclosure framework's primary objective, which is also reflected in ISSB Standards, is to encourage companies to identify and evaluate climate-related risks and opportunities that hold ***material*** significance for their business operations, subsequently incorporating this information into their annual financial reporting procedures. This reporting may take various forms, including sustainability reports, TCFD reports, integration reports, and annual financial reports, among others. The concept of ***materiality*** is central to this framework, suggesting that companies are not required to compile an exhaustive list of all potential risks and opportunities. Instead, they should focus on information pertaining to risks and opportunities that predominantly influence decisions made by the primary users of the report (ISSB 2023b, 2023d). These users could be existing investors and creditors, but also potential investors and creditors and other stakeholders.

2.1 Four Pillars of Climate-Related Disclosure

These global standards are aimed at establishing consistent frameworks for users of general-purpose corporate financial reporting to understand the impacts of climate change on corporate financial performance (such as sales, revenue, cost, earnings, operating cash flows) and financial positions (such as changes in assets and liability and equity), thereby checking the viability of business models. The disclosures include both quantitative and qualitative information. These practices also enable companies to identify, evaluate, and manage both current and potential climate-related risks and opportunities over the short, medium, and long term. Such efforts can lead to improved and informed decision-making in areas such as production, investments, marketing, operations, and relationships with suppliers.

The four-pillar framework is becoming increasingly accepted as a global standard for disclosing sustainability-related information, including on climate change, biodiversity, and other environmental and social issues. The framework is structured around ***governance, strategy, risk management, and metrics and targets***. The development of the ISSB Climate-related Disclosures built upon the TCFD recommendations and the GHG Protocol, incorporating more detailed and comprehensive information requirements. Additionally, the ISSB Standards were formulated by amalgamating existing influential disclosure guidelines from private-sector initiatives, including the Sustainability Accounting Standards Board (SASB) Standards, the Climate Disclosure Standards Board (CDSB) Framework, the Integrated Reporting Framework, and the metrics established by the World Economic Forum. Below, the key features of these four pillars are highlighted:

- **The Governance Pillar** focuses on disclosing a company's governance structure concerning climate-related risks and opportunities, including the role of the board in oversight and management.
- **The Strategy Pillar** identifies material climate-related risks and opportunities from the short-, medium-, and long-term perspectives. It also discloses the actual and potential impacts of material risks and opportunities on various aspects of the company, such as business operations, managerial strategies,

and financial planning—including revenues, operating costs, earnings, assets, capital spending, and other investments.

- The Strategy Pillar includes a climate transition plan with detailed strategic information about the company's responses to identified risks and opportunities. This information may encompass new capital spending and investment plans, asset disposals, market exploration efforts, hiring initiatives, and the creation of new business units, all within the framework of its transition plan.
- The Strategy Pillar also incorporates climate scenario analysis to assess the company's vulnerability to climate changes, as further elaborated in the next section.

- **The Risk Management Pillar** discloses how the company identifies, assesses, and manages climate risks. It also addresses whether these climate risks are integrated into the company's overall risk management framework.
- **The Metrics and Targets Pillar**: This pillar provides key indicators and targets that enable the assessment and management of climate risks and opportunities. While the TCFD recommended that all companies disclose Scope 1 and Scope 2 GHG emissions data, and the disclosure of Scope 3 emissions data depends on materiality, the ISSB Climate-related Disclosures require large, listed companies to disclose GHG emissions data and six other metrics—together known as the seven ***cross-industry metric categories*** as pointed out below. While these metrics are covered by TCFD recommendations, the ISSB Standards impose more detailed and stringent requirements, particularly with regard to GHG emissions data and emissions targets given that such information constitutes the most fundamentally important element in climate-related reporting (ISSB 2023c; Shirai 2023b). Third-party audits of GHG emissions data and other metric categories are desirable. Highlighted below are some of the major disclosure requirements:
  - The seven cross-industry metric categories that are required to be disclosed are: (a) ***GHG emissions data***; (b) ***climate-related transition risks*** (the amount and percentage of assets or business activities vulnerable to climate-related transition risks); (c) ***climate-related physical risks*** (the amount and percentage of assets or business activities vulnerable to climate-related physical risks); (d) ***climate-related opportunities*** (the amount and percentage of assets or business activities aligned with climate-related opportunities); (e) ***capital deployment*** (the amount of capital expenditure, financing, or investment deployed towards climate-related risks and opportunities); (f) ***internal carbon prices*** (explaining whether and how the entity is applying a carbon price in investment decisions, transfer pricing, and climate scenario analysis); and (g) ***remuneration*** (describing whether and how climate-related factors are reflected in executive remuneration).
  - Companies are required to disclose GHG emissions Scope 1, Scope 2, and Scope 3 (excluding carbon credits) in metric tonnes of carbon dioxide (CO_2) equivalent (absolute emissions amount). Additionally, information about the measurement approach, inputs, and assumptions used to calculate emissions should be disclosed.

- GHG emissions data for Scope 1 and Scope 2 should be reported in two groups: one based on the consolidated accounting group (parent and its consolidated subsidiaries) and the other based on other investees such as associates, joint ventures, and unconsolidated subsidiaries.
- GHG emissions targets can be either gross or net. If a net GHG emissions target is used, however, it is necessary to disclose both the gross GHG emissions target and the planned use of carbon credits to achieve the net target. The extent of the use of carbon credits to achieve net GHG emissions targets should also be disclosed.
- Emissions targets should clarify whether they cover Scope 1, Scope 2, or Scope 3 GHG emissions, and the types of GHGs (such as CO_2) covered by the emissions target should be clearly specified.

ISSB Standards do not require companies to set net-zero emissions targets and thus it is important for each country to require their listed companies to set the targets. Compared to the TCFD recommendations, however, companies must meet detailed disclosure requirements including the metrics used (absolute or intensity if a quantitative target is used), the objective of the target (such as conformance with science-based initiatives), the coverage of the target, the period applied, and the interim targets. Moreover, companies should describe the approach adopted in setting each target (including whether the target was validated by a third party) and the mechanisms used to review and monitor the progress against each target (including specific metrics used to monitor progress). Enhanced disclosure helps to improve managerial decision-making and thus to capitalize on opportunities related to rapid technological advancements aimed at emissions reduction and decarbonization. This proactive approach can position companies ahead of their competitors and regulatory changes. Moreover, companies can bolster their transparency and credibility by actively calling for GHG emissions tracking and the traceability of procurement processes associated with sustainable materials and inputs.

2.2 Identifying Material Risks and Opportunities

In the context of the Strategy Pillar, this section primarily concentrates on identifying material risks and opportunities that could impact a company's sales, profitability, cash flows, cost of capital, access to capital, etc. across short-, medium-, and long-term horizons. In doing so, companies need to conduct comprehensive evaluations of their entire operations, including their entire value chain. The main significant climate physical and transition risks that may influence companies are summarized in Table 1 and also highlighted below:

Climate-related Physical Risks: Physical risks pertain to corporate losses, such as damage to factories and offices, and adverse effects on business operations and employees. These risks are linked to the increased frequency and severity of acute events, such as severe and prolonged droughts, heatwaves, wildfires, precipitation variations, cyclones, typhoons, and hurricanes (so-called ***acute events***), as well as chronic events, like sustained temperature increases, rising sea levels, and shifting precipitation patterns (so-called ***chronic events***). As global warming advances, the frequency and magnitude of climate change-induced natural hazards are intensifying. However, it's crucial to note that these events are occurring, and will likely continue to do so, in a nonlinear fashion. Physical risks may also encompass litigation risk (liability risk) stemming from losses associated with the realization of physical risks. Lawsuits are already on the rise and are expected to further escalate in the future. Plaintiffs, or victims of natural disasters, may increasingly employ advanced digital technology to

provide scientific evidence linking GHG emissions-intensive companies directly to extreme natural disasters and the resultant losses. Litigation risk is also borne by government failing to adequately cope with climate adaptive measures.

Climate-related Transition Risks: Companies are poised to encounter a range of transition risks, including policy risk, litigation risk, technology risk, market risk, and reputation risk. The main features of each risk are highlighted below:

- **Policy Risk** stands out as a significant transition risk, often materializing when governments enact stringent climate mitigation policies aligned with the goals of the Paris Agreement. Transition risks become apparent during the process of transitioning the economy and society toward carbon neutrality. Mitigation measures encompass carbon pricing (carbon taxes and emissions trading systems), phasing out subsidies for fossil fuel industries, boosting renewable energy supply and low-carbon transportation through incentives and public investments, and regulations enhancing energy efficiency and limiting emissions. These policy measures are likely to drive corporate and sectoral restructuring by escalating production costs for carbon-intensive activities. Failure to prepare for the risks adequately in advance could render assets of carbon-intensive companies stranded and economically unviable, resulting in losses and an inability to recover investment costs. ***Stranded assets*** can be defined as assets whose undiscounted future cash flows generated by these assets fall below their original cost. It is widely recognized that carbon-intensive assets are susceptible to becoming ***stranded assets*** as higher carbon prices or stricter emissions controls could yield returns lower than anticipated.

- **Litigation Risk** arises from legal claims brought before the courts by various parties, including governments, companies, investors, insurers, nongovernmental organizations, and individuals. These claims can stem from inadequate climate change mitigation actions and insufficient climate-related disclosure. Lawsuits are increasingly taking place, not only against parent companies directly but also against their subsidiaries and suppliers operating worldwide. The global increase in litigation cases underscores the urgency of addressing climate change mitigation measures at a corporate level and ensuring consistent disclosures. Companies setting time-bound carbon-neutral targets may face legal challenges if their actions diverge from their GHG emissions commitments. Companies must exercise caution when advertising and labeling their products and services as “environmentally friendly” to avoid accusations of greenwashing. The rising number of lawsuits and penalties are present against companies for violating environmental regulations. Lawsuits pertaining to climate-related human rights violations against local communities and indigenous people are on the rise, necessitating a comprehensive understanding of the interplay between climate and societal issues. For example, communities may seek lawsuits when installing renewable energy generation facilities adversely affecting their communities. Governments could also be subject to litigation if their infrastructure projects result in environmental damage and losses to community.

- **Technology Risk** is associated with the potential for low-carbon technologies to render existing production systems obsolete, resulting in stranded assets. Even if new technology leading to massive emissions reduction is currently not available in hard-to-abate sectors, the technology breakthrough may happen rapidly amid growing competition in the world and end up generating stranded assets at a much faster pace than expected.

- **Market Risk** may arise from shifts in supply and demand for commodities, products, and services. The demand for carbon-intensive products and services may suddenly decline as climate risk awareness is enhanced. This could result in an abrupt decline in sales. A rapid increase in demand for low-carbon goods and services at a global level may raise the cost of raw materials and inputs, thus leading to higher sales prices.
- **Reputation Risk** is linked to the potential loss or gain of reputation due to shifting preferences among customers, suppliers, investors, and other stakeholders towards low-carbon products and services. Embracing low-carbon offerings could enhance brand value and long-term corporate worth, attracting sustainable demand, high-skilled workers, and valued business partners.

Table 1: Major Climate-Related Physical Risks and Transition Risks

Climate-Related Physical Risks	Climate-Related Transition Risks
Acute Risk	**Policy Risk**
Damages to corporate assets and increased business interruption as a result of acute events (e.g., severe and prolonged droughts, heatwaves, wildfires, precipitation, cyclones, typhoons, hurricanes)	Climate policies (carbon pricing, regulation) lead to corporate restructuring and stranded assets by making carbon-intensive activities more expensive
Chronic Risk	**Legal Risk**
Damages to business activities and corporate assets as a result of chronic events (e.g., sustained rising temperature, rising sea level, changing precipitation patterns)	Increased litigation and penalties as a result of violation of climate-related regulations, inadequate disclosure, inconsistent strategies, greenwashing
Litigation Risk	**Technology Risk**
Increased lawsuits as plaintiffs or victims of natural disasters against GHG emissions-intensive companies claiming direct responsibility for extreme natural disaster events and the resultant losses.	Substitution of existing products and services with lower-emission products and services, low carbon innovation and new technology development
	Unsuccessful investment in new technology and product development
	Cost to transition to lower-emission technology
	Market Risk
	Uncertainty over market demand for low-carbon and energy-efficient products and services
	Increased cost of raw materials and input
	Reputation Risk
	Shifts in consumer preferences
	Loss of reputation due to inaction and negative reactions from stakeholders

Source: Prepared by the author based on TCFD (2022).

Climate-Related Opportunities: Climate change presents various opportunities that can generate positive impact on a company's sales, profitability, cash flows, and access to more affordable capital. Primary climate-related opportunities are summarized in Table 2 and highlighted below:

- **Efficiency Improvement:** Companies have the potential to enhance their operational efficiency across energy, water, materials, and waste management, leading to reduced operational costs. Promoting recycling and reusing disposed products and materials can be part of this effort. Additionally, companies can replace emissions-intensive machinery with more energy-efficient alternatives. The adoption of cogeneration, which combines the production of usable heat

and electricity by utilizing excess steam from electricity generation for heating purposes, can help reduce carbon emissions and lower energy expenses.

- **Energy Use:** Encouraging the increased use of renewable energy sources or other low-emissions energy options is another avenue for companies to explore. This can involve generating renewable energy by installing solar panels on the rooftops of their buildings and factories.
- **Developing Products and Services:** Companies can promote innovation by developing new low-emissions products and services, either by utilizing existing resources or by allocating more funds to research and development (R&D) and capital spending. Procuring low-emissions materials and inputs from suppliers can also contribute to this effort.
- **Market Opportunities:** Private-sector initiatives to develop low-carbon technologies and production methods will increase the supply of low-carbon goods and services. Changes in consumer preferences towards clean energy sources and products will boost demand for low-carbon alternatives. Companies that offer such alternatives may gain access to new clients and markets. This can, in turn, lead to higher corporate value and an enhanced reputation among investors, clients, and customers. A shift in market sentiment towards favoring low-carbon-intensive companies will drive up the prices of securities issued by such firms.
- **Enhancing Resilience:** Companies have the opportunity to enhance their ability to adapt to the impacts of climate change, thereby strengthening their overall resilience.
- **Technology Opportunities:** Ongoing technological advancements and increased R&D have led to a rapid drop in renewable energy prices, thereby facilitating the transition.

Table 2: Major Climate-Related Opportunities

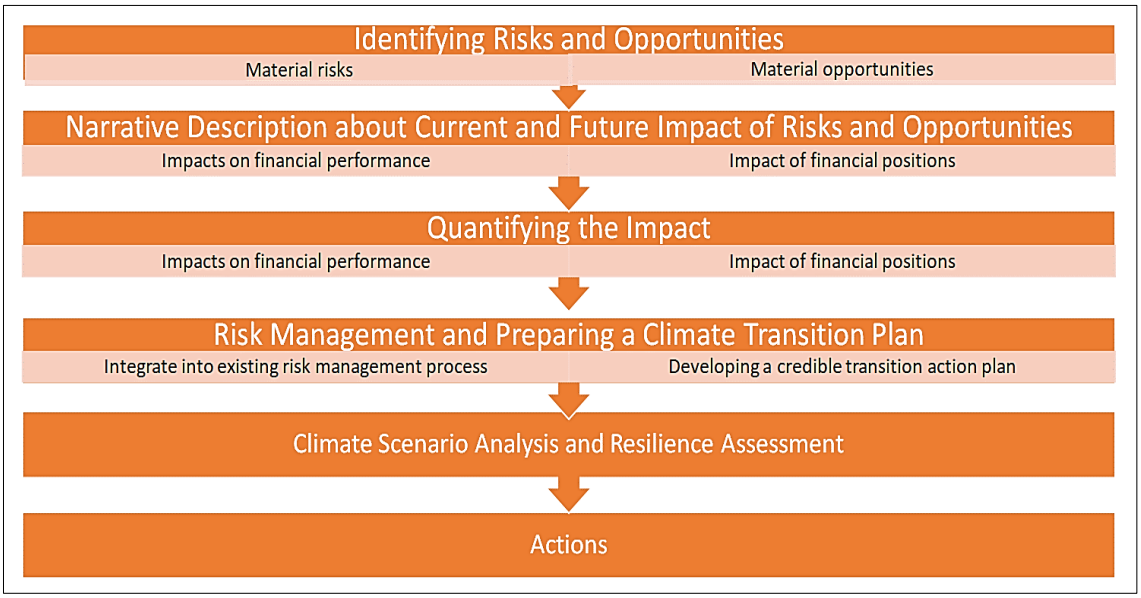
Climate-Related Opportunities	
Resource Efficiency	**Market Opportunities**
Use more environmentally efficient production, transportation, and distribution processes	Increased demand for low-emission products attracting new customers
Reduce water usage and consumption	Higher brand value and reputation
Move to energy-efficient buildings	**Products and Services**
Promoting recycling and reuse	Development of low-emission goods and services
Energy Source	Invest in R&D to promote innovation
Use low-emission energy sources	**Strengthening Resilience**
Develop or use new low-carbon technology	Enhancing corporate ability to cope with climate change
Utilize government subsidies and incentives	Consider resource substitutes and diversify input and materials
	Technology Opportunities
	Technological progress accelerates a rapid drop in renewable energy prices and transition

Source: Prepared by the author based on TCFD (2022).

Identifying risks and opportunities represents the foundational step within the strategic pillar, serving as a starting point for companies aspiring to engage in environmentally sustainable business practices (see Figure 1). Specifically, the task of determining which risks and opportunities that are material to a company poses a substantial challenge, but it stands as an indispensable undertaking. This process demands a meticulous examination encompassing both domestic and international business operations spanning across various business units, locations, and the entire value chain. The assessment of materiality hinges on evaluating the degree to which climate-related risks and opportunities impact a company's present and future financial performance as well as its financial position. These impacts necessitate a contextual understanding within the broader framework of socioeconomic, technological, legal, political, and global factors that shape a company's business environment.

Initially, disclosing these information can take a ***qualitative approach*** in a narrative or descriptive format. However, as companies accumulate analytical experiences and gain access to more internal and external data and information, there is the potential to transition towards a more ***quantitative assessment***. The assessment not only helps them to scrutinize the sustainability of their current business models in the face of identified climate risks, but it also facilitates an exploration of how these models should adapt or transform to seize emerging and prospective opportunities (refer to Figure 1). These considerations may prompt companies to reassess and take action concerning various aspects of their operations, including the types of goods and services they offer, the structure of their business units, their geographical locations, advertising strategies, allocations for research and development, and capital expenditures, as well as their procurement of raw materials and inputs. For instance, a comprehension of material physical risks may compel companies to initiate evaluations of the advantages and disadvantages of their business unit and factory locations in certain areas. Furthermore, transition risks may result in the emergence of stranded assets. As such unexpected write-downs can diminish asset values on the balance sheet and lead to losses on the income statement, companies should figure out the likelihood of facing stranded assets.

Figure 1: The Process of the Strategy Pillar



Source: Prepared by the author based on TCFD (2017, 2020a, 2020b, 2022).

It is imperative that corporate boards and senior management teams possess a profound understanding of these risks and opportunities. Companies routinely engage in risk management by incorporating climate risks into their existing risk management processes, ranking these risks based on their likelihood and significance relative to other risks—the process incorporated in the Risk Management Pillar (TCFD 2020). While climate risks should be integrated into these existing processes, they should not solely be regarded as current or potential risks. Rather, they should also be viewed as emerging risks within medium- and long-term time frames. Consequently, a supplementary approach beyond the traditional shorter time horizons may be warranted, involving collaboration across the company and with suppliers.

2.3 Preparing Climate Transition Plans that Lead to Credible Actions

Once companies have identified material climate-related risks and opportunities and deepened their understanding of the actual and potential impact of these risks and opportunities on their financial performance and positions, the next thing to do is to develop a comprehensive climate transition plan. Investors and other stakeholders no longer consider it sufficient for a company to focus solely on announcing long-term GHG emissions targets, such as achieving net-zero emissions by 2050, without incorporating shorter-term targets and a credible transition plan. A credible climate transition plan should outline a company's holistic business strategy. This includes demonstrating its current and historical GHG emissions performance, specifying ambitious GHG emissions targets (including specific timing, covering all scopes of emissions, and encompassing various types of greenhouse gases) that align with the Paris Agreement goals, and describing a clear pathway outlining how these targets will be achieved. Larger companies are encouraged to take a leadership role by setting a net-zero emissions target by 2050 at the latest and making substantial reductions, approximately halving emissions by around 2030, which is roughly in line with the 1.5°C pathway. Providing quantifiable and verifiable short- and medium-term targets consistent with the net-zero emissions goal is highly recommended. To enhance the credibility of these targets, the importance of aligning them with science-based criteria is emphasized. The plan should also incorporate time-bound financial planning, including a company's capital and operating expenditure plans aimed at reducing GHG emissions and increasing revenue from low-carbon products and services. It should outline scheduled engagements with suppliers to help reduce their Scope 3 GHG emissions. Additionally, describing the assumptions and methodologies used for estimating these targets and addressing uncertainties in the development of the transition plan is desirable.

The preparation of a transition plan serves as an effective means to assess the transition and physical risks that a company may encounter and the extent to which operational and business model transformations may be necessary to mitigate GHG emissions and adapt to global warming. Such a plan fosters a sense of responsibility and ownership not only at the corporate board level but also among all employees. It serves as a foundational document for engaging with stakeholders and can significantly contribute to reducing GHG emissions through meaningful changes in business operations and models. Notably, the European Union (EU) is planning to mandate that large companies (those with more than 500 employees) publish transition plans under the Corporate Sustainability Reporting Directive (CSRD) and the related European Sustainability Reporting Standards (ESRS). The United Kingdom is also in the process of preparing a similar requirement.

As a useful reference in preparing for a climate transition plan, the TCFD has pointed out the Net Zero Company Benchmark's ten disclosure indicators and sub-indicators, which were developed by Climate Action 100+ in 2021 by targeting selected large carbon-intensive global companies. These indicators have proven to be valuable tools for less carbon-intensive companies as well in formulating comprehensive transition plans (Climate Action 100+ 2021). Here, some of the indicators are highlighted below, although ISSB Standards require more detailed or stringent disclosure requirements with regard to some metrics and targets:

GHG Emissions Targets:

- Disclosure of a Net Zero GHG emissions target for 2050 that encompasses at least 95% of Scope 1 and 2 emissions. It should also cover the most relevant Scope 3 GHG emissions categories, where applicable.
- Disclosure of GHG reduction targets, clearly defined across a scope of emissions that covers at least 95% of Scope 1 and 2 emissions, along with the most pertinent Scope 3 emissions (where applicable). These targets should span long-term (2036–2050), medium-term (2026–2035), and short-term (up to 2025) perspectives.

Disclosure Strategy:

- Identification of a set of actions that the company intends to take to achieve its long- and medium-term GHG reduction targets. This should encompass Scope 3, where applicable, and include quantification of key elements of the strategy (e.g., technology or product mix changes, supply chain measures, R&D spending).
- Inclusion of a commitment to "green revenues" from low-carbon products and services in the company's decarbonization strategy. This should also involve disclosure of data and targets related to the share of green revenues in overall sales.

Climate Policy Engagement:

- A specific commitment and position statement by the company to align all lobbying activities with the Paris Agreement goals. Additionally, disclosure of the company's climate-related lobbying activities, such as holding meetings to prepare for policy recommendations against climate policy and submit them to the government.

Climate Governance:

- Disclosure of evidence demonstrating board or board committee oversight of climate risk management. This evidence can be demonstrated through one of the following: (a) appointing a C-suite executive or a member of the executive committee explicitly responsible for climate-related disclosure and reporting, with that executive reporting to the board; (b) having the CEO responsible for climate change and reporting to the board; or (c) having a committee responsible for climate change that reports to the board or a board-level committee.

Just Transition:

- Consideration of the impacts of transitioning to a lower-carbon business model on the company's workers and communities.

TCFD-related Disclosure:

- Utilization of climate scenario analysis to assess the company's strategic and operational resilience. This analysis should incorporate quantitative elements and results, particularly within a 1.5°C scenario. It should also cover the entire company and disclose the methodology employed to establish any Scope 3 targets.

2.4 Developing Climate Transition Plans for Carbon-Intensive Companies

For a carbon-intensive company, formulating a climate transition plan becomes relatively straightforward when feasible low- or zero-emissions alternatives are available at a reasonable cost, as is the case with technologies like solar and wind power, particularly in the realm of electricity generation. However, challenges remain considerable when such alternatives are not currently viable or when substantial uncertainty surrounds the commercialization of new low-emissions technologies within a reasonable time frame. Even in such cases, carbon-intensive companies must explore every possible avenue, harnessing innovation to enhance energy efficiency and promote electrification, leveraging both existing and new technologies.

In practice, nonetheless, there remains a notable absence of comprehensive assessment tools tailored to evaluate the transition progress of companies in hard-to-abate sectors, which encompass industries such as steel, chemicals, cement, heavy manufacturing, transport, metals, and mining. These companies are committed to achieving net-zero GHG emissions by 2050 or even earlier, despite the fact that most of their businesses do not currently fit the profile of "green" entities. While several economies have embarked on developing taxonomies to define environmentally sustainable activities—such as the EU taxonomy for sustainable finance, which incorporates technical screening criteria—the delineation of transition activities is not as well defined as that under the green taxonomy. Given the carbon-intensive nature of many energy systems (including electricity and heat generation, transportation, and manufacturing), a substantial infusion of transition finance is imperative to facilitate their journey toward net-zero emissions.

In response to this pressing need, the Sustainable Market Initiative (SMI), inaugurated by His Majesty King Charles III in January 2020, has formulated a comprehensive framework. This framework aims to assist investors, financial institutions, and stakeholders in identifying, assessing, ranking, and monitoring companies' transition efforts (Sustainable Markets Initiative 2022). The SMI's transition framework is designed to map out a transition continuum, ranging from carbon-intensive companies with no clear transition plans to those actively reducing GHG emissions (the initial point) and progressing toward net-zero emissions (the ultimate goal). This spectrum of transition is depicted through a range of colors, transforming an abstract journey from "black" (the starting point) to "green" (the destination) into a tangible transition process. The precise definitions of "black" and "green" are not the central focus of this framework. Instead, it endeavors to classify companies along the transition spectrum, distinguishing them based on their progress within the undefined space between "black" and "green." To achieve this granularity, the transition spectrum employs four distinct transition colors—"brown," "light brown," "olive," and "light green"—to illustrate where a company resides and the degree of progress it has made along its transition journey.

Furthermore, the SMI's transition framework acknowledges that companies in the midst of transition may pursue different approaches in their quest to achieve net-zero emissions. Broadly conceptualized, two primary transition paths to net zero are embraced: "decarbonizing" and "greening." A decarbonizing company endeavors to attain net-zero emissions by reducing the magnitude of its carbon-intensive activities and products. This reduction is accomplished through enhancements in energy efficiency and innovation. Importantly, it may involve the elimination of emissions from any remaining activities and products through the utilization of removal technologies, such as direct air capture (DAC), or nature-based solutions. In contrast, a greening company seeks to reduce carbon-intensive activities and products, eliminate emissions from these areas, and importantly replace them with green or low-carbon alternatives. This type of company aims to augment the proportion of green activities over time while simultaneously decarbonizing any remaining carbon-intensive activities and products through reductions and removal. The greening transition path may cover more "light green" color space than the decarbonizing transition path.

The assessment criteria are founded on three fundamental attributes of a company's transition plans: (1) emissions ambition, encompassing all emissions scopes, focusing on the 2030 and 2050 targets; (2) emissions reduction, which evaluates the actual GHG emissions reduction performance relative to a reported longer-term baseline, along with short-term reduction efforts; (3) financial actions, specifically examining the level of capital and operational expenditures allocated to decarbonizing the current energy system and establishing green or low-carbon alternatives. These attributes are weighted as follows: 30% for (1), 40% for (2), and 30% for (3), with a greater weight placed on the realized emissions reductions (actions). Each attribute is assessed within the context of the two transition paths—decarbonizing and greening. Financial actions are linked to transition investments and thus serve as a leading indicator for gauging the relative speed and scale of transition. Moreover, the assessment of each of the four transition stages (brown, light brown, olive, and light green) is further refined using descriptors such as "plus," "minus," or "flat=equal." Consequently, the assessment yields 12 distinct scores for evaluating transition activities. This is one plausible approach, although more discussions about appropriate methodologies for assessing the transition processes of carbon-intensive companies in the case that decarbonization technology is not yet available or is available at a prohibitively high cost need to be promoted. The prospect of supportive government measures also crucially influences the likely pace of transition and thus the content of a transition plan. An overview of existing frameworks and criteria related to transition finance for hard-to-abate sector will be reported in Shirai (2023c).

3. CORPORATE-LEVEL CLIMATE SCENARIO ANALYSIS

Among the strategic pillars, another important element emphasized by TCFD recommendations and ISSB Climate-related Disclosures is climate scenario analysis, an analytical exercise used to assess the resilience of business models. Climate scenario analysis could help to identify potentially significant climate-related risks and opportunities under various plausible climate scenarios and promote forward-looking assessment over sustainability of their business activities and preparation. It is important to understand that some climate risks are already manifesting and are likely to intensify, while many other risks, which have not yet materialized, may happen over time but nonlinearly or abruptly. Therefore, companies should recognize that a climate scenario is not aimed at predicting or projecting future events. Rather, it is aimed at

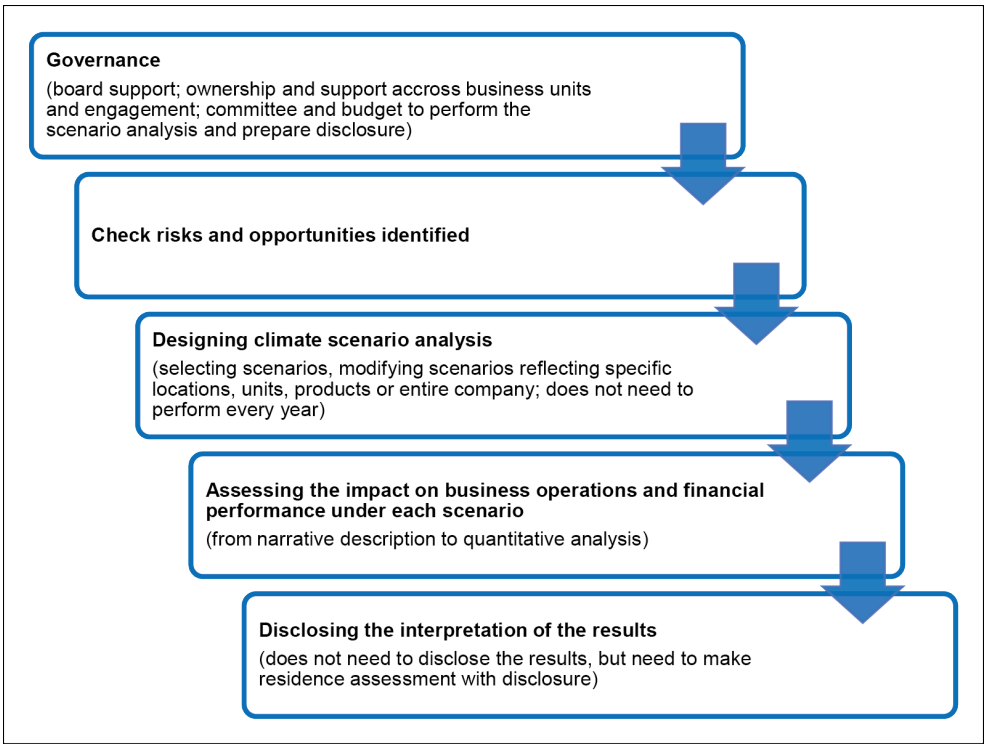
describing a plausible, hypothetical path of development from today with a certain time span (ranging from short to longer terms), which might lead to particular climate-driven aggregate outcomes as well as country-, location-, industry-, and business unit-specific ones. A higher carbon price path is often used to indicate a degree of stringent climate policy as a proxy.

3.1 Process of Performing Climate Scenario Analysis

Climate scenario analysis serves as a valuable tool for identifying potentially significant climate-related risks and opportunities, offering insights into various plausible climate scenarios. It fosters forward-looking assessments regarding the sustainability of business activities and preparedness. In the course of scenario analysis, it is customary for a company to tailor selected scenarios, drawn from existing scenarios and associated models as described below, to align with the company's unique business characteristics and geographical attributes. This customization often involves incorporating some or all of the analytical findings into the scenarios. Following the analysis, companies are expected to disclose the potential impact on their business and operations. This entails a comprehensive examination of risks and opportunities, as well as an evaluation of financial performance, encompassing metrics such as sales, revenue, costs, earnings, operating cash flows, assets, and liabilities under each scenario. It is crucial to consider the sensitivity of these analyses and, most significantly, to elucidate plausible responses and strategies for addressing the identified material risks and opportunities.

Executing this exercise may necessitate the allocation of financial and personnel resources and time toward developing internal research and analysis, along with establishing a decision-making process, including determining how to leverage external sources and expertise. As experience accumulates, companies can refine and expand their analyses. This evolution may commence with a ***descriptive analysis***, gradually advancing to a ***quantified analysis*** that encompasses implications for financial performance under each adopted scenario. Over time, companies may explore the impact in greater detail, delving into major products and services, key business units and locations, or primary sources of raw materials. Conducting scenario analysis on a regular basis is expected to be an integral component of a company's approach to making informed business planning decisions, inclusive of the entire value chain. However, the ISSB does not require companies to perform the analysis every year and the timing of the exercise can be coincided with a multi-year corporate regular strategic planning cycle. Nevertheless, companies must annually assess the climate resilience of their business models by incorporating updated information and insights, even if the content of the information remains unchanged during periods when scenario analysis is not conducted (ISSB 2023d). Climate scenario analysis can also be used for identifying and assessing risks and opportunities, evaluating the impact of these factors on financial performance and positions, and formulating a climate transition plan—the processes already explained above—although the use of analysis for those purposes is not mandated by the ISSB. The ISSB, however, does mandate the use of climate scenario analysis for a company in conducting resilience assessment. A company is not obligated to disclose the specific results of the climate scenario analysis due to the potential inclusion of sensitive business information, but it is required to provide its interpretation of the results. Figure 2 outlines the fundamental steps of the climate scenario analysis process.

Figure 2: The Process of Conducting a Climate Scenario Analysis



Source: Prepared by the author based on TCFD (2017, 2022) and ISSB (2023c, 2023d).

3.2 Main Features of Climate Scenarios

Climate-related scenarios encompass a set of crucial parameters and assumptions that delineate the key drivers and developmental trajectories over the duration of the scenario. To effectively navigate these scenarios, companies must initially identify material risks and opportunities that impact their financial performance and positions, discerning the primary factors contributing to these dynamics. In particular, scenarios generally incorporate parameters, assumptions, and analytical choices that should align with one another. Some key descriptions are provided below:

- **Parameters** employed in the analysis may encompass variables like the discount rate, carbon price, macroeconomic factors (e.g., real GDP, prices, employment), and demographic variables (e.g., population, migration). Among these, the trajectory of the carbon price (e.g., through carbon taxes or emissions trading systems) stands out as one of the most pivotal parameters, directly linked to climate policy mitigation measures and their intensity. Additionally, commodity prices, including those of food, coal, oil, gas, and electricity, can be integral to the analysis.
- **Assumptions** in the analysis relate to various aspects such as the trajectory of temperature increases, GHG or CO_2-equivalent emissions, shifts in climate policies (including carbon price pathways, subsidies, and public investments), advancements and deployment of new technologies, changes in energy demand and composition, and price fluctuations of essential commodities or inputs. For example, companies may decide whether carbon pricing applies exclusively to specific carbon-intensive sectors or to the entire economy, whether differential carbon prices are applicable based on the countries where

their operations are located, and when and how carbon price increases occur. Assumptions can also pertain to geographical or sectoral impacts of physical and transition risks, as well as the time frame of potential impacts. Equally significant are assumptions about technology development, encompassing cost trajectories and the rate of adoption of clean energy sources (e.g., solar, wind, nuclear) and energy storage, carbon capture, storage, and utilization (CCUS), DAC, electric vehicles, biofuels, and more.

- **Analytical choices** pertain to the selection of scenarios, time frames (e.g., 2025, 2030, 2040, 2050, or beyond), the scope of application (e.g., specific business units, entire business units, the entire value chain), and the choice of scenarios and models. Companies should opt for climate scenarios that are most suitable for assessing physical and transition risks related to their businesses. Common climate scenarios may include the current policy (or business-as-usual) scenario, NDCs scenario, Paris Agreement ambitious 1.5°C scenario (roughly equivalent to the net-zero-by-2050 scenario), and Paris Agreement well-below-2°C scenario. The 1.5°C scenario envisions limiting the global average temperature rise to 1.5°C above pre-industrial levels by the end of the century with minimal or no overshoot, while the well-below-2°C scenario aims to keep the temperature rise within 2°C above pre-industrial levels with minimal or no overshoot. Current and NDCs scenarios are widely expected to result in a global average temperature increase well above 2°C, falling short of meeting the Paris Agreement goals and posing heightened physical risks. Depending on the specific models employed, these scenarios may encompass detailed climate policy measures, energy consumption patterns, technological advancements, market dynamics, and risks and opportunities related to reputation.

The TCFD recommends that companies incorporate a range of climate scenarios into their strategic planning, including scenarios aligned with the target limiting global warming to 2°C or lower. These scenarios primarily emphasize the transition to a low-carbon or decarbonized economy, addressing transition risks while also working to mitigate physical risks stemming from global warming. In ensuring progress towards carbon neutrality, companies are increasingly expected by stakeholders to include the 1.5°C scenario in line with the net-zero emissions target. The time frames considered in climate scenario analyses can vary, encompassing shorter periods but generally spanning longer horizons, often projecting 30 years or more into the future, including up to the year 2050.

Climate scenarios can be categorized into two main types: ***climate transition scenarios*** and ***climate physical scenarios***. Transition scenarios examine the technological, political, legal, market, and economic changes required to achieve specific global temperature or emissions pathways, such as limiting warming to 1.5°C or 2°C by the end of the century or reaching net-zero emissions around 2050, along with the associated risks and opportunities. These scenarios illuminate the plausible impacts associated with the process of transition toward a low-carbon economy. In contrast, physical climate scenarios focus on emissions and the resulting physical impacts caused by global warming, such as extreme weather events. Many scenario providers offer a range of scenarios covering different degrees of physical risk and transition risks and opportunities. Climate scenarios can further be classified into ***normative scenarios*** and ***exploratory scenarios***. Normative scenarios are centered on specific normative objectives and outcomes, such as achieving net-zero emissions by 2050 or limiting global warming to 1.5°C by 2100. These scenarios seek to explore how these defined objectives could be realized. On the other hand, exploratory

scenarios do not aim to achieve predefined objectives but instead focus on how certain starting conditions (e.g., climate policies, technology utilization, CO_2 removal) or other external factors may influence future developments.

3.3 Major Climate Scenarios and Models

The ISSB does not prescribe specific climate scenarios or methodologies for climate scenario analysis because of the recognition that the selection of relevant scenarios for a company should be contingent upon its unique business characteristics, operational locations, and the types of physical and transition risks it faces. However, it is essential for a company to provide an explanation regarding the scenarios it utilizes, including the number and types of scenarios, and to clarify whether these scenarios pertain to physical risks or transition risks. In recent years, companies have incorporated various climate scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) into their scenario analyses, tailoring them to accommodate their specific circumstances. These scenarios and models have undergone periodic adjustments and updates. Additionally, companies have increasingly turned to climate scenarios recently provided by the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), a global network comprising over 100 financial regulators and central banks. This paper focuses on the IPCC's Representative Concentration Pathways (RCPs) scenarios, introduced in 2014, followed by the Shared Socioeconomic Pathways (SSPs) scenarios, which were unveiled in 2021. We will also highlight the latest scenarios developed by the IEA and NGFS.

3.3.1 IPCC's Representative Concentration Pathways (RCPs) Scenarios

The IPCC concentrated its efforts on assessing a range of atmospheric CO_2 concentrations and their likely associated global average temperature changes by the end of this century, relative to pre-industrial levels. Specifically, IPCC scenarios examined the patterns of physical impacts resulting from climate change, utilizing global general circulation models to assess the climate response to variations in atmospheric CO_2 concentrations. These scenarios, known as ***climate physical scenarios***, predominantly focused on CO_2 emissions pathways. In the 5th Assessment Report (AR5) Working Group 1 in 2014, the IPCC introduced four Representative Concentration Pathways (RCPs) scenarios, where each refers to the global average temperature range (incorporating uncertainties) to be achieved by the end of this century relative to the period 1986–2005 using the Coupled Model Intercomparison Projects (CMIP) model simulation (IPCC 2013). The RCPs scenarios made a significant advancement compared to earlier scenarios featured in the 3rd and 4th Assessment Reports, in which no climate policy scenarios are incorporated. The main features of each RCP scenario are described below:

1. **The RCP2.6 Scenario** aligns with the objectives of the Paris Agreement, assuming the implementation of essential climate policy measures aimed at limiting the global average temperature increase to 0.3°C–1.7°C (with an average increase of 1.0°C) by 2100, relative to pre-industrial levels. This scenario entails commencing CO_2 emissions reductions by 2020, ultimately achieving net-zero emissions by 2100. It represents an optimistic scenario with the mildest global warming compared to the others.
2. **The RCP4.5 Scenario** envisions a less ambitious reduction in CO_2 emissions than the RCP2.6 scenario, as it does not incorporate climate policy measures. In this scenario, CO_2 emissions peak around 2040 before gradually declining. It

is considered one of the more plausible scenarios, resulting in a global average temperature increase of 1.1°C–2.6°C (with an average increase of 1.8°C) by 2100.

3. **The RCP6.0 Scenario** falls between the more optimistic and pessimistic scenarios, anticipating a global average temperature increase of 1.4°C–3.1°C (with an average increase of 2.2°C) by 2100.
4. **The RCP8.5 Scenario** represents a business-as-usual scenario with no climate policy interventions. Consequently, it leads to a substantial increase in the global average temperature, ranging from 2.6°C to 4.8°C (with an average increase of 3.7°C) by 2100. Under this scenario, the scale and frequency of precipitation, sea level rise, ocean acidification, and the decline of ice and snow in the Arctic Ocean and Northern Hemisphere reach more extreme levels. It is the most pessimistic scenario, characterized by the most significant global warming and associated physical risks.

Extending these scenarios as a foundation, companies can evaluate potential changes in local climate conditions. They can subsequently develop their own climate scenarios that focus on both direct impacts (e.g., floods, droughts) and indirect impacts (e.g., crop production, material shortages, operational disruptions, famines) stemming from critical climate change factors. It is worth noting that these scenarios do not incorporate standardized socioeconomic descriptions, which could offer valuable insights into assessing physical risks.

3.3.2 IPCC's Shared Socioeconomic Pathways (SSPs) Scenarios

Subsequently, in 2021, the IPCC introduced the Shared Socioeconomic Pathways (SSPs) scenarios within the 6th Assessment Report (AR6) WG1 Report (IPCC 2021). These scenarios built upon the foundation of the RCPs scenarios, incorporating a nuanced modeling of socioeconomic factors, including population, education, technology, and climate policy. The goal was to map these factors to the global average temperature by 2100, relative to pre-industrial levels (IPCC 2021). The SSPs scenarios offer a more comprehensive and sophisticated approach than the RCPs scenarios by addressing the achievement or nonachievement of GHG emissions reductions and providing more detailed business-as-usual scenarios (Hausfather 2018). These scenarios fall into two broad categories: low-carbon scenarios that envisage successful GHG emissions reductions, and high-carbon scenarios that predict more substantial warming due to the absence of effective climate policy measures.

Utilizing Integrated Assessment Models, the models make assumptions about how factors such as population, education, urbanization, energy usage, land use, technology development rates, and wealth might evolve throughout the century. These socioeconomic variables, combined with assumptions about the level of climate change mitigation ambition, result in scenarios of CO_2 emissions and corresponding atmospheric concentrations. For instance, population growth could drive increased demand for fossil fuels and water resources, while educational levels can influence the pace of technological advancements. Changes in land use, such as the conversion of forests to agriculture, may lead to higher GHG emissions. These scenarios offer a range of potential future climates, encompassing both high-carbon and low-carbon pathways, depending on societal and policy choices. Table 3 provides an overview of key metrics used in these scenarios, including per capita GDP, population, the proportion of fossil fuels in primary energy, global average temperature, CO_2

emissions, and carbon price (a proxy for the extent of climate mitigation policy). The main features of each SSP scenario are pointed out below:

1. **The SSP1-1.9 (sustainability) Scenario** depicts an optimistic, sustainable, and inclusive future with a target of achieving net-zero GHG emissions around 2050. This results in a global temperature increase of 1.0°C–1.8°C (averaging 1.4°C) by 2100 relative to pre-industrial levels. This scenario prioritizes environmental sustainability and equitable development, emphasizing global initiatives for human well-being, sustainable development goals, clean technologies, and reduced inequality. Investments in education and health increase. Global warming persists and leads to more frequent extreme weather events. This scenario presents relatively low challenges for both mitigation and adaptation.
2. **The SSP1-2.6 (middle-of-the-road) Scenario** envisages net-zero GHG emissions achieved after 2050 but within the latter half of the century. This scenario limits the global temperature increase to 1.3°C–2.4°C (approximately 1.8°C). Societal, economic, and technological developments largely follow historical patterns. Development and income growth are uneven across countries and regions, with slow progress toward common global development goals like reduced inequality. Environmental systems face degradation, and population growth remains moderate, stabilizing in the latter half of the century. Both mitigation and adaptation present moderate challenges.
3. **The SSP2-4.5 (regional rivalry) Scenario** portrays a pessimistic, fragmented world characterized by increased nationalism, security concerns, and regional conflicts driven by energy and food security. This scenario is based on aggregated NDCs submitted to the United Nations through 2030, leading to a global temperature increase of 2.1°C–3.5°C (around 2.7°C) by 2100. CO_2 emissions remain at current levels before declining in the middle of the century, falling short of net zero by 2100. Investments in technology and education decline, and inequality worsens. Population growth varies, with developed countries experiencing low growth and developing countries having higher rates. Limited climate policy actions result in significant environmental degradation in specific regions, posing difficult challenges for both adaptation and mitigation.
4. **The SSP3-7.9 (inequality) Scenario** presents a pessimistic and business-as-usual scenario devoid of climate policy interventions, reflected in low carbon prices. CO_2 emissions are nearly double the current levels, resulting in a global temperature rise of 2.8°C–4.6°C (about 3.6°C) by 2100. Many countries grapple with food shortages, escalating inequality, and heightened competition. Significant disparities in education and economic opportunities, along with power imbalances, contribute to rising inequality within and among nations. This scenario presents low-level challenges to mitigation but difficult challenges to adaptation.
5. **The SSP5-8.5 (fossil-fueled development) Scenario** mirrors a business-as-usual trajectory with no climate policy measures, notably low carbon prices. CO_2 emissions nearly double by 2050 due to extensive fossil fuel use and carbon-intensive energy practices, driving global temperatures to a 3.3°C–5.7°C (about 4.4°C) increase by 2100. This scenario depicts a globally integrated market, accelerated technological advancements, and investments in human capital, health, and institutions. Extensive coal use and emissions-intensive lifestyles result in rapid economic growth but contribute to substantial global

warming without prioritizing environmental concerns. The population peaks and then declines during this century. High-tech economies experience rapid technological development, while investments flow into both fossil fuel and low-carbon energy sources. This scenario poses difficult challenges for mitigation but low-level challenges for adaptation.

While the RCPs Scenarios primarily revolve around CO_2 emissions trajectories and their associated future scenarios based on emissions volume, the SSPs scenarios provide distinct pathways illustrating how society, demographics, and the economy may evolve throughout this century. These pathways serve as inputs into climate models, offering insights into how societal choices influence CO_2 emissions trajectories (WBCSD 2022). Both the RCPs and SSPs scenarios can be effectively utilized by companies in a complementary manner to enhance their understanding of potential outcomes for global average temperature and socioeconomic dynamics under specific conditions. This understanding can then inform the analysis of how these factors may impact a company's business operations, financial performance, and overall standing.

Table 3: IPCC's Shared Socioeconomic Pathways (SSPs) Scenarios and Path of Selected Metrics

Scenario	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Per Capita GDP ($)						**Fossil Fuel** (% of Primary Energy)				
2005	8,791	8,791	8,693	8,431	8,715	85.8852	85.8852	84.91416	85.0396	83.383556
2010	9,891	9,891	9,833	9,421	9,801	84.90192	84.90192	83.54395	85.30583	83.369803
2020	13,439	13,439	13,297	12,659	13,493	84.33913	86.67887	81.35767	85.92308	84.811742
2030	19,332	19,332	17,310	15,316	20,586	71.83293	83.85839	80.57629	86.21695	89.311044
2040	26,606	26,606	21,137	16,698	30,965	55.46905	76.03586	78.94516	86.12363	92.567914
2050	34,148	34,148	25,175	17,440	42,511	47.67697	66.93619	76.46006	85.58797	93.504274
2060	41,955	41,955	29,811	17,976	55,688	42.77815	57.22772	72.86473	84.91492	93.49711
2070	50,523	50,523	35,498	18,700	71,633	39.3019	48.44177	67.97052	84.25636	92.893401
2080	59,671	59,671	42,146	19,490	90,317	31.82977	37.86934	62.84338	83.61074	91.301843
2090	69,886	69,886	49,989	20,362	112,668	24.39037	31.57092	56.45497	83.19504	88.077994
2100	81,258	81,258	59,259	21,415	139,797	18.57704	29.81389	52.88456	82.59891	83.881579
Global Average Temperature (relative to pre-industrial level)						**Carbon Dioxide Emissions** (Million tonnes)				
2005	0.9	0.9	0.9	0.9	0.9	33,166	33,166	37,771	34,374	35,280
2010	1.0	1.0	1.0	1.0	1.0	35,489	35,489	40,294	39,561	36,371
2020	1.2	1.2	1.2	1.2	1.3	33,209	38,390	42,285	48,503	44,610
2030	1.5	1.5	1.5	1.5	1.6	17,968	33,931	44,386	55,001	56,726
2040	1.6	1.7	1.7	1.9	2.0	6,414	25,905	44,492	59,877	69,862
2050	1.6	1.8	2.0	2.2	2.5	968	17,733	42,832	64,001	84,436
2060	1.5	1.8	2.2	2.6	3.0	–1,650	10,566	39,042	67,962	101,302
2070	1.5	1.8	2.3	2.9	3.5	–4,137	4,785	34,193	71,793	117,500
2080	1.5	1.8	2.5	3.3	4.0	–7,370	–2,922	25,824	75,571	129,499
2090	1.4	1.8	2.6	3.7	4.6	–10,568	–8,098	15,469	80,137	130,398
2100	1.3	1.8	2.6	4.1	5.1	–14,340	–8,347	9,115	85,215	126,098
Carbon Price ($)						**Population** (Billion)				
2005	0	0	0	0	0	6.5	6.5	6.5	6.5	6.5
2010	0	0	0	0	0	6.9	6.9	6.9	6.9	6.9
2020	0	9	18	0	0	7.6	7.6	7.6	7.7	7.6
2030	304	33	13	0	0	8.1	8.1	8.3	8.5	8.1
2040	546	72	8	0	0	8.4	8.4	8.8	9.3	8.4
2050	651	100	12	0	0	8.5	8.5	9.2	10.0	8.6
2060	708	110	20	0	0	8.5	8.5	9.4	10.6	8.6
2070	652	148	33	0	0	8.3	8.3	9.5	11.1	8.5
2080	520	243	53	0	0	8.0	8.0	9.4	11.6	8.2
2090	335	186	87	0	0	7.5	7.5	9.3	12.1	7.8
2100	239	140	141	0	0	7.0	7.0	9.0	12.6	7.4

Note: Pre-industrial era refers to 1750.

Source: Prepared by the author based on Our World Data Explorer IPCC Scenarios (https://ourworldindata.org/explorers/ipcc-scenarios).

3.3.3 IEA'S Global Energy and Climate (GEC) Model and Scenarios

The IEA's scenarios revolve around government policies as pivotal determinants of the future global energy landscape, with policy discrepancies being key drivers of variations across scenarios. Concurrently, the GEC Model takes into account a range of factors and influences, encompassing economic and demographic contexts, technology costs and advancements, energy pricing and affordability, corporate sustainability commitments, and social and behavioral elements. The model meticulously incorporates the evolving costs of established technologies, although it does not account for potential breakthroughs in unknown technologies, such as nuclear fusion. The IEA employs the GEC Model to generate climate scenarios, each rooted in a distinct set of assumptions regarding how the energy system may respond to the ongoing global energy challenges and its subsequent evolution. These scenarios offer companies the opportunity to compare and analyze outcomes, thereby fostering insights into the future of global energy. The GEC Model stands as an integrated modeling framework, facilitating the creation of detailed, sector-specific, and region-specific long-term scenarios, which play a crucial role in comprehending energy market dynamics, technology trends, climate policy strategies, and investments across the energy sector, all of which are essential for achieving climate objectives. The model spans 26 individual regions, whose results can be aggregated to offer a global perspective, covering all sectors within the energy system.

The GEC Model relies on an extensive dataset, featuring dedicated bottom-up modeling for three primary domains: (1) final energy demand (including industry, transportation, buildings, agriculture, and other nonenergy uses); (2) energy transformation (including electricity generation, heat production, refineries, biofuel and hydrogen fuel production, transmission and distribution systems, storage, and trade); and (3) energy supply (involving fossil fuel exploration, extraction, trade, and the availability of renewable energy resources). These projections emerge from a unified model that synthesizes the strengths of previous models, namely the World Energy Model and the Energy Technology Perspectives (ETP) model. This integration empowers the model to offer insights into energy markets, investments, technologies, CO2 removal, and the climate policies essential for a clean energy transition. Each scenario within the model integrates assumptions about population, real GDP growth, pricing (fossil fuel prices, carbon prices, subsidies), and actual policies (e.g., the Inflation Reduction Act in the United States). Additionally, each scenario incorporates techno-economic parameters, encompassing innovative technology (e.g., clean technology, hydrogen) and technology costs (e.g., electric vehicle costs, battery costs, iron and steel production costs).

The IEA's World Economic Outlook 2022 and ETP-2023 provide three scenarios that align with the 2020 GEC modeling cycle, consistently updated to incorporate the latest energy market data and cost information (IEA 2022). The main features of each scenario are pointed out below:

1. **The Net Zero Emissions by 2050 Scenario (NZE Scenario)** stands out as a normative and highly desirable pathway, offering a systematic transition blueprint for the global energy system, which is responsible for three quarters of GHG emissions. This scenario is meticulously crafted to align with the objective of limiting the global average temperature rise in 2100 to below 1.5°C, carrying a 50% probability of success. Central to this vision is universal access to modern energy and electricity services, alongside substantial enhancements in air quality, both of which are integral to sustainable development goals. Notably, the achievement of net-zero emissions in this scenario does not rely on emissions reductions from nonenergy sectors. It operates on the assumption of

global cooperation, ensuring that the needs of developing countries are accommodated for a just transition. This scenario skillfully minimizes stranded assets while safeguarding the security of fuel and electricity supplies.

2. **The Announced Pledges Scenario (APS)** is based on the assumption that governments diligently implement all emissions reduction commitments necessary to attain the NDCs and long-term net-zero targets. It further assumes the attainment of access to electricity and clean cooking targets on a global scale. A country's net-zero pledge in this scenario may encompass the use of offset measures, such as emissions absorption through forestry or land use. The APS scenario sheds light on a sobering reality: that the current NDCs, though significant, fall short of the ambition required to fulfill the Paris Agreement goals. It underscores these ambition gaps by quantifying the divergence between current targets and the objective of limiting the global average temperature increase to 1.5°C by 2100. Additionally, the scenario highlights the disparity between existing goals and achieving universal energy access, a vital component of the Sustainable Development Goals (SDGs).
3. **The Stated Policies Scenario (STEPS)** serves as a benchmark scenario grounded in existing policies, operating on the assumption that governments will not enact all the policies necessary to fulfill their NDCs and long-term net-zero commitments. This scenario offers a granular examination, delving into sector-specific and country-specific assessments of the policies currently in place and those in various stages of development to meet these commitments. STEPS explores the trajectory of the global energy system in the absence of additional climate policies. The scope of policies considered extends beyond NDCs, encompassing a broad range of measures, including sector-specific details related to efficiency standards, electrification, specific infrastructure investments, and adopted measures and proposals influencing energy markets.

Among these three scenarios, the Net Zero Emissions by 2050 Scenario is ***normative***, as it is designed to achieve a specific outcome (limiting global warming to 1.5°C by 2100) and demonstrates the necessary steps to attain net-zero CO_2 emissions from energy-related and industrial processes by 2050, while also addressing other energy-related sustainable development goals, such as universal energy access. In contrast, the Announced Pledges Scenario and the Stated Policies Scenario are ***exploratory***, as they are not aimed at specific outcomes but rather establish initial conditions (including climate policy measures and targets) that subsequently shape outcomes through the model's representation of energy systems, encompassing technological advancements and market dynamics. Notably, the 2022 GEC modeling cycle does not incorporate the IEA's well-known Sustainable Development Scenario (SDS), which aims to keep global warming well below 2°C by 2100 while achieving other sustainable development goals. The IEA's scenarios emphasize climate transition scenarios, particularly those involving climate policy measures, such as the Net Zero Emissions by 2050 Scenario, more explicitly than the IPCC's scenarios. Consequently, the IEA's scenarios are often regarded as ***climate transition scenarios***.

The IEA employs carbon prices as critical inputs in these scenarios, projecting specific carbon prices for each sector, akin to a direct tax on emissions. Table 4 provides insight into the projected carbon price trajectories for the years 2030, 2040, and 2050 under each scenario. While each scenario anticipates a gradual increase in carbon prices, tailored to different stages of economic development, the path outlined in the Net Zero by 2050 Scenario is noticeably more aggressive. Notably, the carbon prices applicable to emerging and developing countries surpass the levels seen in the Stated Policies Scenario, underlining the ambition of this transformative pathway.

Table 4: Carbon Prices Set under the IEA's Global Economy and Climate Scenarios

USD (2021) per tonne of CO_2	2030	2040	2050
Stated Policies Scenario			
Canada	54	62	77
Chile, Colombia	13	21	29
PRC	28	43	53
European Union	90	98	113
Republic of Korea	42	67	89
Announced Pledges Scenario			
Advanced economies with net zero emissions pledges[1]	135	175	200
Emerging market and developing economies with net zero emissions pledges[2]	40	110	160
Other emerging market and developing economies	–	17	47
Net Zero Emissions by 2050 Scenario			
Advanced economies with net zero emissions pledges	140	205	250
Emerging market and developing economies with net zero emissions pledges	90	160	200
Other emerging market and developing economies	25	85	180

Source: IEA (2022).

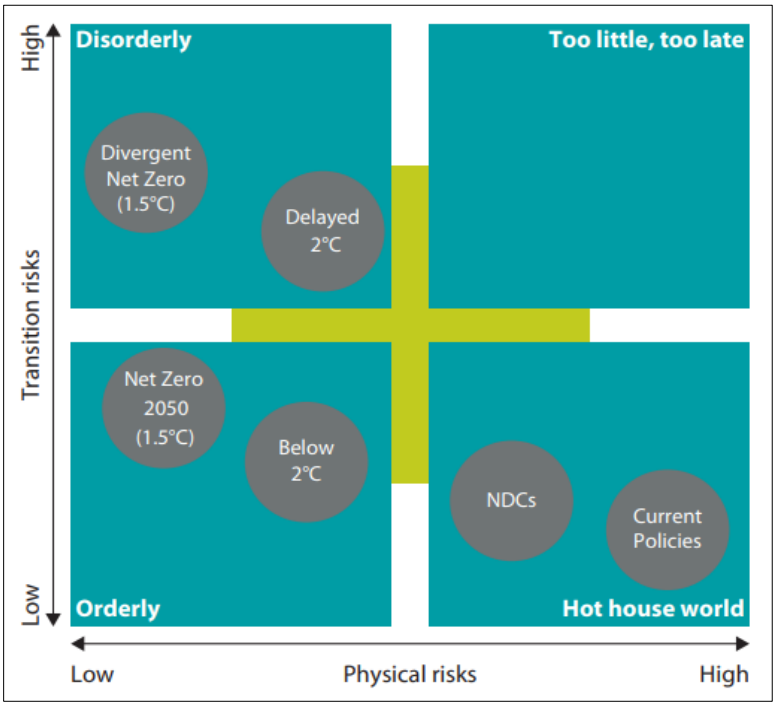
3.3.4 NGFS's Climate Scenarios

The NGFS's scenarios are designed to serve financial authorities, empowering them to conduct comprehensive bottom-up climate scenario analyses tailored to financial institutions within their jurisdictions, including banks and insurance companies. However, it is increasingly recognized that these scenarios are equally valuable to companies, much like the IPCC's and the IEA's scenarios. The NGFS crafts these scenarios through models explicitly engineered to simulate the intricate, nonlinear dynamics of the energy, economy, and climate systems. These simulations incorporate diverse assumptions regarding climate policies, technological advancements, and CO_2 removal strategies, such as increasing forest cover, enhancing land use through sequestration, and cultivating crops for bioenergy with carbon capture and storage (BECCS). Consequently, these scenarios offer an intuitive understanding of the trade-offs between physical risks and transition risks, accompanied by enlightening insights into their implications for GDP, inflation, and long-term interest rates. The representation of climate policy within the NGFS's models involves a gradual increase in real-term carbon taxes, strategically applied to energy services, including transportation, floor space for buildings, and specific industrial materials. This approach efficiently reduces the demand for energy services, assuming full elasticity of demand, or propels technological advancements. Furthermore, carbon taxes generate fiscal revenues, offering flexibility for allocation to public investments, debt repayment, and other critical areas (NGFS 2020, 2022).

The NGFS categorizes its six types of climate scenarios into three primary groups: (1) Orderly Scenarios (comprising the Net Zero [1.5°C] Scenario and Below 2°C Scenario); (2) Disorderly Scenarios (encompassing the Delayed 2°C Scenario and Divergent Net Zero Scenario); and (3) Hot House World Scenarios (comprising the Nationally Determined Contributions [NDCs] Scenario and Current Policies Scenario). These scenarios are intuitively easy to understand. The main features are illustrated in Figure 3 and highlighted below:

1. **The Orderly Scenarios** envisage the early adoption of moderate climate policies that progressively tighten over time. Consequently, both physical and transition risks remain relatively contained. These scenarios assume a medium to high utilization of CO_2 removal techniques.
   - **The Net Zero 2050 Scenario (1.5°C Scenario)** assumes the swift implementation of climate policy measures, such as significant increases in carbon pricing, relative to other scenarios. This leads to the effective containment of transition and physical risks. Technological advancements are expected to occur rapidly, with a global average increased temperature ambition of 1.4°C.
   - **The Below 2°C Scenario** is less favorable than the Net-Zero 2050 Scenario due to the expectation of gradual policy stringency. Moderate technological advancements are assumed, and the global average increased temperature ambition is set at 1.6°C.
2. **The Disorderly Scenarios** delve into higher transition risks resulting from delayed or divergent policies across countries and sectors. Consequently, carbon prices tend to be elevated for a given temperature outcome (as depicted in Figure 4). These scenarios assume a low to medium utilization of CO_2 removal methods.
   - **The Delayed 2°C Scenario** envisages a delay of approximately ten years in climate policy implementation until around 2030, necessitating more stringent measures later to limit global warming to below 2°C. Transition risks are heightened compared to Orderly Scenarios. The pace of technological change may be either slow or fast, with a global average increased temperature ambition of 1.6°C.
   - **The Divergent Net Zero Scenario (1.5°C Scenario)** anticipates the early adoption of climate policy measures but in a divergent manner across sectors and countries, resulting in higher global costs. Rapid technological advancements are assumed, with a global average increased temperature ambition of 1.4°C.
3. **The Hot House World Scenarios** posit that global efforts are inadequate to significantly curtail global warming, even though some environmentally conscious jurisdictions implement certain climate policies. Consequently, these scenarios project severe physical risks, including global warming and rising sea levels. They assume a low to medium utilization of CO_2 removal methods and a slow pace of technological change.
   - **The NDCs Scenario** assumes the achievement of all pledged emissions targets, even if most economies and regions have yet to implement credible, effective climate policies. However, the 2030 targets committed under the NDCs fall short of meeting the Paris Agreement goals, resulting in a global average temperature increase of 2.6°C. The scenario assumes a low to medium use of CO_2 removal methods.
   - **The Current Policies Scenario** assumes higher physical risks than the NDCs Scenario due to the assumption that only currently implemented climate policies will be maintained in the future. There is no envisaged increase in carbon pricing, leading to a global average increased temperature exceeding 3°C. The scenario assumes a low utilization of CO_2 removal methods.

Figure 3: NGFS's Six Types of Climate Scenarios



Source: NGFS (2022).

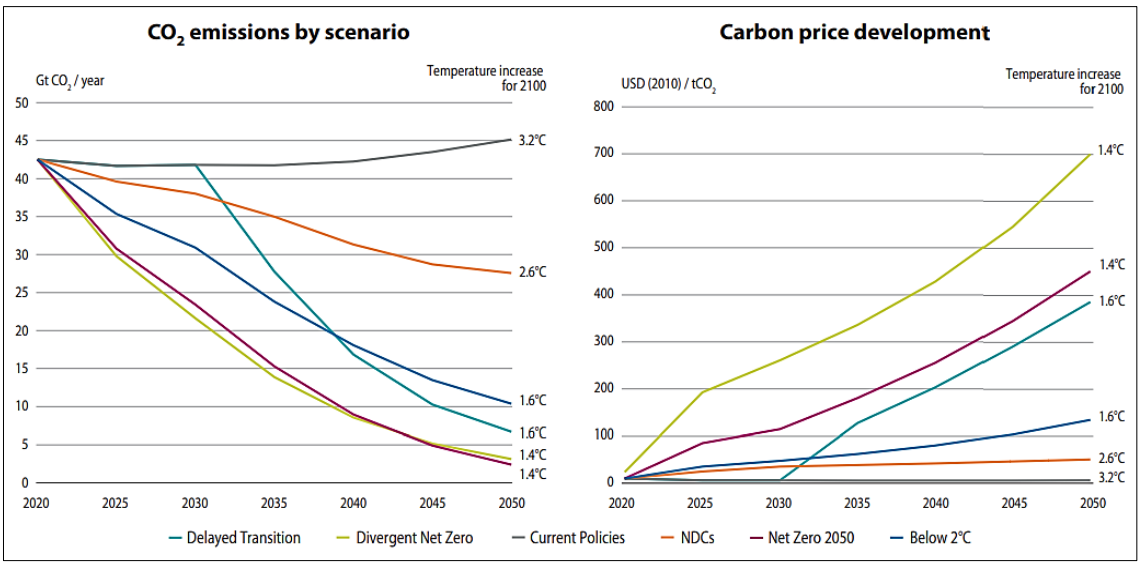
Within the Orderly Scenarios, transition risks assume greater prominence, while physical risks are comparatively lower. Conversely, the Hot House World Scenarios witness a stark contrast, with physical risks escalating significantly while transition risks are more contained (Figure 3). Among these, the primary scenarios of interest include the Net Zero Scenario, Delayed 2°C Scenario, and Current Policies Scenario. These scenarios emerge from the collective insights of three Integrated Assessment Models (namely, GCAM, MESSAGE, and REMIND), which collectively span a broader spectrum of policy and technological dimensions, incorporating diverse regional and industrial intricacies. The integration of multiple models serves the valuable purpose of capturing the inherent uncertainty related to model structures and techno-economic assumptions, offering a comprehensive perspective on the potential future trajectories.

The climate transition scenarios, which aim to limit global warming to below 2°C or around 1.5°C by the year 2100, exclude the NDCs and Current Policies Scenario. While the modeling approaches and data differ, the NGFS's Net Zero 2050 scenario, NDCs Scenario, and Current Policies Scenario can be broadly aligned with the IEA's Net Zero Emissions by 2050 Scenario (NZE Scenario), the Announced Pledges Scenario (APS), and the Stated Policies Scenario (STEPS), respectively. These comparisons have been made in the NGFS's Scenarios report (NGFS 2022).

Moreover, the carbon price trajectory, influenced by carbon taxes, constitutes a critical component of these scenarios (as depicted in Figure 4). The figure illustrates that the NGFS's carbon prices are noticeably higher than those employed by the IEA (as shown in Table 4). This discrepancy arises because the NGFS employs a shadow carbon price, representing the marginal cost of abatement required for specific transitions. It calculates cumulative global CO_2 emissions across all sectors and imposes constraints on these sectors using various carbon prices to align with the climate limits specified in each scenario. Consequently, the NGFS's carbon price is endogenously derived and utilized to regulate emissions consistently with each scenario. In contrast, the IEA uses

explicit carbon prices as inputs, which are then applied at the sectoral level in models to analyze emissions quantities. This allows for the calculation of a specific carbon price (a direct tax) on emissions per sector (WBCSD 2022). Significant carbon price increases tend to elevate energy costs in the short term. This can exert downward pressure on energy prices due to decreased energy demand resulting from full elasticity of demand, as well as adverse effects on financial markets that may lead to reduced output. As a consequence, carbon price hikes result in modest but heightened inflation and unemployment, with the peak anticipated sometime within the 2030s before reverting to previous trends. Nevertheless, the negative impact on unemployment can be mitigated if countries utilize the increased tax revenue resulting from higher carbon taxes to bolster public investment and implement other policy measures to offset damages. Reflecting the elevated inflation, long-term interest rates experience an increase for a certain period until around 2030.

Figure 4: Carbon Dioxide Emissions and Carbon Price Path under the Six Scenarios



Source: NGFS (2022).

Once they have selected a few climate scenarios, for example, from the aforementioned scenarios and models, companies are free to use own estimations and combine them with the existing scenarios. They can also fill out some missing information from other internal or external quantitative and qualitative sources, for example, with regard to specific years, sectors, regions, or types of products or commodities to design future scenarios more suitable for them. Useful insights may be obtained through engagement with their employees in different business units and regions, suppliers, and stakeholders. It should be noted that climate scenario analysis does not need to focus excessively on pursuing numerical accuracy (Ministry of the Environment 2023). Then, under each climate scenario, companies are expected to assess the impacts on their financial performance and positions based on the identified risks and opportunities. In particular, a comparison of several extreme or normative scenarios (such as the Net Zero 2050 Scenario) with business-as-usual scenarios (such as the Current Policies Scenario) helps improve companies' understanding of the impacts on their business models more thoroughly.

4. FINANCIAL INSTITUTIONS' DISCLOSURE AND CLIMATE SCENARIO ANALYSIS INITIATED BY FINANCIAL AUTHORITIES

Financial institutions such as commercial banks hold a pivotal role in facilitating the transition of both the economy and companies toward a low-carbon future. They can provide vital financial support for initiatives such as green loans and bonds, sustainability-linked loans and bonds, as well as activities aimed at achieving net-zero emissions. Financial institutions are expected to make informed decisions to effectively reduce the emissions they finance, particularly those recorded under Scope 3, category 15 (investments) in accordance with the GHG Protocol Corporate Value Chain (Scope 3) Standard. They are also required to promote consistent and trustworthy corporate climate-related disclosures that align with international standards—especially with regard to information related to large companies for which they provide finance. Financial institutions can gain a comprehensive understanding of their exposure to climate-related risks by utilizing data and targets disclosed by the companies they finance and actively engaging with them. Stakeholders increasingly focus on financed emissions to understand a financial institution's exposure and resilience to physical and transition risks and its readiness to seize opportunities in the climate transition plan.

4.1 Climate-Related Disclosure for Net-Zero Financial Institutions

Financial institutions are increasingly expected to make a comprehensive and strategic commitment to achieving net-zero emissions from their financed activities by 2050 or earlier, aligning with the goals set out in the Paris Agreement. This commitment extends across their entire organizational spectrum. It is crucial for financial institutions to ensure that aligned and coordinated actions are undertaken across all business divisions to reduce emissions stemming from their operations, financing, and investment activities. Many of the world's largest financial institutions have already made pledges to achieve net-zero emissions by becoming members of the Glasgow Financial Alliance for Net Zero (GFANZ) and its sector-specific alliances. GFANZ is a coalition of seven net-zero alliances within the financial sector, including initiatives such as the Net Zero Asset Managers Initiative (NZAM), Net-Zero Asset Owner Alliance (NZAOA), Net-Zero Insurance Alliance (NZIA), and Net-Zero Banking Alliance (NZBA). These alliances comprise more than 550 global financial institutions committed to playing a crucial role in supporting the global transition to a net-zero economy. Member institutions of these alliances are expected to voluntarily disclose climate-related information—encompassing targets of reducing financed emissions to net-zero by 2050 or sooner, metrics to monitor the progress relative to the targets, and climate transition plans. Developing a robust transition plan is increasingly recognized as essential for translating net-zero commitments into accountable actions. GFANZ member financial institutions voluntarily set ambitious, science-based commitments to accelerate the transition to net-zero emissions.

In 2022, GFANZ published voluntary recommendations and guidance to assist financial institutions in developing net-zero transition plans (GFANZ 2022). These plans encompass their commitments, transition targets, specific actions to be taken, and the implementation of accountability mechanisms to ensure the credibility of the plans. Furthermore, sector-specific alliances within GFANZ have prepared detailed disclosure indicators to guide financial institutions in their disclosure efforts (CDP 2023). Among

financial institutions, commercial banks hold a particularly critical role in economies and businesses, including small- and medium-sized enterprises. They accept deposits and extend loans to individuals and corporations, including lending for infrastructure, real estate, and various projects, facilitating the efficient allocation of financial resources. Banks often grapple with maturity mismatches arising from a large volume of deposits and longer-term lending. The quality of loans, the macroeconomic environment, and interest rates significantly impact their profitability and viability. Their loans and investments in carbon-intensive industries pose inherent and growing risks due to evolving environmental regulations and climate policies, and rapid technological advancements. To begin with, banks could make efforts to comprehend credit risks associated with carbon-intensive companies, such as premature write-downs or increases in stranded assets among various financial risks. Failing to manage climate risks and opportunities within their lending and investment portfolios may lead to reduced returns and heightened vulnerability, undermining the sustainability of their business models.

Banks pledging to achieve net-zero emissions through participating in GFANZ's banking alliance, are expected to disclose GHG emissions linked to their financing activities in alignment with net-zero targets. Notable disclosure indicators and actions set out by the NZBA include:

- Transitioning all operational and attributable GHG emissions stemming from lending and investment portfolios to align with pathways to net zero by 2050 or earlier, in line with limiting global temperature rises to 1.5°C by 2100. These targets should be science-based, reviewed, and, if necessary, revised at least every five years after they have been established.
- Utilizing decarbonization scenarios from reputable and well-recognized sources that employ conservative approaches, with minimal or no overshoot, and relying on negative emissions technologies.
- Prioritizing efforts in sectors with the highest GHG intensity and emissions within portfolios.
- Establishing science-based GHG emissions targets for 2030 or earlier.
- Publishing an annual report and monitoring actions to ensure alignment with the commitments.

These disclosure and emissions-reduction efforts are crucial in enabling stakeholders to better understand a bank's exposure to climate risks and its dedication to the transition to a net-zero emissions economy.

4.2 ISSB's Disclosure Requirements for Commercial Banks

In addition to adhering to general requirements set under the ISSB's Climate-related Disclosures, banks are mandated to provide specific metrics as stipulated by industry-based disclosure requirements tailored for commercial banks (ISSB 2023a). Some key metrics are highlighted below:

Transition Risk Exposure Quantitative and Qualitative Metrics:

- **Gross exposure to carbon-related industries** (presentation currency), by industry, as well as total gross exposure to all industries, and percentage of total gross exposure for each carbon-related industry. Carbon-related industries include but are not limited to: (a) oil, gas, and consumable fuels; (b) chemicals, construction materials, metals and mining, and paper and forest products;

(c) air freight and logistics, airlines, marine, and road and rail; (d) automobiles; (e) homebuilding; (f) beverages and food products; (g) electric utilities, gas utilities and multi-utilities; (h) real estate management and development. Companies shall use the latest version of the Global Industry Classification Standard (GICS) six-digit industry-level code for classifying counterparties. Companies using other classification standards are required to disclose the information. As for funded amounts, gross exposure is defined as the funded carrying amounts (the amount before subtracting the loss allowance, when applicable) expressed in the presentation currency of the company's financial statements.

- **Percentage of gross exposure to asset classes** included in the financed emissions calculation. The percentage shall be calculated by dividing the gross exposure included in the financed emissions calculation by the total gross exposure to all industries and asset classes.
- **For each industry by asset class (absolute unit):** (1) **absolute gross** (Scope 1, Scope 2, Scope 3 emissions each), and (2) **gross exposure** (i.e., financed emissions). These are measured in metric tonnes (t) CO2 equivalent and presentation currency.
- **For each industry by asset class (intensity unit):** (1) **gross emissions intensity** by Scope 1, Scope 2, and Scope 3 emissions each, and (2) **gross exposure** (i.e., financed emissions). These are measured in metric tonnes (t) CO_2 equivalent per unit of physical or economic output and presentation currency.
- **Description of the methodology** used to calculate financed emissions. Gross emissions are GHGs emitted into the atmosphere before accounting for offsets and credits that have reduced or compensated for emissions. The description shall include the method used to attribute the entity's share of emissions in relation to the size of its gross exposure.

4.3 Climate Scenario Analysis Promoted by Financial Authorities

As financial institutions embark on disclosing climate-related information in alignment with global standards, encompassing transition plans, scenario analysis, and the establishment of GHG emissions reduction targets related to their operations (Scope 1 and Scope 2) and financed emissions (encompassed within Scope 3), financial authorities are increasingly using climate scenario analyses for banks and other financial institutions within their respective jurisdictions. The rationale behind this heightened focus is the ever-expanding role of climate change within the financial sector. There is a growing consensus that climate risks should be integrated into the broader framework of financial risks, prompting financial authorities to deepen their comprehension of these risks and enhance their monitoring and supervisory methodologies to safeguard financial stability. An increasing number of central banks and financial supervisors have already initiated the implementation of climate scenario analyses targeting major banks (and insurance companies in some cases) as an integral component of prudential policies. Through these scenario analyses supported by financial authorities, central banks and financial regulators can enhance their grasp of climate-related financial risks and offer practical guidance to the financial institutions under their supervision. Furthermore, such initiatives can indirectly influence the

behavior of corporate clients by encouraging financial institutions to mitigate GHG emissions stemming from their financial service activities.

Climate risk scenarios can be analyzed through two primary approaches: a ***top-down*** or a ***bottom-up*** methodology. In the top-down approach, central banks and financial regulators assess the financial impact of climate change on financial institutions based on data provided by these institutions, supplemented by additional macroeconomic and financial data. This approach offers the advantage of ensuring a more consistent calculation methodology and facilitates comparisons across different financial institutions. However, it often necessitates the inclusion of additional qualitative information to yield more meaningful risk management assessments concerning climate risks. In contrast, the bottom-up approach involves financial authorities selecting multiple climate scenarios, major economic variables, and other relevant factors for utilization in the scenarios. The major analytical work is carried out by large financial institutions, who are tasked with conducting their calculations based on these selected parameters. This approach encourages financial institutions to cultivate their own internal quantitative and qualitative analytical capabilities, fostering a deeper understanding of how climate change may impact their balance sheets across each scenario. This approach not only enhances institutions' understanding but also encourages voluntary responses to climate change risks. Moreover, it is hoped that financial institutions will take further initiatives by using this exercise as an opportunity to autonomously and comprehensively explore additional scenarios that align with their capabilities (Shirai 2023a).

Climate scenarios serve as essential elements when assessing the sensitivity of economic entities to climate-related financial risks. Standardized scenarios, such as those prepared by the NGFS, can facilitate the comparison of risk exposure across different financial institutions and lead to stress-testing exercises that bear implications for capital adequacy. The effectiveness of climate scenario analysis fundamentally hinges on a robust understanding of potential transmission channels for climate risk drivers. For instance, it is imperative for financial institutions and financial authorities to comprehend how a financial institution's portfolios may be impacted by carbon price hikes, particularly those anticipated in transition scenarios. This understanding should include factors such as geographic locations, sectors, and production facilities, as well as their influence on the business activities of corporate clients.

So far, the majority of financial authorities have relied on NGFS scenarios (NGFS 2022) as a foundational framework for structuring their climate scenarios. Final authorities are expected to publicly disclose the collective outcomes of their climate scenario analyses, rather than revealing results specific to individual institutions. The dissemination of such information holds the potential to heighten awareness of climate risks within financial institutions, potentially motivating them to voluntarily enhance their climate risk management systems. In 2022, the FSB and the NGFS jointly published a report summarizing the findings of their review of climate scenario exercises conducted by financial authorities (FSB and NGFS 2022). The report unveiled that a majority of financial authorities employed the NGFS's scenarios as a reference point to assess the vulnerability of their financial systems. These scenarios were utilized for scenario narratives or alignment with key variables. Financial authorities often customized the scenarios to accommodate country- or region-specific factors, resulting in significant variability in practices concerning the scope, identification of physical and transition risk drivers, and design choices for exploratory scenarios.

Among financial authorities, a prevailing perspective revealed from the report was that these exercises were used with the aim of raising awareness among financial institutions and enhancing their risk management capabilities. The results indicated that striving for comparability across jurisdictions at this stage might be premature. Interestingly, many exercises did not reveal significant climate risk impacts under the NGFS's Orderly Scenarios, while more pronounced adverse effects on GDP and financial losses were observed under the Disorderly Scenarios. Additionally, more substantial losses attributed to physical risks were identified under the Hot House World Scenarios. Overall, however, the impact of climate risks on financial sectors appeared to be concentrated within specific industries, thus varying across jurisdictions. The moderate outcomes could be attributed to the exploratory nature of these climate scenario exercises, often hindered by limited data availability. Consequently, it was challenging to fully consider second-round effects and nonlinear characteristics of extreme climate events (such as Minsky Moment and Green Swan events), and to assess vulnerability to tail risks. Therefore, the moderate impact might signify an underestimation of the degree of vulnerability. These exercises are likely to improve over time as more data become accessible due to enhanced disclosure requirements and external sources, along with the development of more refined modeling methodologies.

5. CONCLUSIONS

This paper emphasizes the strategic aspect of the climate-related disclosure framework established by the TCFD recommendations, as well as the ISSB Climate-related Disclosures introduced in June 2023. Notably, the ISSB Climate-related Disclosures go beyond the conventional reporting of Scope 1 and Scope 2 emissions data, mandating the disclosure of detailed Scope 3 emissions data, accompanied by comprehensive disclosure guidelines. Although the net zero emissions target was not required, these evolving and stringent disclosure requirements, coupled with existing reporting standards, are transforming ISSB Climate-related Disclosures into global benchmarks that many countries are expected to adopt as mandatory obligations for publicly listed companies.

Companies are facing increasing pressure from stakeholders to proactively identify climate-related risks and opportunities, establish comprehensive climate transition plans, and conduct rigorous climate scenario analyses. The prevailing consensus holds that a credible transition plan is a time-bound strategic roadmap outlining how a company intends to achieve short-, medium-, and long-term GHG reduction targets. These targets should be aligned with science-based emissions trajectories, encompassing short-term (five- to ten-year) emissions reduction objectives consistent with the 1.5°C global warming target and long-term science-based net-zero targets to be realized by 2050 at the latest (CDP 2023, Climate Action 100+ 2021). Importantly, companies are encouraged to disclose verifiable and quantifiable key performance indicators, enabling regular monitoring of their progress by investors and other stakeholders. A credible climate transition plan should offer comprehensive strategic insights into a company's response to identified risks and opportunities. This includes considerations such as capital allocation, investment planning, asset divestment, market exploration, workforce expansion, and the creation of new business units. Furthermore, companies should assess the resilience of their business models through robust climate scenario analyses. These exercises are integral for companies seeking to enhance transparency and credibility in fulfilling their committed emissions targets.

Corporate climate-related disclosures are becoming an indispensable component of business strategies. This is a departure from the past prevalent practices of just leaving it to the responsibility of a sustainability committee or team within the company and the mere announcement of long-term GHG emissions targets. Enhanced disclosure not only contributes to increased corporate transparency but also bolsters credibility concerning pledged emissions targets. By incorporating climate-related considerations into their current and future strategies, companies may be able to enhance their corporate value and competitive advantage in an evolving global landscape.

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