# THE RISING TIDE:
# BUILDING A CLIMATE-RESILIENT SEMICONDUCTOR VALUE CHAIN



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## About this Report

In this report, SEMI's Environmental Risk Mitigation and Reporting (ERMR) Working Group and Nasdaq partnered to conduct industry-level evaluation of corporate climate disclosures in the semiconductor sector, leveraging Nasdaq Sustainable Lens™. The study evaluated publicly available corporate annual financial reports, sustainability reports, low-carbon transition and climate action plans, and other sustainability and climate information of 100 leading semiconductor companies and assessed their disclosure alignment and comprehensiveness on the four core pillars of the Taskforce on Climate-related Financial Disclosures (TCFD) framework - Governance, Strategy, Risk Management, and Metrics and Targets.

This is the first study that provides a baseline of climate-related disclosures across all segments of the semiconductor value chain. The study also identifies the strengths, gaps and challenges faced by the industry in implementing the TCFD recommendations, and it provides suggestions and best practices to improve climate disclosures. The study aims to raise awareness of climate risk as a key business risk and demonstrate how semiconductor companies can improve their corporate climate disclosures in alignment with the International Financial Reporting Standards (IFRS) built upon the TCFD recommendations.

## Convening Partners

**SEMI** is an industry association bringing together more than 3,000 member companies to foster connection, collaboration and innovation in the semiconductor sector. In 2022, at COP27, SEMI facilitated the launch of the Semiconductor Climate Consortium (SCC), a global industry association representing over 90 companies within the semiconductor value chain, focused on the challenges of climate change and working to speed up industry-level efforts to reduce greenhouse gas (GHG) emissions. Together, members of the SCC and the wider SEMI Sustainability Committee have launched the Environmental Risk Mitigation and Reporting (ERMR) Working Group to foster peer to peer learning and collaboration around environmental risk governance, assessment, mitigation and reporting throughout the semiconductor sector. Among the Working Group objectives is to conduct a baseline assessment at value chain level to better understand the current state of climate disclosures in all segments of the semiconductor value chain. The Working Group includes subject matter experts in sustainability and climate risk management from multiple semiconductor member companies and it has played a leading role in developing this report.

**Nasdaq** is a global technology company serving the capital markets and other industries. Nasdaq's Capital Access Platforms business delivers transparency to the corporate issuer and investment community by empowering clients to effectively navigate the capital markets, achieve sustainability goals, and drive governance excellence. The platform used to derive the data-driven insight in this white paper, Nasdaq Sustainable Lens™, is one such solution within the Nasdaq Capital Access Platforms business portfolio. Nasdaq Sustainable Lens applies capabilities of large language models (LLMs) to publicly available sustainability disclosures helping companies to conduct research, gap analysis and peer benchmarks as well as gather valuable data-driven insights to inform corporate sustainability initiatives and prepare for reporting and disclosures.

# Key Takeaways

### 1. Maturity of climate disclosures at a semiconductor value chain level is in the 'Established' phase

This study provides the first baseline assessment of semiconductor companies, specifically evaluating the alignment of their climate disclosures with TCFD recommendations. The analysis utilized Nasdaq Sustainable Lens and concentrated on the assessment of publicly available disclosures of 100 member companies in the SCC and the wider SEMI Sustainability Committee spanning across the global value chain. Overall, the assessment identified that the TCFD reporting maturity at the semiconductor value chain level is at the high end of Nasdaq's 'Established' range, surpassing the average level observed for the broader market.

### 2. Corporate climate reporting varies by semiconductor value chain segment

Among the semiconductor value chain segments, fabless companies, including integrated circuit (IC) design, hyperscalers, and end users, show leadership in TCFD disclosures, with the highest level of climate reporting against each disclosure recommendation. Chemicals and materials companies, as well as fabs, direct manufacturers, and outsourced semiconductor assembly and test (OSAT) closely follow the practices of fabless companies. Compared to other value chain segments, equipment manufacturers show more limited reporting of climate information and data, particularly around quantitative climate scenario analysis, internal carbon price, and long-term net zero commitments.

### 3. Corporate roadmaps need additional clarity on short-term climate targets towards the path to net zero

Disclosures that appear to be most comprehensive include GHG emissions and other environmental metrics (e.g., energy, water, and waste) as well as corporate near-term GHG reduction targets. The study showed that 75% of companies included in the assessment have publicly announced GHG reduction targets. Many of these targets are near-term, whereas fewer companies have set longer-term, more ambitious carbon neutral or net zero commitments. Acknowledging that near-term targets help companies to focus their immediate climate efforts, a significant gap still remains between these short-term goals and the more ambitious long-term net zero commitments necessary for a 1.5°C aligned low-carbon transition.

### 4. Addressing organizational resilience to climate change appears to be the biggest challenge

Among all value chain segments, the most under-reported TCFD disclosure topics are tied to climate resilience strategy and quantitative assessment of the current and future impacts of climate change on business and financial planning. These categories include climate scenario analysis, quantitative physical and transition climate risk assessments, and setting an internal carbon price. Although nuances exist based on geographic regions and specific value chain segments, addressing the core question of how a company's business strategy will perform under various climate scenarios remains a major gap at an industry level.

### 5. Ensuring climate resilience of the value chain is a business imperative

The development of today and tomorrow's technology innovations, spanning from artificial intelligence (AI) and quantum computing to automated systems and electric vehicles (EVs), fundamentally relies on semiconductor solutions. Recognizing the vulnerability of the semiconductor value chain to existing and potential climate-related risks and proactively building a path towards climate resilience is crucial for long-term business continuity.

# Introduction

## Climate Risk as Business Risk to Semiconductors

Semiconductors play a critical role as the building blocks of the modern digital infrastructure and emerging technologies, such as AI, 5G networks, autonomous vehicles, and quantum computing. Fundamental to all industrial activities, semiconductors are key to economic growth and national security worldwide. According to the U.S. Congressional Research Service, from 2012 to 2022, global sales of semiconductors doubled, reaching 602 billion USD, in response to the need for accelerated digitization and connectivity.[1] By the turn of the decade, the semiconductor market is expected to exceed 1 trillion USD in sales, according to an analysis by McKinsey.[2]

Businesses that support the semiconductor industry are highly diverse with respect to the products and services they provide and range from semiconductor design and manufacturing to assembly, testing, and packaging. The industry also relies on a global network of suppliers of manufacturing equipment, materials, and chemicals. As a result, it has one of the most complex and segmented supply chains with a global operational footprint. According to a study by Accenture and the Global Semiconductor Alliance, the various inputs to a typical semiconductor chip often cross more than 70 international borders before a final product makes its way to end customers.[3] To ensure their global supply chain resilience, semiconductor companies need to understand the array of present and potential business risks.

The World Economic Forum's Global Risks Report 2023 identified climate-related risks in the top four of all global risks by severity over the next decade.[4] Failure to mitigate and adapt to climate change is ranked as one of the most severe threats, but it is also the risk for which the world is seen to be the least prepared. Physical climate-related risks, such as extreme heat, drought, floods, and sea level rise, are already being felt across various geographies, magnifying disruptions to business continuity and adding costs to fiscal balances. Transition risks associated with a shift to a low-carbon economy, can influence the demand for semiconductors, the cost and availability of materials and energy, as well as the reputation and competitiveness of semiconductor companies. While the focus of this study is on climate risks, we acknowledge that low-carbon transition also presents a climate-related opportunity. The role of semiconductors extends beyond powering devices and data infrastructure systems; they enable critical climate solutions, such as renewable energy storage, smart grids, and EVs.

Many business leaders are already recognizing economic implications of climate-related risks and the need for climate adaptation. For example, more than 50% of CEOs that participated in PwC's 26th Annual Global CEO Survey claim that their companies are likely to be exposed to climate risk in the next five years.[5] However, not all companies are equally prepared to face these challenges. During fiscal year 2022 reporting, 58% of companies disclosed in line with at least five of the eleven TCFD recommended disclosures, and only 4% of companies disclosed in line with all eleven recommendations.[6] According to CDP, just over 21% of companies that disclosed in 2023 had a climate transition plan, but only 0.4% of those demonstrated best practice by disclosing against all key indicators that define a credible climate transition plan.[7]

The TCFD has been the major framework used by companies to disclose their climate-specific information, such as their climate-related risks and opportunities, and how they manage and integrate them into their business strategies. However, the level of alignment and quality of disclosures vary across different sectors and regions.

## Evolution of Climate-related Disclosures

As the impacts of climate change become more evident and stakeholder expectations evolve, companies are expected to disclose how they are optimizing their operations and integrating climate into their business decisions. The most common disclosure types include corporate annual Sustainability and ESG Reports, financial filings, responses to industry climate questionnaires, such as CDP Climate, standalone low-carbon transition and climate action plans, and sustainability policies.

The reporting framework most widely adopted for corporate climate disclosures globally is associated with the TCFD. The TCFD was established in 2015 by the G20's Financial Stability Board (FSB) to enable companies to report climate-related information that is material, comparable, forward-looking, and decision-useful to their investors. The TCFD framework has had a significant uptake in industry and has been formally supported by 4,900 organizations across 103 jurisdictions. TCFD recommendations revolve around four core disclosure pillars – Governance, Strategy, Risk Management, and Metrics & Targets. To report in alignment with the TCFD recommendations, companies have been providing information about their climate risk oversight at the Board and management levels, their current and potential climate-related risks and opportunities across their direct operations and supply chains under different climates scenarios, their low-carbon transition plans, as well as climate metrics and targets to track progress on identified risks and opportunities.

After eight years since its establishment, the TCFD fulfilled its remit, and in 2023, the FSB asked the IFRS' International Sustainability Standards Board (ISSB) to take over the monitoring of the progress of corporate climate-related disclosures. To further consolidate and align various reporting requirements across the TCFD and other frameworks, the IFRS issued its new Sustainability Disclosure Standards - IFRS S1 General Requirements for Disclosure of Sustainability-related Financial Information and IFRS S2 Climate-related Disclosures. Companies that would apply IFRS S1 and IFRS S2 will thus meet the TCFD recommendations. Specifically, IFRS S2 is consistent with the TCFD four core recommendations and 11 recommended disclosures. For clarity, IFRS also provides a detailed summary that explains differences between TCFD and IFRS S2.[8]

In March 2024, the U.S. Securities and Exchange Commission (SEC) finalized the rules on the enhancement and standardization of climate-related disclosures for companies registered in the USA, and the requirements are largely aligned with the TCFD recommendations. Thus, the final rules require companies to disclose their material climate-related risks, i.e., risks that have impacts to the company's business, results of operations, or financial condition. Companies are also asked to report activities they are taking to mitigate or adapt to such risks, information about their board- and management-level oversight of climate-related risks, material Scope 1 and Scope 2 GHG emissions, as well as climate targets. In addition, companies are required to disclose in their financial statements impacts, such as costs and losses, from severe weather-related events and other natural conditions. It is evident that climate risk is taking a central place in the final SEC rules, signaling to companies the importance of assessing, financially quantifying and managing their material climate risks, in order to effectively respond to investors' needs for more consistent, comparable, and reliable climate-related information.

## Study Approach

The baseline assessment of corporate climate disclosures was conducted using Nasdaq Sustainable Lens. Nasdaq Sustainable Lens is a software-as-a-service (SaaS) intelligence solution that harnesses the power of generative AI to equip sustainability, investor relations, legal and accounting professionals with on-demand, data-driven insights from over 9,000 companies globally. By collecting and standardizing publicly available data from sustainability disclosures, Nasdaq Sustainable Lens leverages a proprietary methodology to assess a company's sustainability and climate disclosures relative to framework and regulation guidance. Disclosure texts are categorized based on their adherence to guidelines set forth by disclosure frameworks, calculated using LLMs to ensure a standardized approach to assessment. For this study, the disclosure-level assessment is performed at the individual company level and is aggregated at the semiconductor segment level and ultimately at the value chain level.



The scope of this study included the assessment of 100 companies within the SEMI and the Semiconductor Climate Consortium membership. The selected companies are distributed globally across the entire semiconductor value chain and represent top companies by revenue. For the purposes of this study, companies were grouped into four value chain segments:

- Chemicals and materials
- Equipment manufacturers
- Fabless, hyperscalers, and end users
- Fabs, direct manufacturing and Outsourced Assembly and Testing (OSAT)

To assess the maturity of each segment of the semiconductor value chain, Nasdaq Sustainable Lens evaluated climate disclosures of each of the 100 companies against TCFD recommendations. All climate disclosures were sourced from publicly available documents between 2021 through 2023, including corporate sustainability reports, annual 10K financial filings and annual reports, proxy statements, and other public disclosures, such as standalone TCFD reports and sustainability policies.

First, companies' adherence to TCFD recommendations was measured for the most granular disclosure level – guidance item level (see Table 1).

| Assessment Level | Assessment Process |
|---|---|
| Guidance Item Level | • Disclosure extraction from reports<br>• Disclosure maturity assessment against TCFD recommendations |
| Recommendation Level | • Grouping of guidance items<br>• Aggregated assessment of all guidance items within the recommendations based on Nasdaq predefined statistical methods |
| Theme Level | • Aggregated assessment of all recommendations, providing a holistic view of the company's climate disclosure |

Table 1: Nasdaq Sustainable Lens TCFD-aligned climate disclosure assessment levels and process

Evaluations from each of the guidance items were aggregated to the recommendation level. Evaluations at the recommendation level were aggregated at the theme level and then macro theme level in alignment with the TCFD pillars, i.e., Governance, Strategy, Risk Management and Metrics and Targets (Table 2). The macro theme level assessments were then aggregated to calculate overall company level scores. At each assessment level, all companies were aggregated into their respective semiconductor value chain segments.

| Theme | Recommendation | Guidance Item |
|---|---|---|
| Governance | Board Oversight of Climate | Board Oversight of Climate Issues |
| Governance | Board Oversight of Climate | Processes to Inform Board on Climate |
| Governance | Board Oversight of Climate | Board Oversight of Climate Targets |
| Governance | Management Role in Climate | Management Responsibility for Climate |
| Governance | Management Role in Climate | Processes to Inform Management on Climate |
| Strategy | Strategy Risk of Climate | Physical and Transition Climate Risks to Business |
| Strategy | Strategy Risk of Climate | Climate-related Opportunities for Business |
| Strategy | Strategy Impact of Climate | Impact of Climate Risks & Opportunities on Business |
| Strategy | Strategy Resilience of Climate | Climate Scenario Analysis |
| Risk Management | Risk Identification of Climate | Processes for Climate Risk Identification |
| Risk Management | Risk Management of Climate | Processes for Climate Risk Management |
| Risk Management | Risk Integration of Climate | Climate Enterprise Risk Management Integration |
| Metrics & Targets | Climate Metrics | Metrics for Measuring Climate Risks and Opportunities |
| Metrics & Targets | Climate Metrics | Internal Carbon Price |
| Metrics & Targets | GHG Emissions | Scope 1 GHG Emissions |
| Metrics & Targets | GHG Emissions | Scope 2 GHG Emissions |
| Metrics & Targets | GHG Emissions | Scope 3 GHG Emissions |
| Metrics & Targets | Climate Targets | GHG Reduction Targets |
| Metrics & Targets | Climate Targets | Net Zero Targets |
| Metrics & Targets | Climate Targets | Other Climate-related Targets |

Table 2: Nasdaq Sustainable Lens TCFD-aligned climate disclosure levels

Nasdaq Sustainable Lens generated a representative maturity of corporate disclosures by considering both the depth (e.g., TCFD alignment) and breadth of disclosure adherence (e.g., number of extracts). Thus, depending on the disclosure alignment with the TCFD recommendations, as well as the frequency of disclosures on a TCFD topic, Nasdaq Sustainable Lens placed each company's disclosure into one of the Nasdaq-defined TCFD maturity levels (see Table 3).

By utilizing AI-powered software, we were able to conduct a comprehensive analysis at a level of granularity that would have been impractical through manual assessment alone. Additionally, this analysis facilitated the elimination of human bias and judgment from the process, ensuring more evidence-based and transparent results.

| TCFD Maturity Level | Description | Example Disclosure Indicators |
|---|---|---|
| Starting | A company has no or some climate -related information in its public documents, but it is not aligned with most of the recommended TCFD guidance. | • The Board has not yet considered or has just begun to consider climate and its potential impact on the company.<br><br>• The company does not have a clear strategy for addressing climate risks and may be in the early stages of gathering data and conducting risk assessments. |
| Developing | A company has some climate -related information in its public disclosures, and some of it is aligned with the recommended TCFD disclosure guidance. | • The Board has recognized the importance of addressing climate-related risks and has begun to develop a strategy for doing so.<br><br>• A company has begun conducting qualitative climate scenario analysis. It recognizes the potential impact of different climate scenarios on business operations, although comprehensive, quantitative data are not yet available. |
| Established | A company has comprehensive information in its public documents, and it mostly is aligned the recommended TCFD guidance. | • The company established Board committee oversight of risks, most likely created a dedicated sustainability taskforce, and took some steps to integrate climate risks into its overall risk management framework.<br><br>• A company has conducted and disclosed climate scenario analysis as part of its risk management process. The reports include qualitative analysis and may include some quantitative data related to potential impacts under different climate scenarios. |
| Advanced | A company where almost all the climate-related information it has disclosed is aligned with recommended TCFD guidance. | • The Board established a climate committee and regularly reports on its progress in addressing climate risks.<br><br>• A company has integrated climate scenario analysis into its risk management and strategic planning processes. It uses a range of scenarios, including 1.5°C, 2°C, and 4°C. |

Table 3: Nasdaq-defined TCFD-aligned climate disclosure maturity levels

# Key Takeaways

## Takeaway 1. Maturity of climate disclosures at a semiconductor value chain level is in the 'Established' phase

The study identified the maturity level of companies across the semiconductor value chain at the high-end of Nasdaq's 'Established' maturity level as it relates to the TCFD disclosure alignment (Figure 1). When leveraging Nasdaq Sustainable Lens to analyze maturity of climate disclosures for the broader market represented by over 9,000 global companies across all industries beyond semiconductors, the average TCFD maturity level was at the high end of 'Developing.' Thus, the semiconductor companies included in this assessment surpass the market average, showing about 40% higher TCFD alignment. This maturity level is comparable to the performance of the largest 250 publicly traded global companies by market capitalization, indicating that semiconductor value chain companies in general have comprehensive climate-related disclosures.

Nasdaq-defined levels of TCFD maturity are based on the depth (e.g., TCFD alignment) and breadth of disclosure adherence (e.g., number of extracts). Therefore, the results of this study are primarily indicative of the state of corporate climate disclosures rather than the ability of individual companies to show resilience to climate change impacts. This baseline assessment is an important first step to better understanding the semiconductor industry-level exposure to climate-related impacts and needs to be complemented by more in-depth quantitative climate risk and opportunity assessments.

In addition, this baseline assessment presents a useful starting point for the semiconductor industry as a whole to better understand the maturity of various value chain segments, enhance segment-level management of climate-related risks and improve the completeness of climate disclosures.



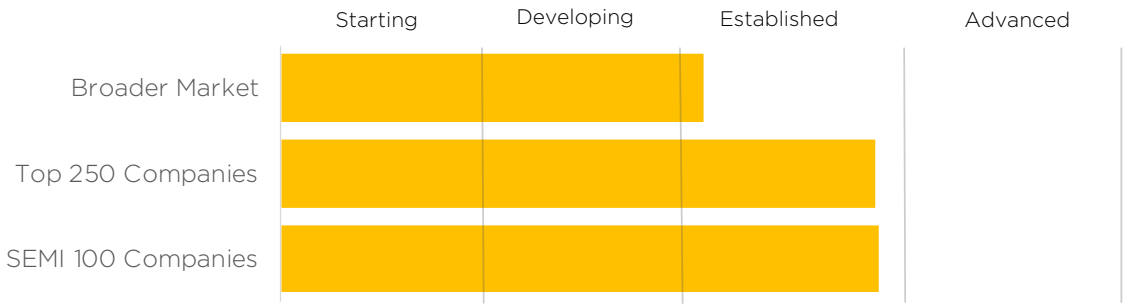



Figure 1: Maturity of climate disclosures of 100 SEMI and SCC companies in comparison to top 250 global companies and broader market

## Takeaway 2. Corporate climate reporting varies by semiconductor value chain segment

The baseline assessment evaluated overall trends across the semiconductor value chain and did not aim to look at the performance of individual companies. Therefore, the results are aggregated at a semiconductor segment level. On average, 100 companies included in this assessment show comprehensive climate disclosures falling into the 'Established' TCFD maturity level. However, there is a significant variability in the disclosure maturity within each segment and across the value chain (Figure 2). Some companies are still in the process of building their understanding of how climate change may impact their business, while there are industry leaders taking concrete actions to measure and evaluate their exposure to physical and transition climate risks under different scenarios. The maturity spectrum illustrates that climate action is a long-term commitment that requires time, resources, a buy-in from company's leadership, support from the board, and a cross-functional approach to climate project development and implementation, among others.

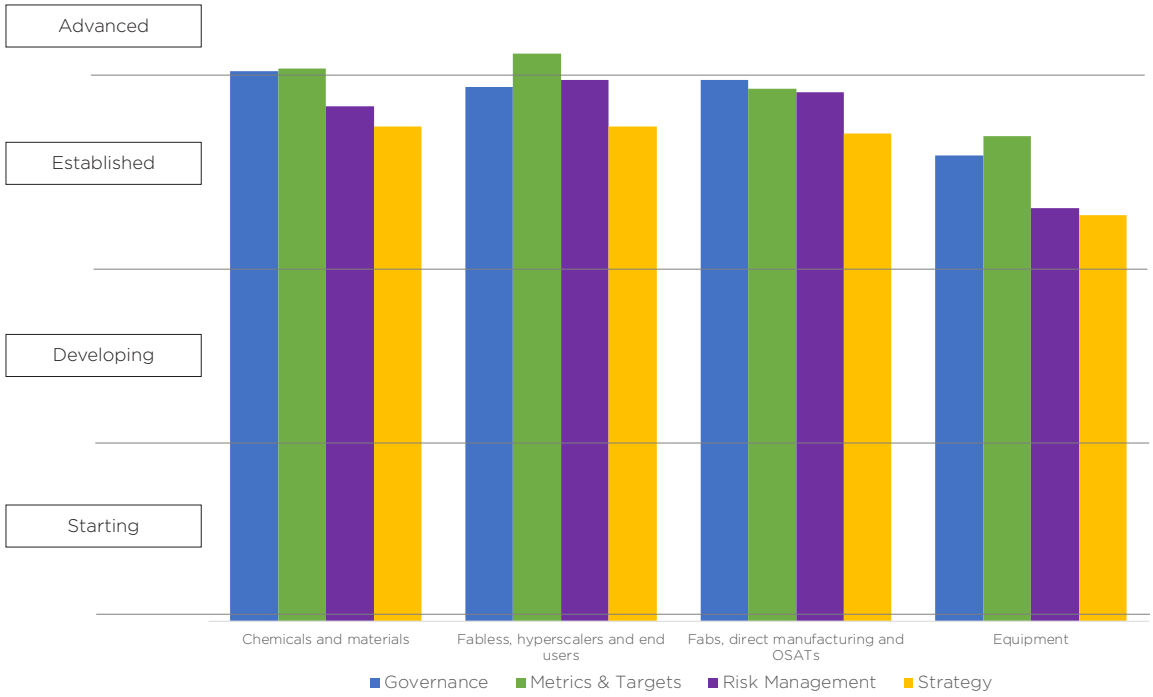



Figure 2. TCFD-aligned climate disclosure maturity by semiconductor value chain segment

## Semiconductor segment-level insights



**Fabless Companies.** On average, fabless companies, including IC design, hyperscalers, and end users, have demonstrated leadership in TCFD-aligned climate disclosures. They particularly excel in reporting across three out of the four TCFD pillars, including Strategy, Risk Management, and Metrics & Targets. The fabless category stood out in its highest performance in Metrics & Targets, reaching the 'Advanced' maturity level. This suggests that fabless companies have comprehensive Scope 1, Scope 2, and Scope 3 GHG emission disclosures and also appear to have more comprehensive disclosures on measuring the impact of physical and transition climate risks on business, reporting Board-level oversight of climate issues, and integrating climate into broader Enterprise Risk Management (ERM) systems. Majority of fabless companies included in the assessment are headquartered in the US and the European Union (EU), and they likely face increased regulatory pressure and more stringent reporting requirements than other jurisdictions, including disclosing against the TCFD. In addition, in the fabless group, there are many B2C and B2B companies with significant public exposure, and it is possible that they view climate-related risks from the perspective of their reputational and brand risks.



**Chemicals and materials companies.** Companies supplying chemicals and materials to support the semiconductor industry show a similar trend as the fabless companies, with the highest performance in Metrics & Targets and Governance, followed by Risk Management and Strategy. Specifically, the companies showed the highest performance in disclosing GHG emissions, GHG reduction targets, measuring the impact of climate risks and opportunities on business, and reporting their internal processes to inform the Board on climate progress. The results also align with an understanding of the regulatory and stakeholder environments, as about half of the chemicals and materials companies included in the assessment have headquarters in the US and the EU. In addition, the chemical industry was an earlier adopter of climate reporting than pure semiconductor companies and has gained a lot of momentum over the past decade, due to regulatory requirements, investor expectations, and industry-level recognition of the urgent need to address climate change.



**Fabs, direct manufacturers, and OSATs.** Companies involved in direct manufacturing of semiconductors performed evenly across three out of the four TCFD pillars, including Governance, Risk Management, and Metrics & Targets. On average, direct manufacturers appear to have slightly lower performance than fabless companies and chemical and materials companies, although there are disclosure areas where they showed the strongest performance compared to all the other segments. Specifically, fabs and direct manufactures had the strongest disclosures of climate scenario analysis and management-level responsibility for climate. It appears that the companies in this segment conducted assessments of how climate-related risks might impact their direct operations, production and distribution networks under different climate scenarios. Given that climate-related impacts can disrupt business continuity of major semiconductor manufacturing hubs, analyzing those impacts under various scenarios can help ensure continuity, minimize production downtime, and help to build operational resilience.



**Equipment manufacturers.** On average, companies making equipment and machinery for semiconductor manufacturing showed the lowest disclosure levels in each TCFD pillar, as compared to the other semiconductor value chain segments. This was primarily due to the lack of disclosures on internal carbon pricing and under-reporting on quantitative climate scenario analysis, processes for climate risk identification and management, and integration of climate considerations into broader ERM systems. They were on par with other segments on Metrics & Targets, including GHG emissions, near-term GHG reduction targets, and metrics for measuring climate risks and opportunities. Many companies, however, showed a lack of disclosures on long-term net zero commitments. Unlike fabless and chemicals and materials companies, some equipment manufacturers might have not faced direct regulatory and stakeholder pressure to disclose climate-related information. For example, companies with the lowest performance appear to be headquartered in the Asia-Pacific region, where there has been reduced pressure to disclose climate risks. At the same time, there are several industry leaders with a large presence in the EU that tend to have not only comprehensive climate disclosures but have also developed standalone TCFD Reports.

## Takeaway 3. Corporate roadmaps need additional clarity on short-term climate targets towards the path to net zero

On average, all segments across the value chain demonstrated the highest performance in Metrics & Targets, particularly GHG emission reporting and near-term GHG reduction goals (Figure 3). The study showed that 75% of companies included in the assessment have publicly announced GHG reduction targets. These findings corroborate the recent research conducted by SEMI and BCG which revealed that companies in the chip manufacturing segment account for 63% of Scope 1 and Scope 2 GHG emissions of the overall industry. Simultaneously, they outpace the industry average GHG reduction by 2050 (90% versus 30%).[9]

The majority of announced GHG reduction targets are near-term, whereas fewer companies have set longer-term, more ambitious carbon neutral or net zero commitments. Given that semiconductor companies operate in a dynamic industry characterized by rapid technological advancements and high competition, focusing on shorter-term climate commitments allow companies to take a pragmatic approach to address pressing climate challenges without significantly compromising or transforming their business operations. By prioritizing GHG emissions reporting and setting near-term goals, companies directly respond to stakeholder expectations and regulatory requirements which increasingly emphasize Scope 1, Scope 2 and Scope 3 GHG reporting, while more aspirational net zero goals may lack the immediacy required to satisfy market demands. In addition, near-term climate targets more closely align with corporate business plans spanning three to five years, whereas climate change impacts manifest themselves over longer timescales. Therefore, meaningful climate action requires both near-term and long-term views.

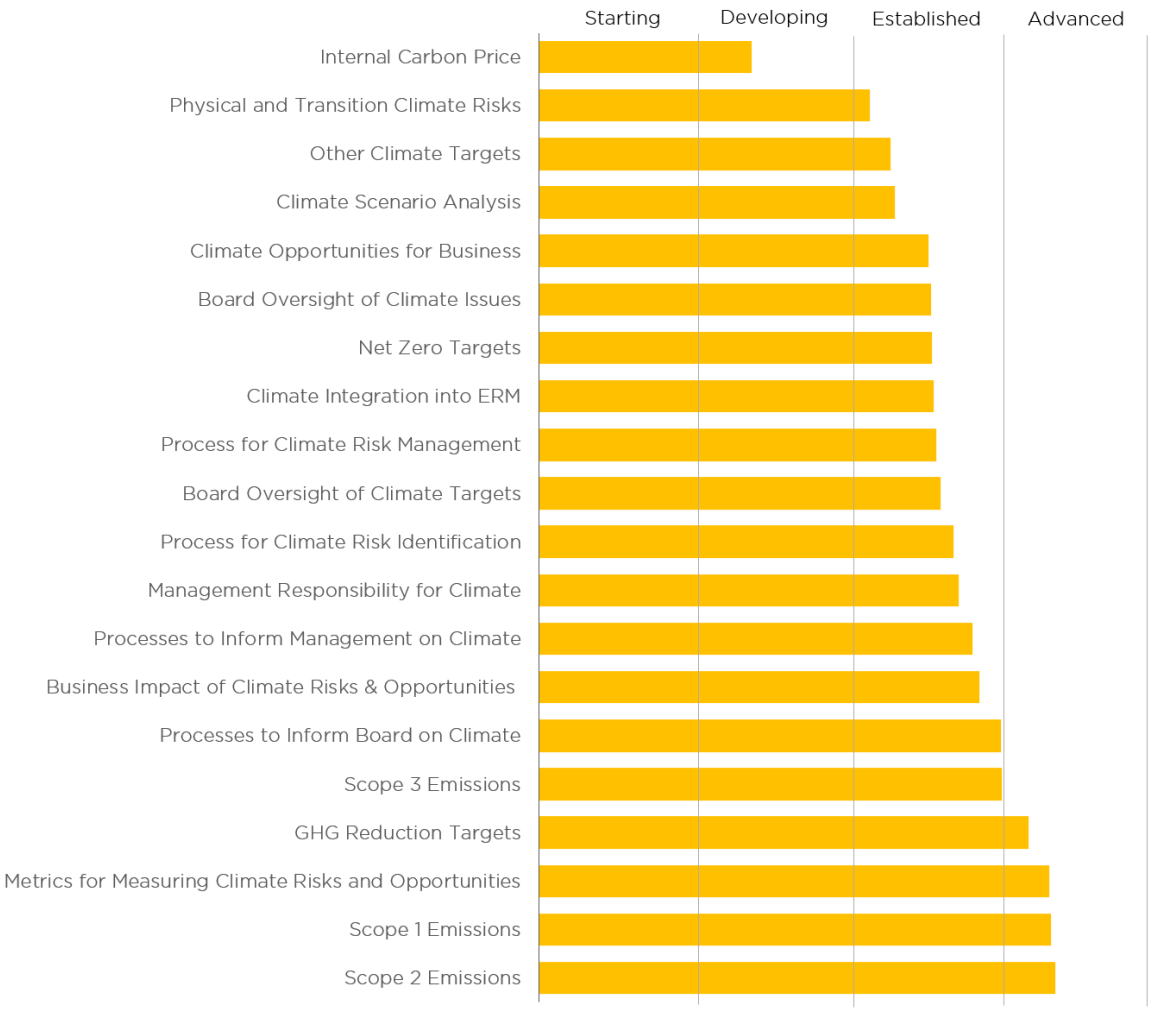



Figure 3. TCFD-aligned disclosure maturity at a value chain level

## Takeaway 4. Addressing resilience to climate change appears to be the biggest challenge

The biggest gaps in TCFD alignment among all value chain segments are tied to categories that require a quantitative assessment of the current and future impacts of climate change on businesses (Figure 3). These categories are associated with measuring climate resilience and include climate scenario analysis, identification and integration of climate risks into broader ERM processes, as well as establishing an internal carbon price to quantify GHG-related impacts.

These findings are aligned with an understanding that assessing climate risks is inherently complex. Quantifying climate risks requires sophisticated modeling and applying various climate scenario analysis under different timeframes. Many companies lack the expertise or resources to conduct comprehensive quantitative climate risk assessments. In fact, 39 out of 100 companies included in the assessment appear to be in 'Starting' and 'Developing' maturity phases when it comes to scenario analysis, with almost half of those companies being considered in small and medium-sized market capitalization bands. Similarly, physical and transition risks appear to be the second least disclosed TCFD topic across all value chain areas, with 42 out of 100 companies being placed in the 'Developing' phase. Among the companies that have disclosed their climate risks, US-based companies showed the highest performance, most likely due to high stakeholder pressure.

The disclosure area that seemed to show the lowest performance across the full value chain is setting an internal carbon price (Figure 4). As noted above, among all the segments, equipment manufacturers had the lowest disclosure level for carbon pricing, suggesting that many companies in this segment have not set a carbon price or have not disclosed this information publicly (Figure 4). Although many companies that did not report a carbon price were based in the Asia-Pacific region, the analysis also showed that companies based specifically in Japan were the most aligned with TCFD recommendations as they relate to an internal carbon price guidance. It is likely that companies face challenges in estimating the actual cost of their GHG emissions and setting an internal carbon price to address the long-term and uncertain impacts of their carbon footprint.

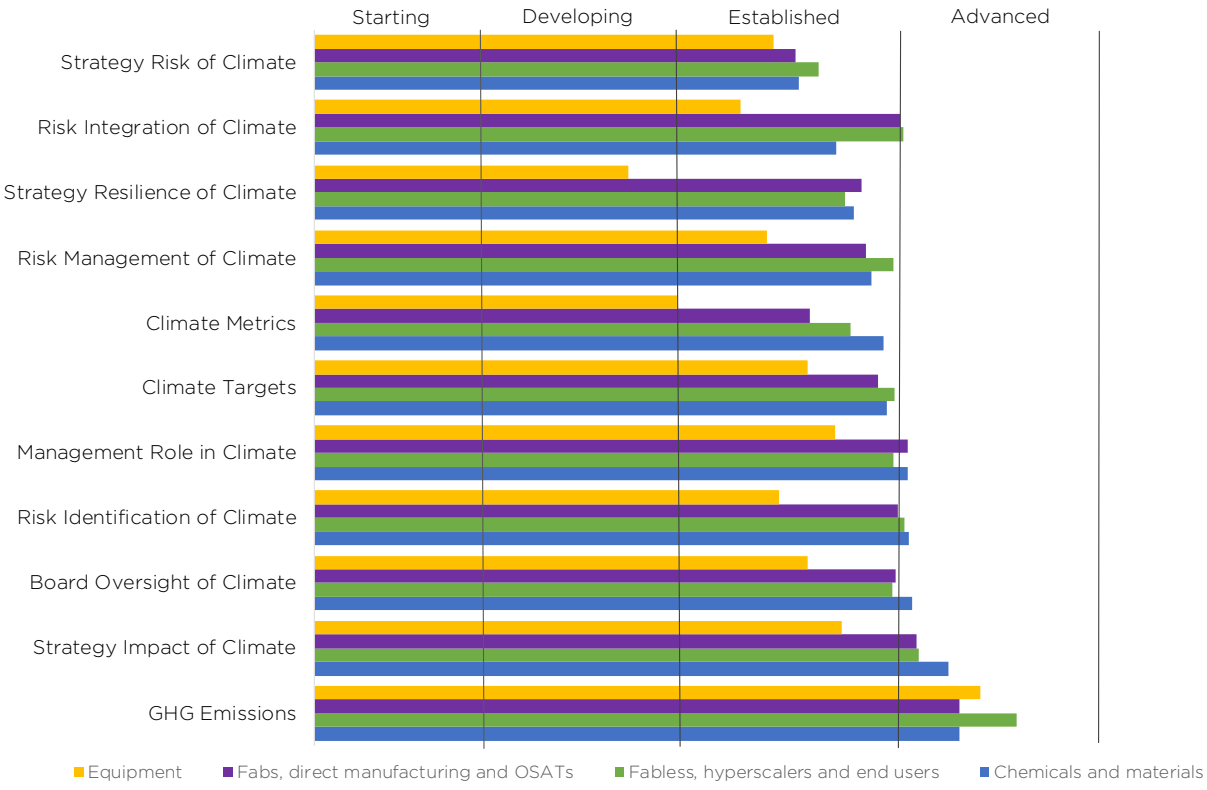



Figure 4: Segment-level climate disclosure maturity by TCFD pillar

## Takeaway 5. Ensuring climate resilience of the value chain is a business imperative

Recognizing the increasing impact of climate risks on their ability to do business, semiconductor companies are paying closer attention to evaluating their organizational exposure and vulnerability to these risks. The maturity level of climate disclosures included in this assessment was categorized as 'Established', signifying the companies' recognition of the importance of building climate resilience across the full value chain. This study found that fabs appear to be in the top 10% regarding broader disclosures aligned with the TCFD. Additionally, among all other industry segments, fabs exhibit the strongest performance in climate scenario analysis. The world's semiconductor manufacturing hub is primarily concentrated in the Asia-Pacific region, which historically faced heightened exposure

to physical climate-related risks. For example, research by Moody's Analytics revealed that in Taiwan, costs associated with climate risks, such as sea level rise, could escalate by 30% by 2050.[10] Similarly, climate-induced water stress can significantly impact global semiconductor manufacturing, leading to production cost increases of approximately 35%. It is important that companies in this region take action to stress test their assets and enhance operational resilience. These efforts are crucial for mitigating any knock-on impacts across the supply chain and ensuring the long-term climate resilience of the semiconductor value chain.



## Improving Climate Disclosure Maturity

The incorporation of TCFD recommendations into IFRS standards aims to enhance transparency, consistency, and comparability in climate reporting, and companies applying IFRS S1 and IFRS S2 will thus meet the TCFD recommendations. In the meantime, TCFD-aligned recommendations are being adopted by more and more jurisdictions. The EU Corporate Sustainability Reporting Directive (CSRD) language on climate disclosures broadly aligns with the four pillars of the TCFD. In addition to the EU, several countries have adopted TCFD-aligned official reporting requirements, including the UK, Switzerland, Canada, Brazil, Hong Kong, Japan, New Zealand, and Singapore. China has recently announced new reporting requirements for large cap and dual-listed Chinese companies around a broad range of environmental, social, and governance topics, including climate reporting in line with the TCFD framework. There is also the emergence of regional reporting requirements. For example, in late 2023, California passed two laws (SB253 and SB261) that will require public and private companies that do business in California to disclose their GHG emissions and their climate-related financial risks.

It is clear that companies will continue reporting their progress through climate disclosures aligned with the TCFD, and there are lessons to be learned from companies that have made climate a strategic priority, including how they track and communicate their climate-related information and data.

Case studies below outline effective examples from semiconductor companies that made tangible progress in each of the TCFD pillars, including activities and thought processes to integrate climate into Governance, Strategy, Risk Management, and Metrics & Targets and ensure the long-term climate resilience of the semiconductor value chain.

Lam RESEARCH

## Lam Research: TCFD-aligned governance structure supports net zero goals

Lam Research Corporation (Lam) is one of the first semiconductor equipment manufacturing companies that received SBTi approval for its near-term GHG emissions reduction targets and set a long-term goal to achieve net zero GHG emissions by 2050. Recognizing the importance of strong governance to operationalize and achieve its net zero goal, Lam has established an ESG governance structure that extends throughout the organization and leads up to the Board of Directors (Figure 5). The Board, assisted by its Nominating and Governance Committee, has the primary ESG oversight responsibility, including oversight of the company's overall ESG strategy and goals, ESG report, sustainability initiatives, and climate-related goals. The management team provides ESG updates via presentations or written reports to the Board or the Nominating and Governance Committee four times a year.

The ESG Executive Steering Committee, which consists of the CEO and members of the CEO staff, has executive-level responsibility for guiding Lam's ESG strategy, approving and supporting ESG initiatives, and driving accountability and action across the company. To monitor the ongoing progress toward net zero, Lam established the Net Zero Leadership Team which consists of working groups with representation across various business functions, including Facilities, Supply Chain, Logistics, and Products. The Net Zero Leadership Team reports to CEO staff quarterly. Having specific goals, the working groups work to address tactical implementation of Lam's ESG strategies and initiatives around Scope 1, Scope 2, and Scope 3 GHG emissions, as well as water and waste management. Learn more about Lam's Net Zero strategy.




Figure 5: ESG governance structure at Lam Research

## Intel: Climate strategy informs a TCFD-aligned climate transition action plan

Intel has pledged to achieve net-zero Scope 1 and 2 GHG emissions in its global operations by 2040 and net-zero upstream Scope 3 GHG emissions by 2050. In November 2023, Intel published a Climate Transition Action Plan (CTAP) that describes its overall climate strategy, including a roadmap demonstrating how the company will achieve its greenhouse gas reduction targets, what actions can be taken to mitigate climate-related risks, and what methods are used to incentivize employees across all levels of the company to reduce GHG emissions and accelerate progress toward the net-zero goals. Developed with key internal subject matter experts, the roadmap outlines the initiatives both within Intel's operational control and those that will require strong industry and value chain collaboration.

Another key component of Intel's climate strategy outlined in its CTAP is the identification of climate-related risks and opportunities. Intel leveraged its company-wide Enterprise Risk Management (ERM) process and adapted it to identify the top climate-related risks and opportunities impacting Intel. The identified top risks and opportunities served as the starting point for Intel's scenario analysis, where the potential impact of these risks and opportunities were assessed under possible future scenarios. Moving forward, the resulting top climate-related risks will also be integrated back into the ERM process through which top overall risks to Intel are presented to the Board.

To accelerate progress toward its short, medium, and long-term sustainability goals, including net-zero targets, Intel uses its annual performance bonus to incentivize GHG reductions and other sustainability goals across all levels of the company. This program has been effective as Intel has achieved or surpassed every annual sustainability target that has been tied to employee compensation for the last decade. In 2023, Intel set annual performance bonus goals to reduce Scope 1 and 2 GHG emissions by 130,000 MT CO2e on an annualized basis and achieve at least 95% renewable electricity globally, and the company surpassed both of these targets. By tying short-term sustainability goals to employee compensation, Intel can prioritize the implementation of critical projects necessary to advance progress to its medium and long-term goals.

ASML

## ASML: Climate scenario analysis helps to prepare business for climate risk

ASML applies the TCFD recommendations to conduct quantitative assessments of both physical and transition climate-related risks and opportunities and better understand its business exposure to potential impacts of climate change. The assessment considers two climate scenarios, a 1.5°C scenario and a 4°C scenario across the 2030 and 2050 timeframes. These scenarios were chosen to represent lower and upper boundary conditions under both low-carbon transition and business-as-usual and worst-case emissions trajectories. The 1.5°C scenario is based on the International Energy Agency's (IEA) Net Zero Emissions by 2050 scenario, and it projects deep decarbonization in the coming decades, resulting in global net zero GHG emissions in 2050. The 4°C scenario is based on the IPCC RCP 8.5 pathway, in which current GHG emissions levels continue to increase and roughly double by 2050. The climate scenario analysis considered potential impacts of climate change on ASML's full value chain, including its own manufacturing facilities, major suppliers by spend and key customers by revenue.

The results of the assessment resulted in several heatmaps, including: (1) hotspots of transition risks under a 1.5°C scenario, including policy, legal, market, technology and reputational risks; (2) acute and chronic physical risks under a 4°C scenario, including outputs of insurance business models adapted to the impacts of physical climate risks in the medium- and long term; and (3) climate-related opportunities, including resource efficiency, renewable energy, products and services, markets, and resilience.

The results of the scenario analysis were integrated into ASML's Enterprise Risk Management (ERM) process. This includes the identification, analysis and evaluation of each risk, with relevant financial and non-financial risk factors, and risk mitigation action. This ERM process ensures that actions to mitigate risk are monitored through a system of multidisciplinary assessments and operational reviews. From a transition risk perspective, decarbonization is an integral part of ASML's Sustainability strategy, with several KPIs set to decrease emissions and increase energy efficiency. From a physical risk perspective, several actions have been taken to mitigate potential impacts of climate-related risks, such as including extreme weather potential in the upgrade and design of new buildings, putting in place insurances to mitigate financial implications due to physical climate change impacts, and controlling for other risks such as flooding and windstorms.

Overall, ASML's risk and opportunity assessment under various climate scenarios over multiple time horizons helped the company to better understand its exposure, identify hotspots and develop risk management measures to address and begin adapting to climate change impacts. Learn more about ASML's Risk Management approach.

## NXP: Setting climate targets helps to prepare for a low-carbon transition

An important disclosure pillar under the TCFD framework is Metrics & Targets. Companies are encouraged to set GHG reduction and other climate goals and to continuously measure, track and report their progress towards low-carbon transition. As a global semiconductor company, NXP operates numerous manufacturing facilities which consume significant amounts of electricity and utilize chemicals that are known to have high global warming potentials, such as perfluorinated compounds (PFCs) and heat-transfer fluids (HTFs). PFCs are used to etch integrated circuitry onto silicon wafers and to clean the internal chambers of deposition equipment. HTFs are applied in manufacturing processes and device testing to maintain a required temperature. Currently there are no viable alternatives to eliminate all sources of these emissions from production processes completely. Recognizing this challenge, NXP set a goal to become carbon neutral by 2035, encompassing its Scope 1 and 2 emissions. To meet this goal, NXP will prioritize the implementation of technically and socio-economically feasible solutions, such as optimizing its manufacturing processes, implementing energy efficiency onsite and expanding its renewable energy procurement. NXP intends to offset any remaining Scope 1 and Scope 2 emissions.

NXP's climate neutrality goal has been complemented by a mid-term target to reduce absolute Scope 1 and Scope 2 emissions by 35% by 2027 from a 2021 baseline. NXP has also set annual emission reduction targets that are tied to the annual incentive plan of all NXP employees, driving ownership and accountability across the company.

NXP's GHG reduction plan includes a three-fold approach: (1) reduce, remove or replace chemicals with a high global-warming potential in manufacturing processes, (2) decrease energy consumption and 3) execute a carbon-free energy transition plan. Since electricity is the largest contributor to NXP's GHG emissions from own operations, the company has also set a renewable electricity target, committing to increase its share of renewable electricity consumption to 50% by 2027. This approach helps NXP to achieve carbon neutrality while gradually reducing the reliance on carbon offsets in the future. Since 2021, NXP has decreased its Scope 1 and 2 emissions by 24%.

In 2022, NXP also committed to the Science Based Targets Initiative (SBTi). The targets cover Scope 1, Scope 2 and Scope 3 emissions and are currently being reviewed by SBTi. To align with the Corporate Sustainability Reporting Directive (CSRD) requirements, by 2026, NXP intends to publish its Climate Transition Plan outlining its GHG reduction roadmap and how the company will prepare itself for low-carbon transition. Learn more about NXP's climate goals and GHG reduction efforts in its 2023 Corporate Sustainability Report.

## Looking Ahead

This study showed that over the past few years, companies across the semiconductor value chain have increased public reporting of their climate-related information and made tangible efforts to integrate TCFD-aligned climate considerations into their business processes, strategy, and decision making. Since the inception of the Environmental Risk Mitigation and Reporting (ERMR) Working Group, member companies have been advancing their thinking around climate risk and resilience and are looking forward to building upon the findings of this analysis, continue measuring and tracking the industry's performance in each TCFD disclosure areas, and develop collective action approaches to building climate resilience in the full value chain.

This study also illustrated that technology, and in particular AI, can act as an enabler – to provide more granular and comprehensive data-driven insights. Through AI-powered tools such as Nasdaq Sustainable Lens with the built-in ESG AI copilot, companies can automate tasks that traditionally require extensive manual effort - such as benchmarking and gap analysis. The tool provides access to public documents from over 9,000 companies, allowing users to summarize disclosures, answer stakeholder queries, and benchmark against reporting standards.

To continue advancing resilience across the semiconductor value chain, the ERMR Working group aims to develop understanding, alignment, and thought leadership around environmental risk assessment, mitigation, and reporting at a value chain level. The Working Group has three key focus areas: (1) Enhancing disclosure transparency within the value chain; (2) Gaining more robust understanding of industry-specific exposure to climate risks and opportunities; (3) Building climate resilience across the value chain by enhancing adaptive capacity and leveraging collective action. Although there is a lot of work ahead, the industry is motivated to advance collective understanding around this critical topic and take action towards enhancing climate resilience across the semiconductor value chain.

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To learn more about Nasdaq Sustainable Lens, visit www.nasdaq.com/solutions/corporate-esg-solutions/esg-ai or email contact@nasdaq.com.

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