Invisible Emissions

A forecast of tech supply chain emissions and electricity consumption by 2030

GREENPEACE

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Introduction

Electricity consumption from the global technology supply chain is rising rapidly and, in the absence of meaningful climate targets, the sector's greenhouse gas emissions are increasing. More than three-quarters of the global electronics industry's emissions come from suppliers, including semiconductor manufacturers, display manufacturers, and final assembly.[1] More than one-third of the semiconductor manufacturing industry's market share is in East Asia, with the region also central to display manufacturing and final assembly supply lines.[2]

The high electricity consumption by semiconductor manufacturers makes the sector stand out, even among other high emissions sectors like display manufacturing and final assembly.[3] The majority of electricity on grids across East Asia is from fossil fuel combustion,[4] making the semiconductor industry a significant source of greenhouse gas emissions.

The semiconductor manufacturing industry is projected to increase production levels into 2030 and beyond. Semiconductor chips are a key component of the supply chain for electronics, from smartphones to artificial intelligence (AI) hardware to automobiles. Globally, the semiconductor manufacturing industry is projected to double its market size in revenue by 2030,[5] with some sectors, such as electric vehicles, projected to grow relatively faster than others.

Most key suppliers across semiconductor manufacturing, display manufacturing, and final assembly have issued net zero commitments to achieve carbon neutrality in their operations by 2050.[6] Existing net zero commitments are not ambitious enough to respond to climate change.[7] Most electronics industry suppliers studied have set long-term targets for carbon reduction, but their timelines do not reflect the level of ambition that is necessary in the face of catastrophic climate change.

None of the suppliers identified in this report have committed to 100% renewable energy across their operations by 2030. And no suppliers' existing climate commitments are aligned with the Intergovernmental Panel on Climate Change (IPCC)'s recommended emissions cuts to limit global warming to 1.5 degrees Celsius in relation to the reference period (1850–1900). East Asia, the home of most semiconductor companies, is particularly susceptible to climate change-related disasters, as well as economic and financial risk. We cannot wait until 2050 to act on climate change, and any scenario in which governments or companies aim to achieve neutral emissions will require reducing emissions by half by 2030.[8, 9] To achieve neutral emissions will require adopting 100% renewable energy by 2030.[10]

This report contains a sector-wide emissions projection for the global semiconductor industry in 2030, as well as emissions projections for East Asia's three biggest semiconductor manufacturers, two display manufacturing companies and one final assembly company. Due to data limitations, the report does not include a sector-wide projection for the display manufacturing industry and final assembly industries. The report includes a detailed emissions profile of 13 companies, comprising four semiconductor companies, five display companies, and four final assembly companies.

1 World Economic Forum & Boston Consulting Group (2021). Net-Zero Challenge: The supply chain opportunity. Retrieved March 22, 2023, from https://www.weforum.org/reports/net-zero-challenge-the-supply-chain-opportunity/

2 Analysed from top 20 companies' annual report.

3 Greenpeace & Stand.earth (2022). Supply Change. Retrieved March 22, 2023, from https://www.greenpeace.org/static/planet4-eastasia-stateless/2022/10/89382b33-supplychange.pdf

4 Greenpeace International (2014). GreenGadgets: Designing the Future. Retrieved March 22, 2023, from https://www.greenpeace.org/international/publication/7503/green-gadgets-designing-the-future/

5 Ondrej Burkacky, Julia Dragon, & Nikolaus Lehmann (2022). The semiconductor decade: A trillion-dollar industry. Retrieved March 22, 2023, from https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry

6 Greenpeace & Stand.earth (2022). Supply change. Retrieved March 22, 2023, from https://www.greenpeace.org/static/planet4-eastasia-stateless/2022/10/89382b33-supplychange.pdf

7 Intergovernmental Panel on Climate Change (2023). Synthesis Report of the IPCC Sixth Assessment Report. Retrieved March 26, 2023, from: https://www.ipcc.ch/report/ar6/syr/

8 UN Climate Change (2022). Climate plans remain insufficient: More ambitious action needed now. Retrieved March 22, 2023, from https://unfccc.int/news/climate-plans-remain-insufficient-more-ambitious-action-needed-now

9 Carbon Disclosure Project, United Nations Global Compact, World Resource Institute & World Wide Fund (2021). SBTi corporate net-zero standard. Retrieved March 22, 2023, from https://sciencebasedtargets.org/resources/files/Net-Zero-Standard.pdf

10 Intergovernmental Panel on Climate Change (2022). The evidence is clear: The time for action is now. We can halve emissions by 2030. Retrieved March 22, 2023, from https://www.ipcc.ch/2022/04/04/ipcc-ar6-wgiii-pressrelease/

The methodology used in this report calculates the future emissions of semiconductor manufacturers as a factor of production levels and electricity consumption, and the looming difference between projected emissions cuts and existing sources of clean energy on the local energy grid used by existing semiconductor fabrication plants (hereafter, 'fabs') in these companies' operations.

Renewable energy will be essential to decarbonize the semiconductor manufacturing and the consumer electronics sectors. By developing a strong understanding of future electricity consumption and associated emissions projections, we can see the sheer amount of renewable energy capacity required for tech companies to deliver long-term net zero commitments. In particular, as companies undertake emissions cuts as electricity consumption increases, this report reveals a disconnect between long-term goals and mid- or near-term planning, where delayed energy transitions create steeper, high risk decarbonization pathways for these companies. If companies delay transitioning their energy sources away from high emissions fossil fuels, they exacerbate environmental, health, regulatory, and financial risk.

Key findings

1 **Emissions from the global semiconductor industry are skyrocketing.**

Based on projected market size and existing climate commitments from semiconductor manufacturers, the semiconductor manufacturing industry[11] is on track to consume 286 terawatt hours (TWh) of electricity globally in 2030, higher than Australia's 2021 electricity consumption.[12]

a. The industry is projected to emit 86 million metric tons of carbon dioxide equivalent (CO_2e) in 2030, more than Portugal's total emissions in 2021.[13]

b. Zero semiconductor manufacturers analyzed in this report have issued climate commitments in line with the Intergovernmental Panel on Climate Change (IPCC) recommendations to limit global warming to 1.5 degrees Celsius. Likewise, zero display manufacturing or final assembly supply chain companies in East Asia have issued commitments that are in line with the 1.5 degrees Celsius target.

2 **Electricity consumption by TSMC, Taiwan's largest semiconductor manufacturing company, is on track to grow 267% by 2030, the biggest increase of all semiconductor manufacturers in East Asia.**

By 2030, TSMC is on track to consume as much electricity as roughly one-fourth of Taiwan's population.[14]

a. In 2021, renewable energy comprised only 9% of TSMC's total energy usage, far lower than renewable energy usage rates of the chipmaker's biggest rivals.

b. Electricity consumption from Taiwan's semiconductor manufacturing industry as a whole is on track to increase 236% between 2021 and 2030. By 2030, semiconductor manufacturers in Taiwan will consume twice as much electricity as did New Zealand in 2021, according to the forecast.[15] The increase is due in large part to TSMC's growing electricity consumption. By 2030, about 82% of electricity consumption by Taiwan's semiconductor manufacturing industry is projected to come from TSMC.

c. Besides TSMC, only two other companies studied, Luxshare Precision and SK Hynix, are projected to see electricity consumption growth by 2030 that exceeds 200%. Between 2021 and 2030, Luxshare Precision and SK Hynix's electricity consumption is forecast to increase 270%, and 215%, respectively.

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11 Referring to the front-end process of the semiconductor industry

12 International Energy Agency (2023). Australia data explorer. Retrieved March 22, 2023, from https://www.iea.org/countries/australia

13 Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO_2 and Greenhouse Gas Emissions". Published online at OurWorldInData.org. Portugal: CO_2 Country Profile. Retrieved March 22, 2023, from https://ourworldindata.org/co2/country/portugal

14 Statista Research Department (2023). Annual electricity consumption per capita in Taiwan 2010-2020. Retrieved March 22, 2023, from https://www.statista.com/statistics/334268/taiwan-per-capita-electricity-consumption/#:~:text=In%202020%2C%20electricity%20consumption%20in,11.5%20megawatt%20hours%20per%20capita.

15 International Energy Agency (2023). New Zealand data explorer. Retrieved March 22, 2023, from https://www.iea.org/countries/new-zealand

3 **By 2030, Samsung Electronics' semiconductor manufacturing emissions will exceed those of any tech suppliers studied, at 32 million metric tons of CO_2e per year.**

Samsung Electronics is South Korea's largest semiconductor manufacturer. The company's electricity consumption from semiconductor manufacturing is projected to reach 55 TWh by 2030, higher than Singapore's national electricity consumption in 2020.[16] However, Samsung has been slow to transition to renewable energy in South Korea.

a. In 2022 nearly 75% of Samsung Electronics' electricity consumption took place in South Korea. However, Samsung has not issued a 2030 climate commitment for its operations inside South Korea.

b. Emissions from South Korea's semiconductor manufacturing industry are projected to rise through 2029 due in large part to Samsung Electronics' continued emissions growth.

c. South Korea's semiconductor manufacturing industry is projected to consume 109 TWh of electricity by 2030, a 164% increase from 2021.

4 **Emissions from semiconductor manufacturer Samsung Electronics, display manufacturer Samsung Display, and final assembly company Luxshare Precision are on track to increase through 2030, long after emissions from other companies peak.**

Emissions from Samsung Electronics, Samsung Display and Luxshare Precisions are not likely to peak before 2030 because all three companies lack 2030 targets.

a. It is essential that tech companies issue climate targets that are effective by 2030 to ensure that their emissions peak in line with a 1.5 degree Celsius heating limit.

5 **Renewable Energy Certificates (RECs) accounted for 84% of all renewable energy sourced by the semiconductor manufacturing industry in 2021.**

RECs are financial instruments that represent existing renewable energy projects. The purchase of RECs does not add any new renewable energy to the grid. For this reason, RECs are one of the least impactful forms of renewable energy procurement.

a. Instead of purchasing RECs, semiconductor manufacturers should purchase renewable energy with addictionality though Power Purchase Agreements (PPAs), onsite generation and investment.

   i. In Taiwan, for example, large electricity consumers like TSMC have bought up the majority of existing RECs instead of constructing their own renewable energy infrastructure. TSMC dominates Taiwan's electricity market and should pursue carbon neutrality by building onsite solar and investing in renewable energy power stations, rather than through the purchase of RECs.

16 International Energy Agency (2023). Singapore data explorer. Retrieved March 22, 2023, from https://www.iea.org/countries/singapore

Methodology and data sources

Research background

The global technology sector is growing quickly, and the industry's electricity consumption continues to rise. Electricity use from the global tech sector is projected to grow by more than 60% between 2020 and 2030. Because the sector relies heavily on fossil fuels, rising electricity consumption has been accompanied by an increase in carbon emissions. The climate impact of the consumer electronics supply chain is significant. Consumer electronics suppliers, including semiconductor manufacturers, display manufacturers and final assemblers, account for more than three-quarters of the electronics industry's total emissions.[17]

The semiconductor industry

Methodology

This report applies a methodology to project future electricity demand and greenhouse gas emissions for semiconductor manufacturers at the company level.

First, we estimate each company's 2030 market share by revenue based on historical trends. Company-specific revenue growth can then be estimated based on the difference between the company's 2021 absolute revenue and 2030 market share by revenue projections.[18] Given that the semiconductor manufacturing sector's electricity consumption is largely driven by production levels, future scope 1 and scope 2 emissions can both be mathematically described as functions of baseline electricity consumption (or baseline emissions), change in production level, production-emission factor change, and emissions reductions, as illustrated in equations 6, 11, and 17, respectively.

To test the correlation between revenue and production levels, we analyzed the revenue and emissions of 16 semiconductor manufacturers over five years of historical reported data. As shown in Figure 1, an r2=0.52 for scope 1 and an r2=0.63 for scope 2 indicates revenue is moderately to high correlated with emissions. Further literature review indicates that revenue is strongly correlated with the semiconductor manufacturing industry's emissions.[19] The basic assumption the report holds is that the increasing production will lead to an increase in revenue in the semiconductor industry.

17 World Economic Forum & Boston Consulting Group (2021). Net-Zero Challenge: The supply chain opportunity. Retrieved March 22, 2023, from https://www.weforum.org/reports/net-zero-challenge-the-supply-chain-opportunity/

18 Authors' analysis based on company reported data to CDP and financial disclosure.

19 Authors' analysis based on company reported data to CDP and financial disclosure.

Figure. 1 Correlation between revenue and scope 1 emissions

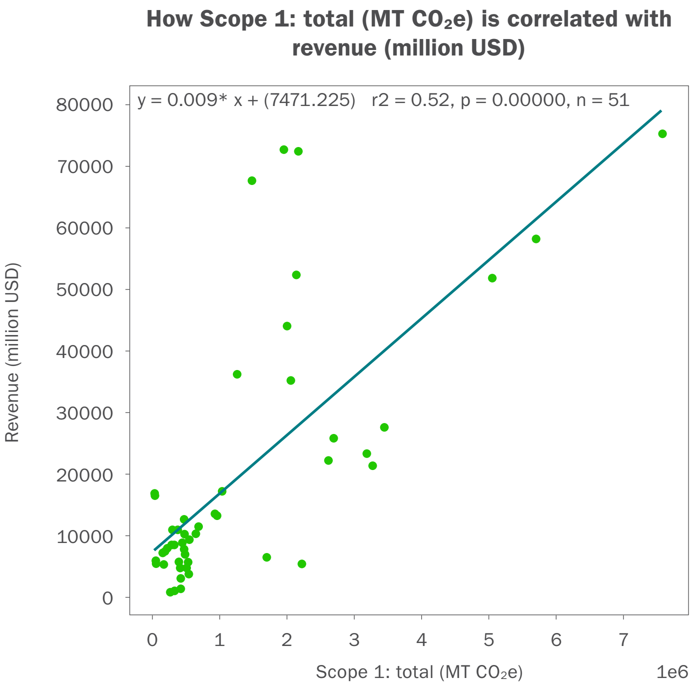
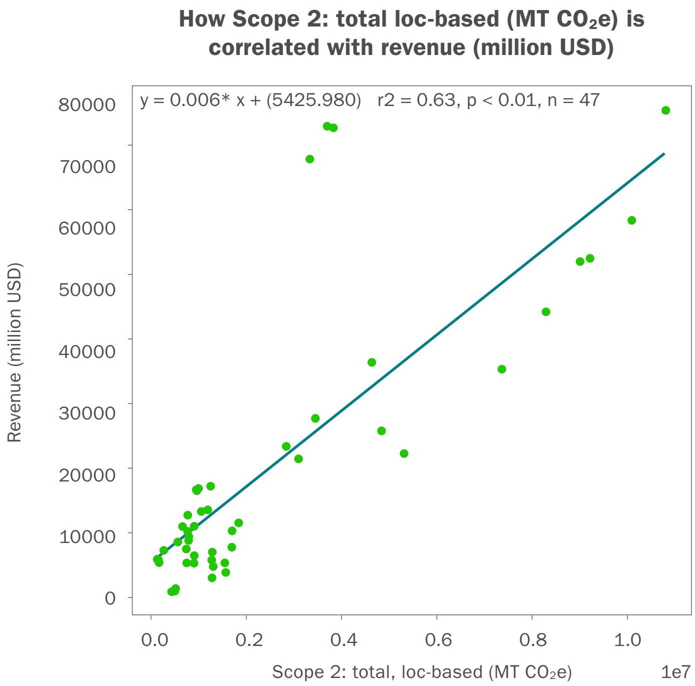


Figure. 2 Correlation between revenue and scope 2 emissions



Source: Authors' analysis based on company reported data to CDP and financial disclosure.

Baseline electricity consumption or baseline emissions data is taken from companies' 2021 reporting. Production changes are estimated by projected revenue growth. Companies do not publicly share information on semiconductor chip production projections, so we used future market size by revenue as a proxy for future production demand, assuming a direct correlation between market size by revenue and production levels. Production-emission factor change is determined using current company production distribution by node size. While wafer size, grid emission factor, and the global warming potentials of new fluorinated chemicals will also impact production-emission factor change, no sufficient data were found in the literature to reliably integrate them into intensity change estimations.

All data collected and used for modeling is summarized in Table 1.

We analyzed companies' climate commitments and carbon targets to develop company-specific models to estimate emission reduction requirements if those targets are 100% achieved in time. Because companies do not often disclose emissions reduction instruments (e.g., power purchase agreements (PPAs), renewable energy certificated (RECs)) by specific quantity, we reviewed the disclosure of previous actual efforts on emissions reductions by companies in recent years and assumed those trends would continue into 2030 to project what emissions reductions instruments are likely to be used and how much.

For most companies, 2030 projections were disaggregated to the regional level using companies' report emissions and consumption distributions by region during the baseline year (2021). In the cases where companies have region-specific carbon targets (e.g., Samsung, Micron Technology), we developed regional projections and then aggregated up to the company level.

Table 1. Data used in projection modeling.

Date type	Granularity	Coverage	Time coverage	Sources
Total and by-region, historical Scope 1 emissions	Company	16 companies (>96% of the market)	2017 - 2021	Company annual disclosure reports to CDP, annual corporate sustainability reports
Total and by-region, historical market-based and location-based Scope 2 emissions	Company	16 companies	2017 - 2021	Company annual disclosure reports to CDP, annual corporate sustainability reports
Total and by-region, historial electricity consumption	Company	16 companies	2017 - 2021	Company annual disclosure reports to CDP, annual corporate sustainability reports
Company carbon commitments	Company	16 companies	2021 - 2022	Company websites; the latest corporate sustainability reports
Historical company revenue	Company	16 companies	2011 - 2021	Company annual financial reports
Fab name and locations	Fab	153 fabs (100% coverage for the 16 companies)	2022	Company websites; corporate sustainability reports
Market growth projection by 2030	Sub-sector	Sector	2017, 2030	McKinsey 2022, ASML 2021
Correlation between node size and production efficiency	Sector	From 350nm to 3nm	2000 - 2021	Semiconductor Engineering 2022, Lithovision 2021; Das and Mao 2020; EPRI 2000
Node-size distribution by region	Region	Worldwide	2020	IC Insights 2021

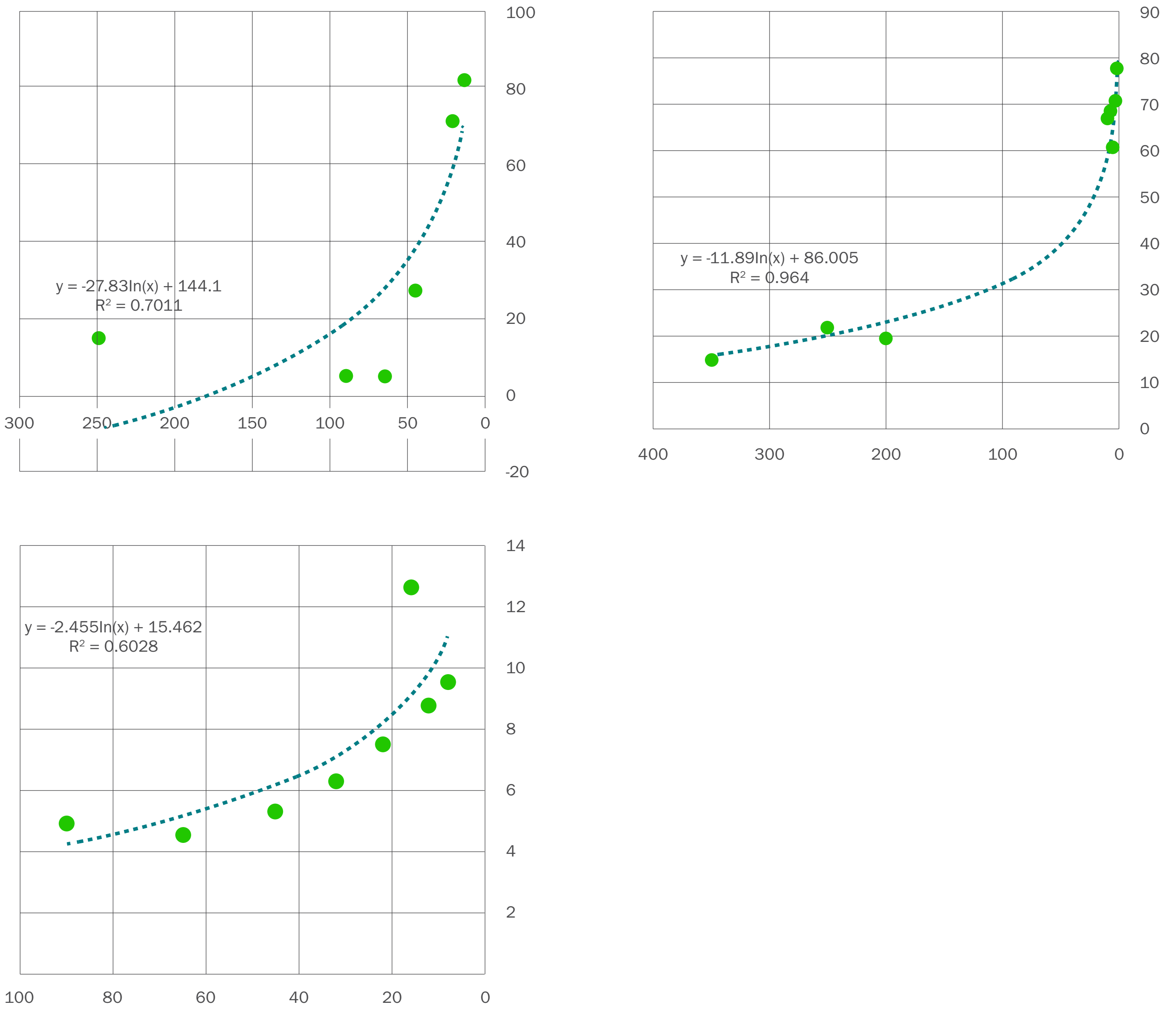
Correlations between node size and electricity consumption

It is more energy intensive for manufacturers to produce semiconductor chips with smaller node sizes because processing steps (e.g., mask counts in the photolithography process) are higher in comparison to chips with larger node sizes.

Figure 3 illustrates the relationship between node size and mask count and turnaround times, which are used as proxies for measuring the complexity of a given manufacturing process. The correlation shown is described in equation N1, and used in our modeling.

$y = -2.455\ln(x) + 15.462$ (Eq. N1)

Figure 3. The relationship between node size and electricity intensity, mask count, and turnaround times.

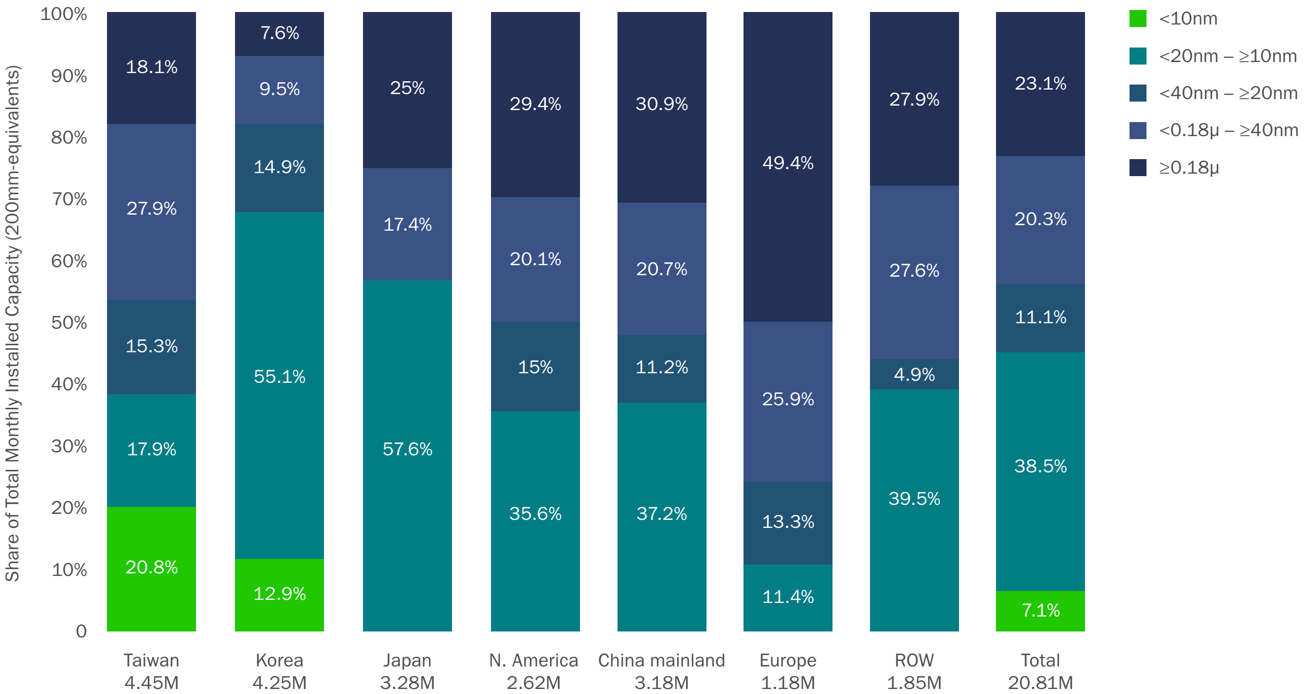


Notes: X-axes are all reversed node sizes ranging from 350nm to 3nm; Y-axes are different, from left to right, electricity intensity, mask count, and turnaround time, respectively.[20]

20 Authors' analysis based on data from Das and Mao 2020, Lithovision 2020, EPRI 2000, and Semiconductor Engineering 2022.

Figure 4 illustrates the node size production distribution across regions by the end of 2020, and Table 2 has 2020 and projected 2030 node size distributions. The projections are developed based on the 2020 distribution and the author's judgment.

Figure 4. Global monthly installed capacity for geographic region at December 2020 by node size.



Source: IC Insights, 2021.[21]

Table 2. Current and projected 2030 node size production distributions by region.

	Distribution in 2020					Projected distribution in 2030				
Region	**>= 0.18u**	**<0.18u - >=40nm**	**<40nm - >=20nm**	**<20nm - >=10nm**	**<10nm**	**>= 0.18u**	**<0.18u - >=40nm**	**<40nm - >=20nm**	**<20nm - >=10nm**	**<10nm**
Taiwan	18%	28%	15%	18%	21%	9%	14%	8%	9%	60%
Korea	8%	10%	15%	55%	13%	3%	3%	5%	19%	70%
Japan	25%	17%	0%	58%	0%	18%	12%	0%	40%	30%
North America	29%	20%	15%	36%	0%	21%	14%	11%	25%	30%
China mainland	31%	21%	11%	37%	0%	25%	17%	9%	30%	20%
Europe	49%	26%	13%	11%	0%	40%	21%	11%	9%	20%
Rest of the world	28%	28%	5%	40%	0%	25%	25%	4%	36%	10%
World total	23%	20%	11%	39%	7%	20%	15%	7%	24%	34%

Source: 2020 data from IC Insights, 2021; 2030 data developed by authors.

21 Daniel Nenni (2021). Retrieved March 22, 2023, from https://semiwiki.com/forum/index.php?threads/global-wafer-capacity-2021-2025.13705/

Future projection calculations

Scope 1

Scope 1 emissions come from process gasses and stationary combustions, and emission reductions from gas abatement as well as renewable energy that replaces combustion. Baseline and future emissions can be calculated with Eq. 1 and Eq. 2, respectively.

$EM_{S1,\,b} = P_b \times EF_{S1,\,b,\,P} - EMR_{S1,\,b,\,GA} - EMR_{S1,\,b,\,SC}$ (Eq. 1)

$EM_{S1,\,f} = P_f \times EF_{S1,\,f,\,P} - EMR_{S1,\,f,\,GA} - EMR_{S1,\,f,\,SC}$ (Eq. 2)

In the equations above, *EM* is emission, *P* is production, *EF* is emission factor, *EMR* is emission reduced, *SC* is stationary combustion, *GA* is gas abatement, *b* is baseline, *f* is future, *S1* is scope 1.

$P_f = P_b \times \Delta P$ (Eq. 3)

$EF_{S1,\,f,\,P} = EF_{S1,\,b,\,P} \times \Delta PE_{S1}$ (Eq. 4)

$\Delta PE_{S1} = \frac{W_f}{W_b} \times \frac{N_f}{N_b} \times \frac{F_f}{F_b}$ (Eq. 5)

In the equations above, *ΔP* is the production change, *ΔPE* is the production efficiency change, *W* is wafer size-production efficiency correlation, *N* is the node size-production efficiency correlation, and *F* is the weighted average of fluorinated gasses' global warming potentials.

Eq. 6 below can be derived from Eq 1 through 5.

$EM_{S1,\,f} = \Delta P \times \left(\frac{W_f}{W_b} \times \frac{N_f}{N_b} \times \frac{F_f}{F_b} \right) \times (EM_{S1,\,b} + EMR_{S1,\,b,\,GA} + EMR_{S1,\,b,\,SC}) - EMR_{S1,\,f,\,GA} - EMR_{S1,\,f,\,SC}$ (Eq. 6)

Scope 2

Scope 2 emissions come from purchased electricity, steam, heat, and cooling. Baseline and future emissions can be calculated with Eq. 7 and Eq. 8, respectively.

$EM_{S2,\,b} = EL_b \times EF_{S2,\,b,\,EL} + SHC_{S2,\,b} \times EF_{S2,\,b,\,SHC} - EMR_{S2,\,b,\,RE} - EMR_{S2,\,b,\,SHC}$ (Eq. 7)

$EM_{S2,\,f} = EL_f \times EF_{S2,\,f,\,EL} + SHC_{S2,\,f} \times EF_{S2,\,f,\,SHC} - EMR_{S2,\,f,\,RE} - EMR_{S2,\,f,\,SHC}$ (Eq. 8)

In the equations above, *EL* is electricity, *SHC* is steam, heat, and cooling, *RE* is renewable energy, S2 is scope 2.

$\Delta PE_{S2} = \frac{W_f}{W_b} \times \frac{N_f}{N_b} \times \frac{GF_f}{GF_b}$ (Eq. 10)

In the equation above, *GF* is grid emission factor.

Eq. 11 below can be derived with Eq 1 through 10.

$EM_{S2,\,f} = \Delta P \times \left(\frac{W_f}{W_b} \times \frac{N_f}{N_b} \times \frac{GF_f}{GF_b} \right) \times (EM_{S2,\,b} + EMR_{S2,\,b,\,RE} + EMR_{S2,\,b,\,SHC}) - EMR_{S2,\,f,\,RE} - EMR_{S2,\,f,\,SHC}$ (Eq. 11)

Electricity consumption

Electricity is consumed for production and operations. Baseline and future electricity demand can be calculated with Eq. 12 and Eq. 13, respectively.

$EL_b = P_b \times EF_{EL,\ b,\ P}$ (Eq. 12)

$EL_f = P_f \times EF_{EL,\ f,\ P}$ (Eq. 13)

In the equations above, *EL* is electricity demand,

$P_f = P_b \times \Delta P$ (Eq. 14)

$EF_{EL,\ f,\ P} = EF_{EL,\ b,\ P} \times \Delta PE_{EL}$ (Eq. 15)

$\Delta PE_{EL} = \frac{W_f}{W_b} \times \frac{N_f}{N_b}$ (Eq. 16)

Eq. 17 below can be derived from Eq 1 through 16.

$EF_f = \Delta P \times (\frac{W_f}{W_b} \times \frac{N_f}{N_b}) \times EL_b$ (Eq. 17)

Data sources

There is relatively little public information projecting planned future chip production levels from semiconductor manufacturers. This report uses future market size as a proxy for future chip production demand, such that the market size (calculated in terms of revenue) would grow a certain percent by 2030 is also a projection that chip production would grow by that percentage as well. There is a body of research suggesting that production largely drives the semiconductor manufacturing sector's emissions.[22] Because semiconductor manufacturers' chip revenue is in direct correlation to electricity consumption, this report generates an estimate of future electricity consumption associated with increased production.

The correlation between revenue and emissions

The global semiconductor manufacturing industry's market size in revenue in 2021 was $556 billion USD, according to World Semiconductor Trade Statistics (WSTS). The market was driven mostly by smartphones, personal computers, consumer electronics, automotive, and industrial electronics, among other applications, with some applications expected to see relatively faster growth in the next decade, such as electric vehicles.[23]

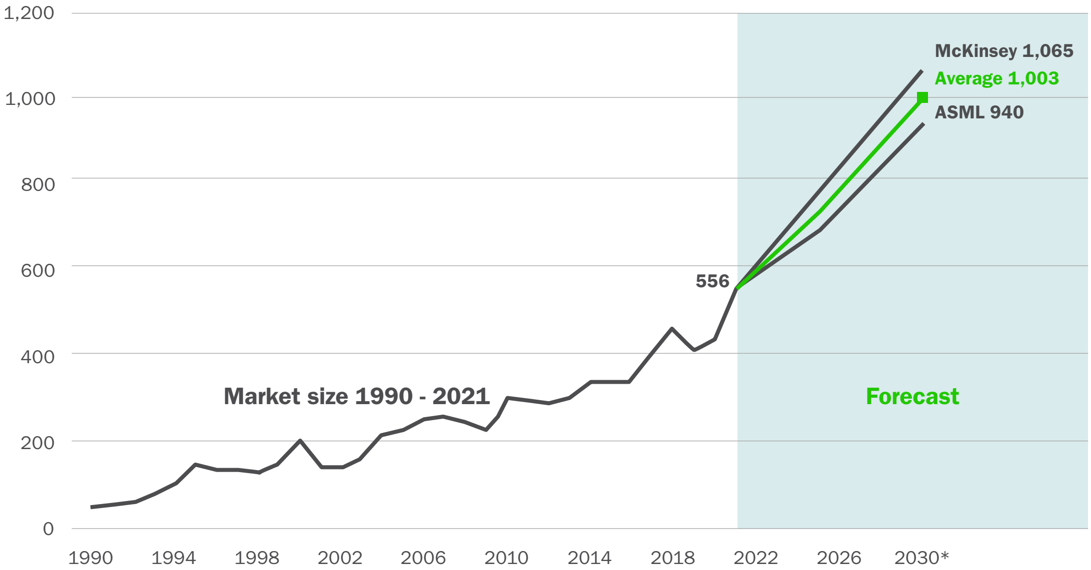
This report arrived at the figure by comparing market size projections by ASML and McKinsey, where ASML forecasted estimates for the market's various segment applications from 2020 to 2025, and projected a market size for 2030 based on the annual growth rate of the actual, historical market size in 2015 and the forecasted market size for 2025, but did not estimate segment growth rates from 2025 to 2030. McKinsey's analysis also focused on segment application growth rates, and forecasted from 2021 to 2030, with no specific forecast for 2025. This report summed the segments into market-wide estimates and averaged them between the two separate analyses.

22 Analysed from companies' ESG reports.

23 ASML (2022). 2021 Annual Report, page 28. Retrieved March 22, 2023, from https://www.asml.com/en/investors/annual-report/2021

These projections taken together indicate the global semiconductor market will represent $1.003 trillion USD by 2030, almost doubling from 2021, when the market size was $556 billion USD, as shown in Figure 5.

Figure 5. Global semiconductor market size projection to 2030 (in billion US dollars)



Source: Authors' analysis based on data from World Semiconductor Trade Statistics, ASML 2021, Mckinsey 2022.[24]

Market size by section

Table 3 and Figure 6 show forecasts for 2025. Table 3 shows market size in revenue projections for segment applications.

Table 3. Semiconductor market size worldwide in 2020, 2025, and 2030, by application (in billion US dollars)

Market	2020	2025*	2030*
Smartphone	116	162	210
Personal computing	100	121	132
Consumer electronics	48	74	98
Automotive	39	82	131
Industrial electronics	50	82	119
Wired and wireless infrastructure	38	53	63
Servers, data centers, and storage	76	119	187
Total	467	693	940

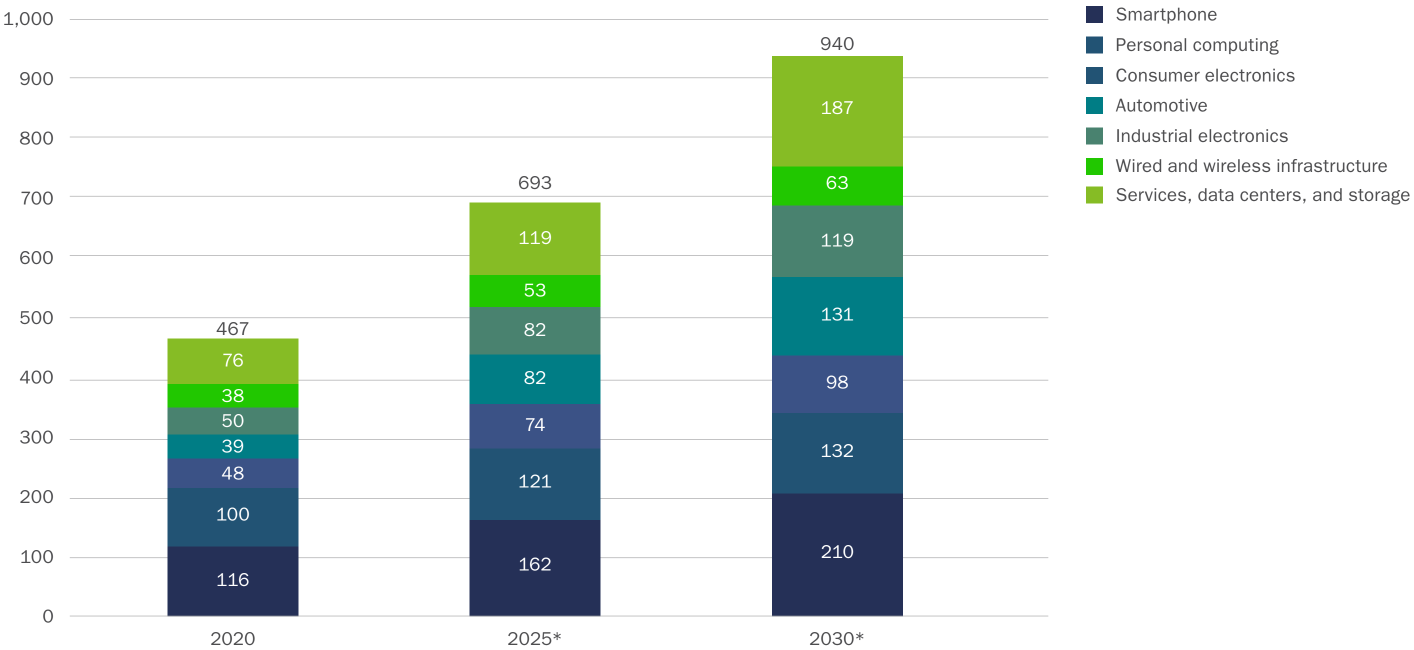
Source: ASML Annual Report 2021.[25]

24 NB: McKinsey 2022's analysis forecasts a 2030 market size. ASML 2021's analysis forecasts a 2025 market size that combines the outlook for segment application markets, and then forecasts the market size into 2030 based on CAGR during 2015-2025 and the 2020 market size.

25 ASML (2022). 2021 Annual Report, page 28. Retrieved March 22, 2023, from https://www.asml.com/en/investors/annual-report/2021

Supplemental notes*: forecast by publisher based on the outlook of industry application

Figure 6. Semiconductor market size worldwide in 2020, 2025, and 2030, by application (in billion US dollars)



Source: adapted from ASML 2021.

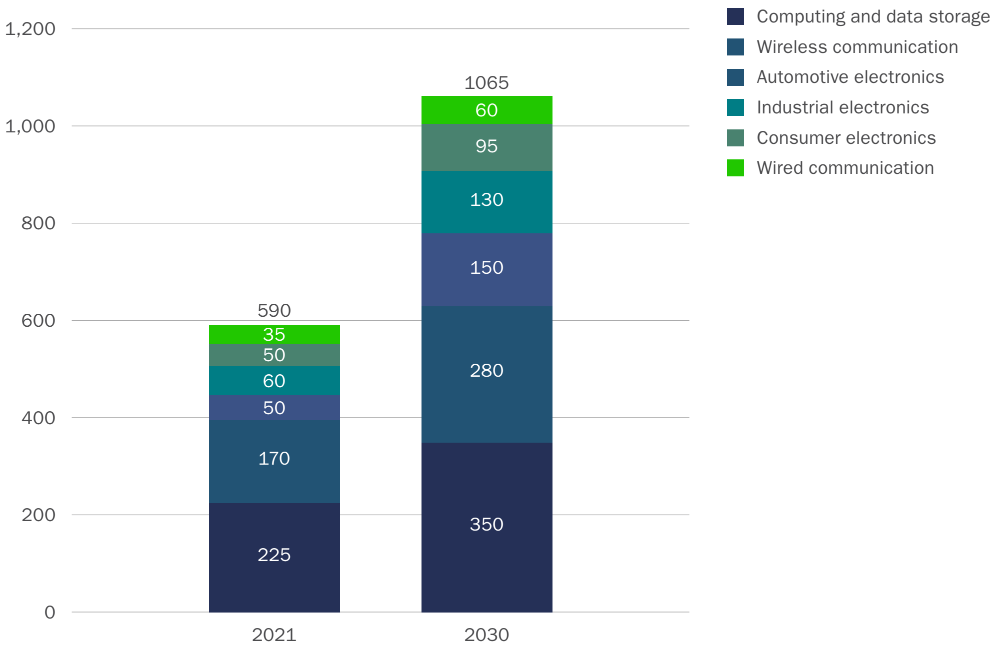
Table 4. Global semiconductor market value by vertical, indicative (in billion US dollars)

Market	2021	2030
Wired communication	35	60
Consumer electronics	50	95
Industrial electronics	60	130
Automotive electronics	50	150
Wireless communication	170	280
Computing and data storage	225	350
Total	590	1065

Notes: McKinsey's analysis based on a range of macroeconomic assumptions
Source: McKinsey & Company[26]

26 Ondrej Burkacky, Julia Dragon, & Nikolaus Lehmann (2022). The semiconductor decade: A trillion-dollar industry. Retrieved March 22, 2023, from https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry

Figure 7. Semiconductor market size 2030 projection (in billion US dollars)

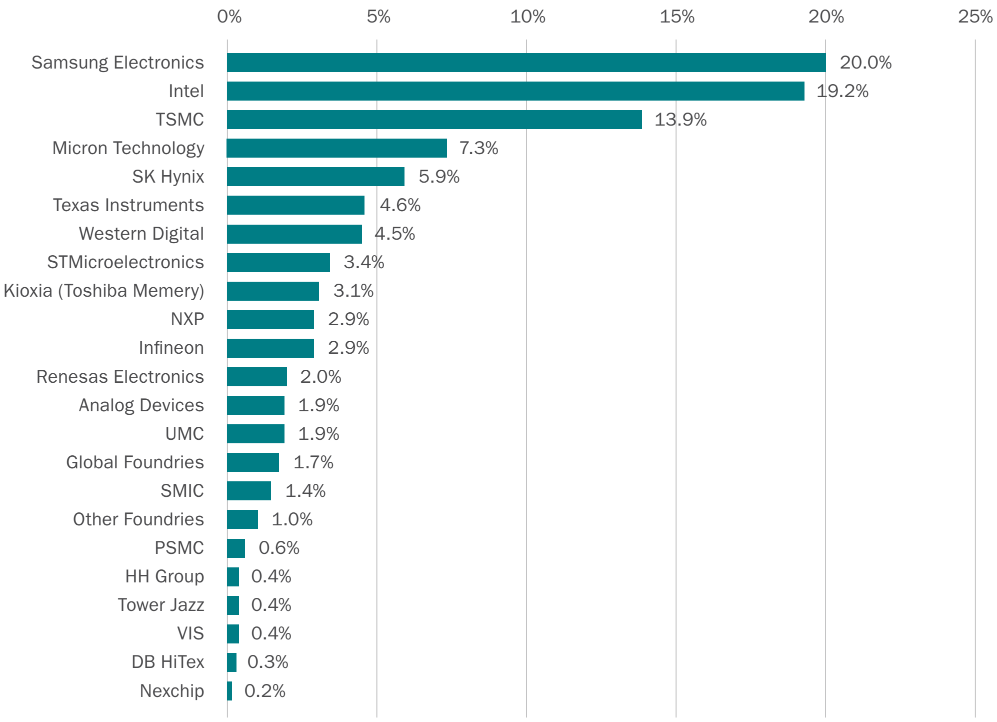


Source: adapted from McKinsey, 2022

Company projections

To identify key companies and their respective market shares, this report used market share reporting from industry analysts,[27, 28] and financial report filings from companies. This analysis focuses on both integrated device manufacturers (IDMs), such as Samsung Electronics and Intel, and foundries, such as TSMC.

Figure 8. Key semiconductor manufacturers and their market shares in 2021.



Source: Authors' analysis, selecting the world's leading semiconductor manufacturing companies from Gartner and Trendforce reporting, and then aggregating data from annual financial reports of companies themselves.

27 https://www-statista-com.cmu.idm.oclc.org/statistics/266143/global-market-share-of-leading-semiconductor-vendors/

28 https://www-statista-com.cmu.idm.oclc.org/statistics/1246563/global-market-share-of-leading-semiconductor-manufacturers/

Sources of scope 1 and scope 2 emissions for semiconductor manufacturers

The Greenhouse Gas Protocol defines scope 1 emissions as direct emissions from company-owned and company-controlled resources, including stationary combustion of fuels and heating sources as well as process emissions from onsite manufacturing.[29]

Available reporting on scope 1 emissions from semiconductor manufacturers through US EPA GHGRP reporting schemes[30] shows that, of a semiconductor fab- or facility-level manufacturing facility's emissions, 12.2% of the total CO_2e comes from stationary combustion. 87.8% of emissions comes from process gasses and heat transfer fluids, which have a very high global warming potential. Almost half of emissions from the use of process gasses and heat transfer fluids come from the plasma etching and wafer cleaning processes, while 37.7% of emissions come during chamber cleaning. The remainder comes from heat transfer and chemical vapor deposition.

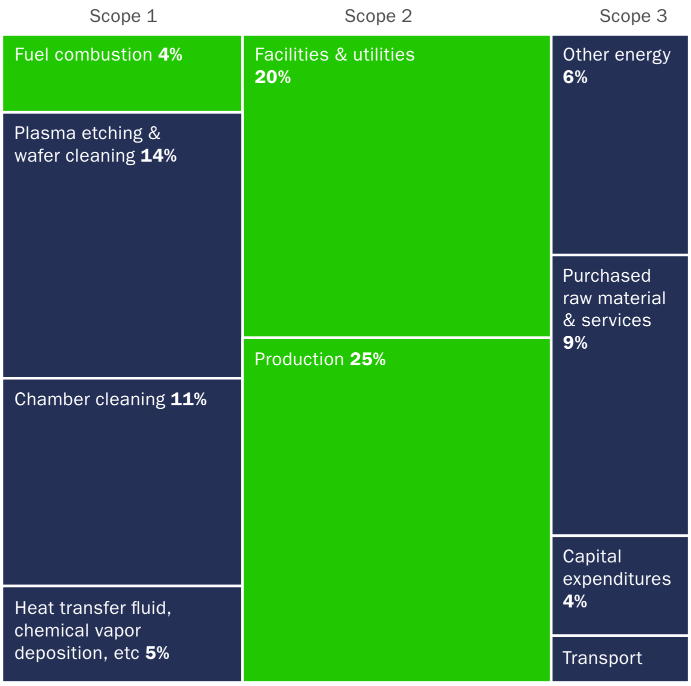
Scope 2 emissions are indirect emissions from the generation of purchased energy.

McKinsey estimates that 56% of scope 2 emissions from semiconductor manufacturers come from production, while 44% come from facilities and utilities.[31]

About 50% of a fab's total emissions can be reduced by transitioning from fossil fuels to renewable energy to source electricity, including 45% of total emissions that come from scope 2 emissions and the 4% of total emissions that come from scope 1 stationary combustion.

Scope 1 emissions could be further reduced by adopting gas abatement systems and the development of new chemicals that have a lower Global Warming Potential (GWP), particular process gasses and heat transfer fluids. That is not modelled here.

Figure 9. Carbon emissions breakdown by source for a typical fab.



Notes: 1. Green indicates areas where most emissions are CO_2 and can be reduced by switching to renewable energy; 2. Scope 3 downstream are excluded.
Sources: Authors' analysis aggregating data from a) McKinsey 2022, and b) US EPA GHGRP.

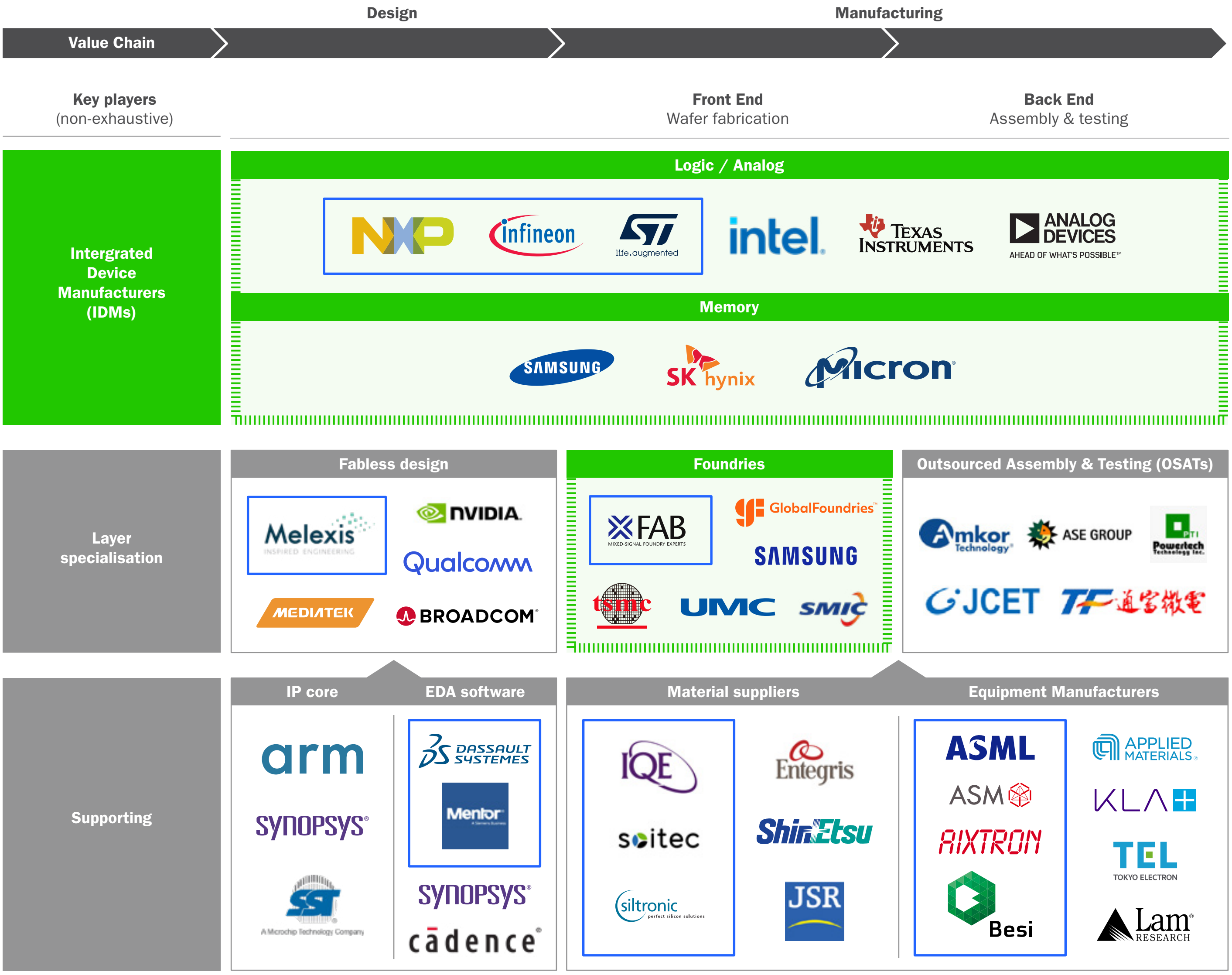
29 World Resource Institute & World Business Council for Sustainable Development (no date supplied). Greenhouse gas protocol. Retrieved March 22, 2023, from https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf

30 Environmental Protection Agency (2022). Greenhouse Gas Reporting Program (GHGRP). Retrieved March 22, 2023, from https://www.epa.gov/ghgreporting/data-sets

31 Ondrej Burkacky, Julia Dragon, & Nikolaus Lehmann (2022). The semiconductor decade: A trillion-dollar industry. Retrieved March 22, 2023, from https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry.

Figure 10 illustrates sections of the semiconductor industry design and production value chain, from front-end wafer fabrication and back-end assembly and testing. This report focuses on companies in wafer fabrication, which includes both integrated device manufacturers (IDMs) and foundries.

Figure 10. Semiconductor industry value chain.



= EU based

Source: ING Research - Notes: (1) Does not have own production facilities, (2) Powertech Technology Inc., (3) TongFu Microelectronics Co., Ltd. List of companies to illustrate, not exhaustive.

Corporate climate commitments

We collected and analyzed the most recent climate commitments announced by the companies, and summarized them in Table 5.

Table 5. Most recent climate commitments announced by companies.

Company	Scope 1 commitment	Scope 2 commitment
Analog Devices	Carbon neutral in 2030	Carbon neutral in 2030
Global Foundries	Reduce 25% from 2020 to 2030	No near- or medium-term targets
Infineon	Net zero in 2030 through purchasing renewable energy	Net zero in 2030 through purchasing renewable energy
Intel	10% absolute reduction from 2020 to 2030	10% absolute reduction from 2020 to 2030
Kioxia	No near- or medium-term targets	10% reduction by 2030 from 2020 through energy saving activities
Micron Technology	Net zero in 2050, with 42% reduction by 2030 from 2020;	Net zero in 2050, with 100% renewable energy in US by 2027
NXP	Net zero in 2035, 2027 medium-term goals 35% reduction from 2021	Net zero in 2035, 2027 medium-term goals 35% reduction from 2021
Renesas Electronics	38% reduction by 2030 from 2021	38% reduction by 2030 from 2021
Samsung Electronics	Net zero in 2050 without any near- or medium-term targets	Net zero in 2050, 100% renewable energy in 2027 for facilities outside Korea.
SK Hynix	Net zero in 2050, with 2030 emissions maintained at 2020 level	Net zero in 2050, with 2030 emissions maintained at 2020 level
SMIC	No near- or medium-term targets	No near- or medium-term targets
STMicroelectronics	Net zero in 2027	Net zero in 2027
Texas Instruments	8% reduction by 2025 from 2021	8% reduction by 2025 from 2021
TSMC	Net zero in 2050, with 2030 emissions maintained at 2020 level	Net zero in 2050, with 2030 emissions maintained at 2020 level
UMC	No overall absolute reduction targets, only efficiency-related ones (reducing 45% per unit production by 2030 from 2010)	No overall absolute reduction targets, only efficiency-related ones (reducing 45% per unit production by 2030 from 2010)
Western Digital	42% reduction by 2030 from 2020	42% reduction by 2030 from 2020

Source: Authors' analysis of corporate sustainability reports.

Projection methodology and data sources for display manufacturing and final assembly companies

The projection methodology and general assumptions are the same as the ones we used for the semiconductor manufacturing industry. For the analysis of display manufacturing and final assembly companies used in this report to provide context and a broader understanding of electricity consumption and emissions from East Asia's electronics supply chain industry, there is still limited information on emissions from these sectors, so we assume that emission level increases are linear to production rises and that production emissions intensities are consistent if no clear short- or mid-term targets are set by the company. All data collected and used for modelling are summarized in Table 6.

Table 6. General information of data and information collected and used in projection modeling.

Date type	Granularity	Coverage	Time coverage	Sources
Total historical scope 1 emissions	Company	3 companies	2019-2021	Company annual disclosure reports to CDP; annual corporate sustainability reports
Total historical market-based and location-based Scope 2 emissions	Company	3 companies	2019-2021	Company annual disclosure reports to CDP; annual corporate sustainability reports
Total historical electricity consumption	Company	3 companies	2019-2021	Company annual disclosure reports to CDP; annual corporate sustainability reports
Company carbon commitments	Company	3 companies	2021-2022	Company websites; the latest corporate sustainability reports
Historical company revenue	Company	3 companies	2019-2021	Company annual financial reports; annual corporate sustainability reports
Company growth projection by 2030	Company	Luxshare	2021-2030	Minsheng Securities 2023
Market growth projection by 2030	Sector	The display sector	2021, 2030	MarketsAndMarkets 2021

Global semiconductor manufacturing industry emissions forecast

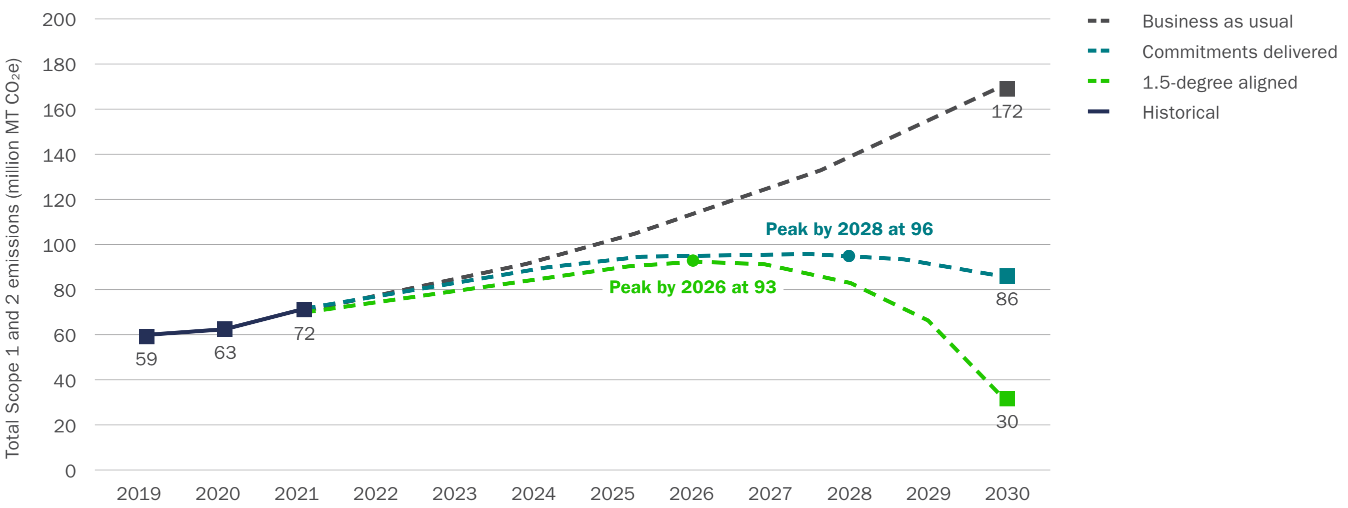
By 2030, the global semiconductor manufacturing sector's total scope 1 and scope 2 emissions are projected to reach 172 million metric tons of CO_2e under the "business as usual" scenario, 86 million metric tons under the "commitments delivered" scenario and 30 million metric tons under the "consistent with 1.5 degrees" scenario, illustrated in Figure 11. The 2019 and 2021 historical total of scope 1 and scope 2 emissions from the global manufacturing sector were 59 million metric tons of CO_2e and 72 million metric tons of CO_2e, respectively, a 22% increase in two years.

If these companies cut emissions to be in the "consistent with 1.5 degrees Celsius" scenario, emissions would peak in 2026 at 93 million metric tons of CO_2e.

Under the "commitments delivered" scenario, emissions peaks for scope 1 and scope 2 emissions from foundries and IDMs included are projected to peak at 96 million metric tons of CO_2e by 2028 (assuming that all foundries and IDMs delivered on existing climate commitments). Companies would need to cut an extra 56 million metric tons of CO_2e to be aligned with the 1.5 degrees target.

From 2019 to 2021, the global semiconductor manufacturing sector's total scope 1 and scope 2 emissions rose from 59 million tons of CO_2e in 2019 to 72 million metric tons of CO_2e in 2021, a 22% increase in just two years.

Figure 11. Historical (2019-2021) global semiconductor manufacturing sector GHG emissions and projections, shown with dashed lines (2022-2030).



Notes: Data for 2019, 2020, and 2021 are aggregations of actual emissions reported by companies; Data for 2022 and onwards are projections.
Source: Authors' analysis.

Regional

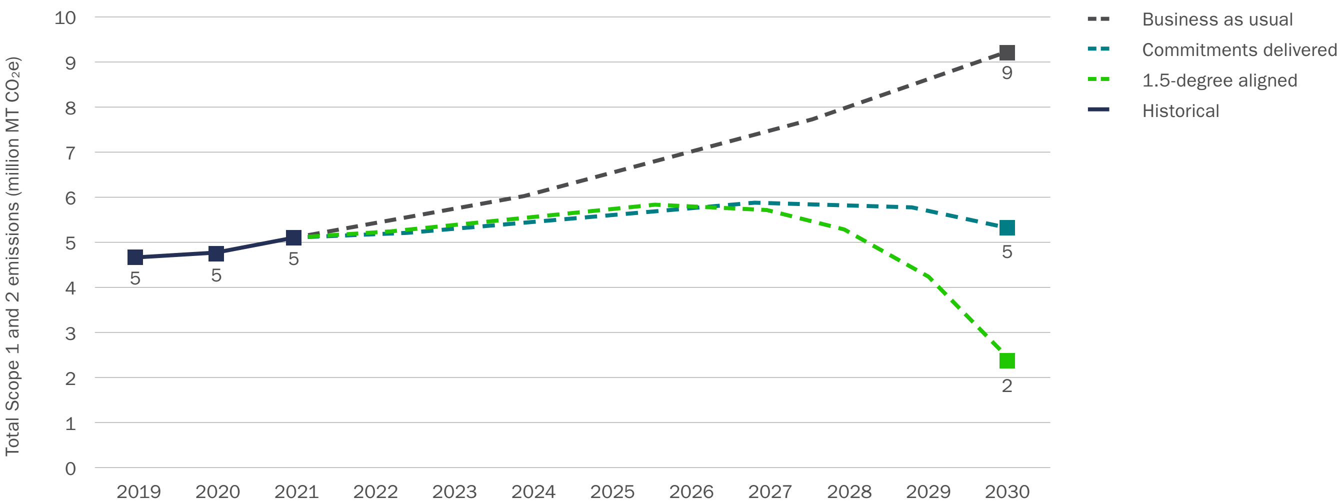
Japan

Under the “commitments delivered” scenario, Japan’s total emissions from major semiconductor manufacturers are likely to peak in 2027 at around 6 million metric tons of CO_2e, as shown in Figure 12.

The biggest contributor is Kioxia, which has the largest market share and has committed to achieve 1% scope 2 emissions reductions every year from 2020 to 2030. Renesas Electronics’ pledge to reduce emissions by 48% between 2021 and 2030 for both scope 1 and scope 2 emissions also contributes significantly to this peak timing. This is despite Renesas Electronics’ relatively small footprint. This is shown in Figure 13.

Japan’s semiconductor manufacturing sector’s electricity consumption will grow moderately in the “business as usual" scenario, as shown in Figure 14, which in this model is linked to two factors, production change and node size. Under a commitments delivered scenario, we factor in Japan’s Act on Rationalizing Energy Use, where companies are committed to reduce an average 1% of energy intensity annually across mid- and long-term targets.[32]

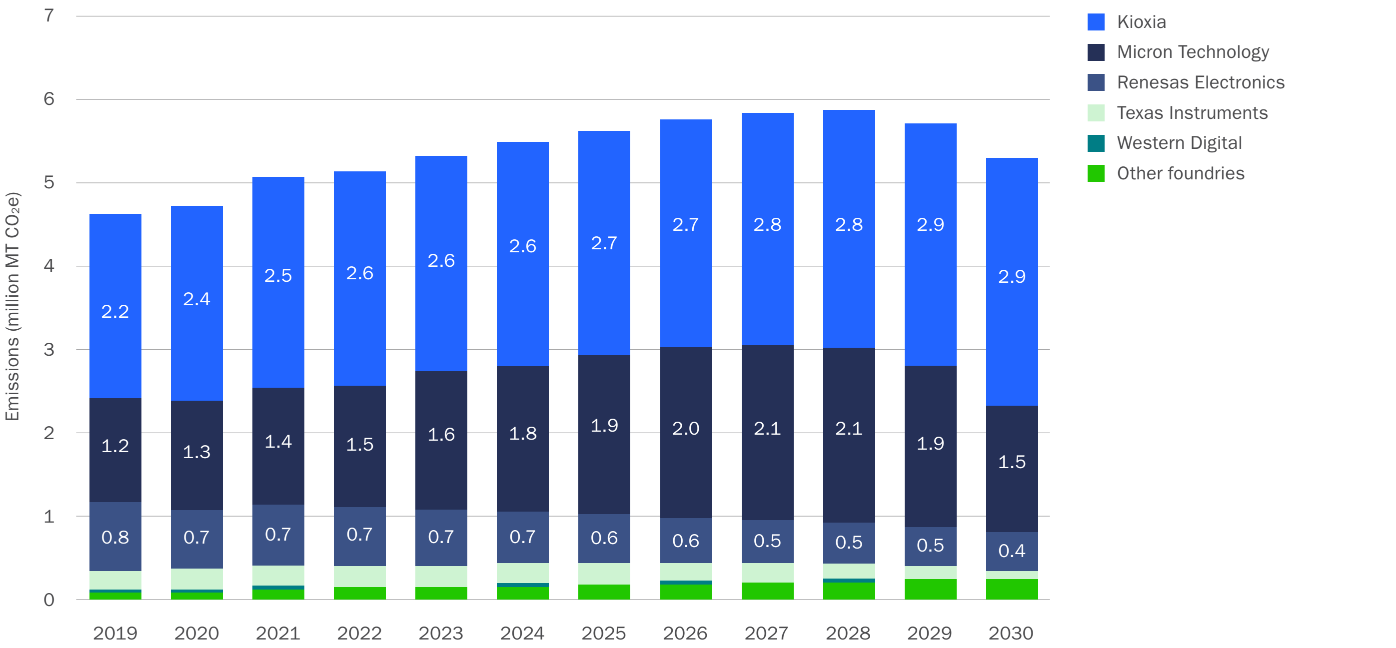
Figure 12. Historical (2019-2021) data from Japan’s semiconductor manufacturing sector’s GHG emissions and its projections (2022-2030).



Source: Authors’ analysis.

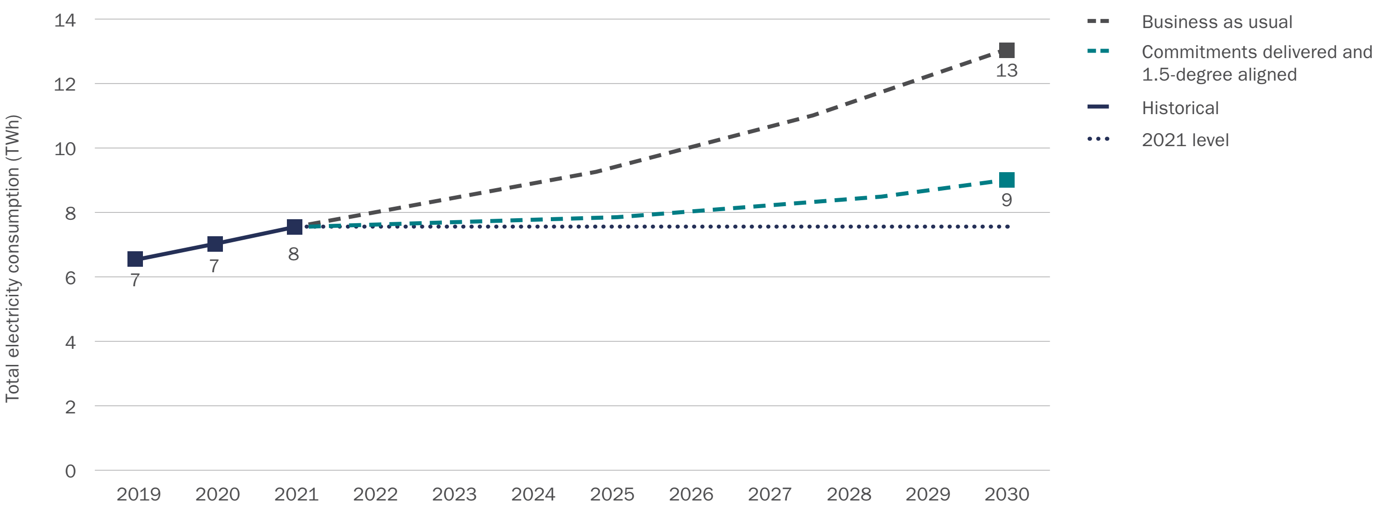
32 International Energy Agency (2017). Act on the rational use of energy (Energy Efficiency Act). Retrieved March 22, 2023, from https://www.iea.org/policies/573-act-on-the-rational-use-of-energy-energy-efficiency-act

Figure 13. Historical (2019-2021) data from Japan's semiconductor manufacturing sector's GHG emissions by company and its projections (2022-2030) under a "commitments delivered" scenario.



Source: Authors' analysis.

Figure 14. Historical (2019-2021) data from Japan's semiconductor manufacturing sector's electricity consumption and its projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.[33]

33 Data scope: companies' manufacturing sites in Japan

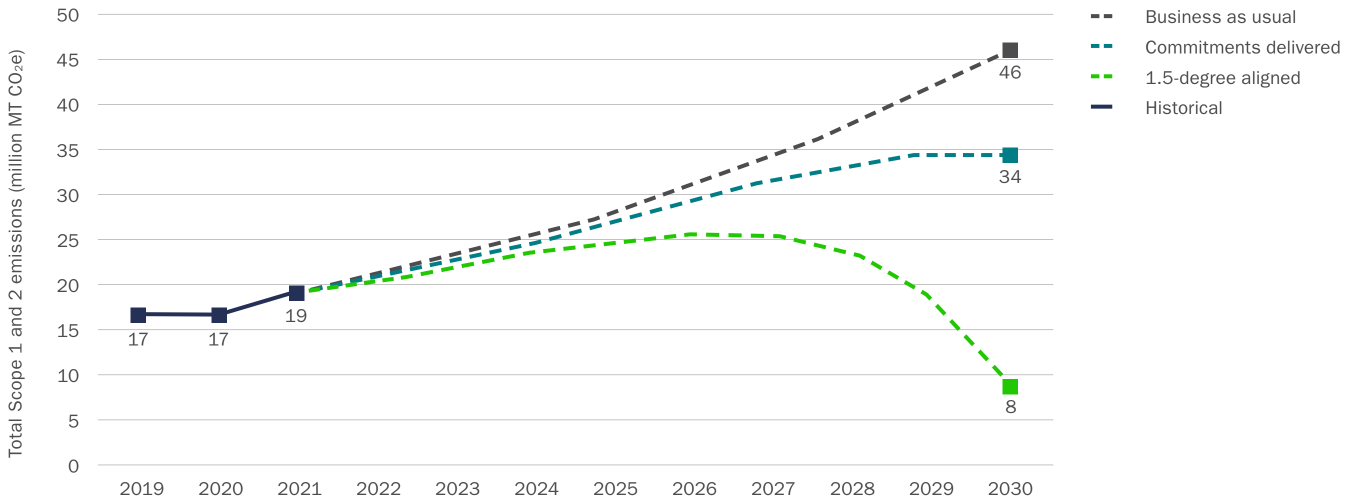
South Korea

Under the “commitments delivered” scenario, total emissions from major semiconductor manufacturers in South Korea would peak in 2029 at 35 million metric tons of CO_2e, as shown in Figure 15, but would likely then plateau and potentially even continue to rise afterwards.

The majority of the reduction comes from SK Hynix’s commitment, despite its relatively smaller market share than Samsung. Samsung Electronics’ emissions continue to grow, both in terms of absolute amount and percentage share of total emissions, as shown in Figure 16. If Samsung Electronics’ domestic manufacturing continues to grow as estimated by industry analysts and the company does not make serious emissions cuts to respond to climate change, then South Korea’s semiconductor manufacturing sector could continue to increase each year’s total scope 1 and scope 2 emissions.

Electricity consumption is projected to reach 109 TWh by 2030, a 164% increase from 2021 levels, as shown in Figure 17.

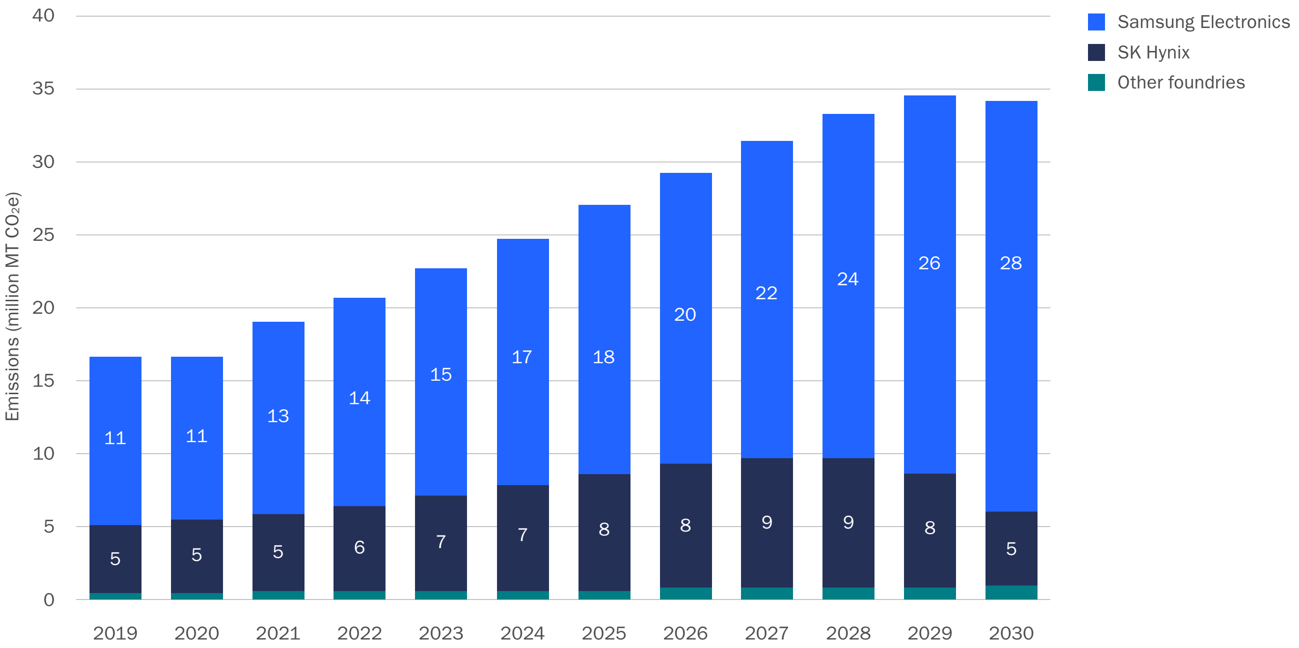
Figure 15. Historical (2019-2021) data from Korea’s semiconductor manufacturing sector’s GHG emissions and its projections, shown in dashed lines (2022-2030).



Source: Authors’ analysis.

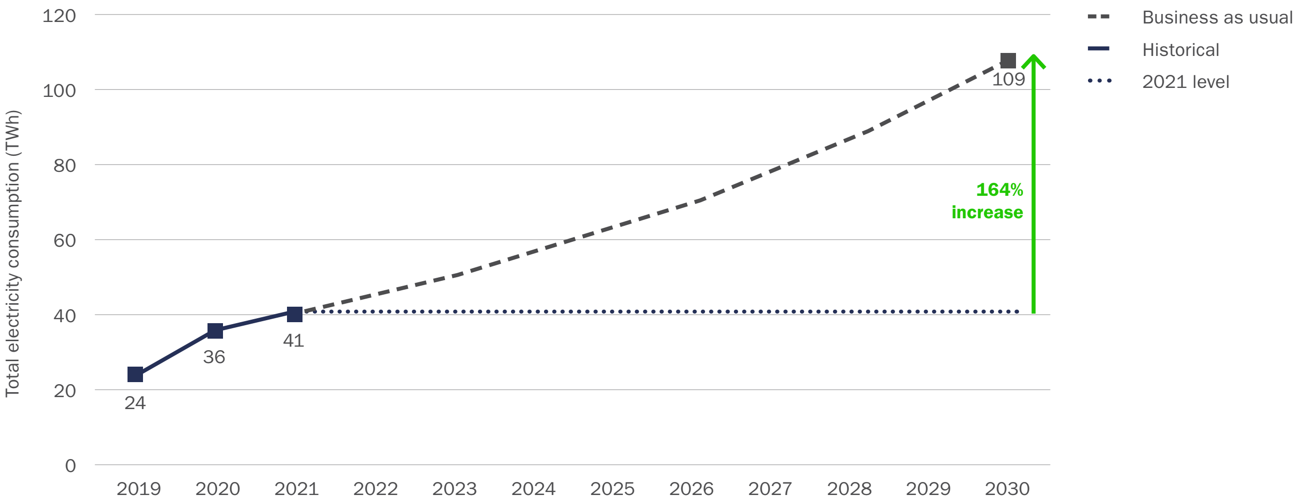
33 Data scope: companies’ manufacturing sites in Japan

Figure 16. Historical (2019-2021) data from Korea's semiconductor manufacturing sector's GHG emissions by company and its projections (2022-2030) under "commitments delivered" scenario.



Source: Authors' analysis.

Figure 17. Historical (2019-2021) data from Korea's semiconductor manufacturing sector's electricity consumption and its projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.[34]

34 Data scope: companies' manufacturing sites in South Korea.

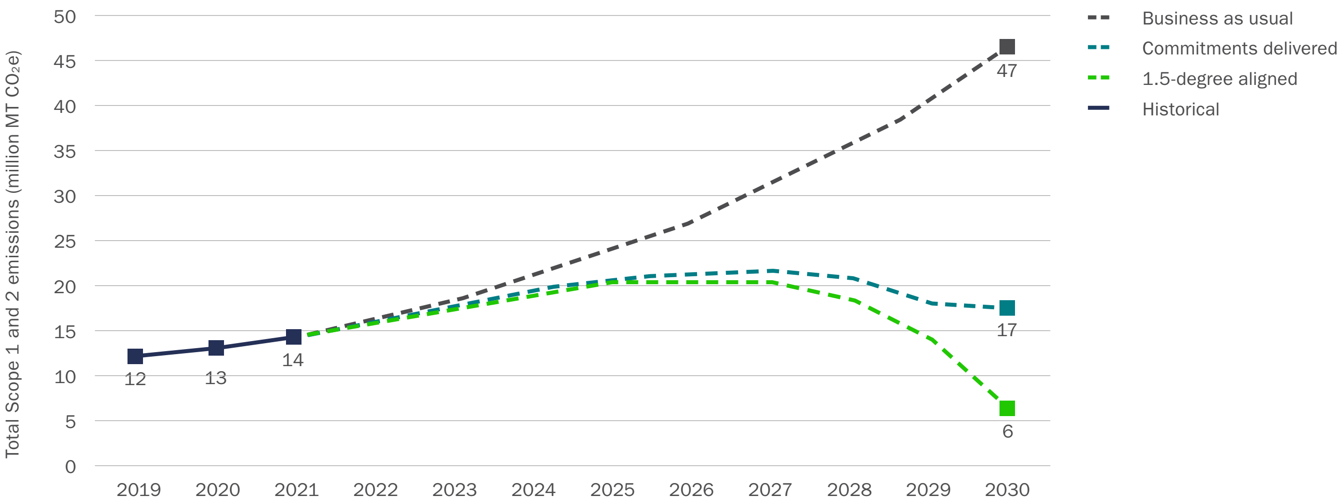
Taiwan

Under the “commitments delivered” scenario, Taiwan’s semiconductor manufacturing industry is likely to reach peak carbon emissions by 2027 at around 22 million metric tons of CO_2e, shown in Figure 18.

TSMC’s dominant market position and existing emissions reduction commitments make it a key contributor, as shown in Figure 19. Other key companies, including Micron and UMC, expect to moderately increase total carbon emissions. Micron has no scope 2 target outside of its United States operations. UMC doesn’t have a scope 2 target.

Taiwan’s semiconductor manufacturing industry is projected to consume 74 TWh of electricity in 2030, as shown in Figure 20, higher than the electricity consumption of New Zealand in 2021 and a 236% increase compared to the company’s electricity consumption in 2021.[35]

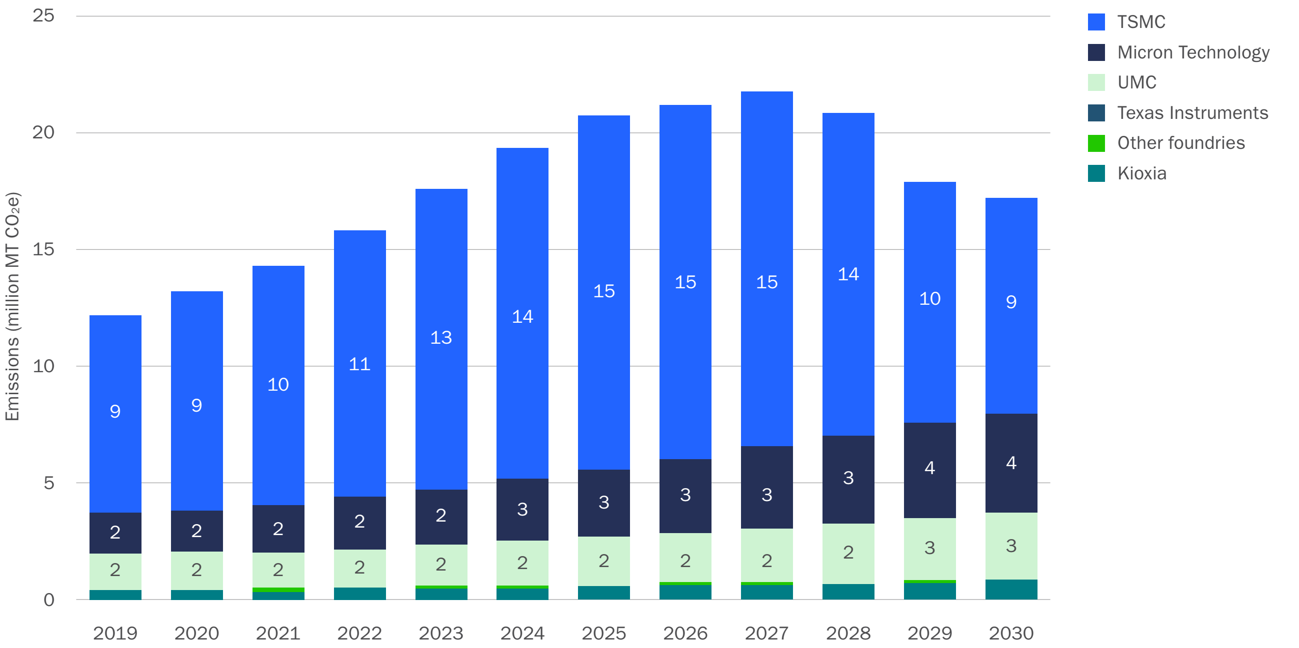
Figure 18. Historical (2019-2021) data from Taiwan’s semiconductor manufacturing sector’s GHG emissions and its projections, shown in dashed lines (2022-2030).



Source: Authors’ analysis.

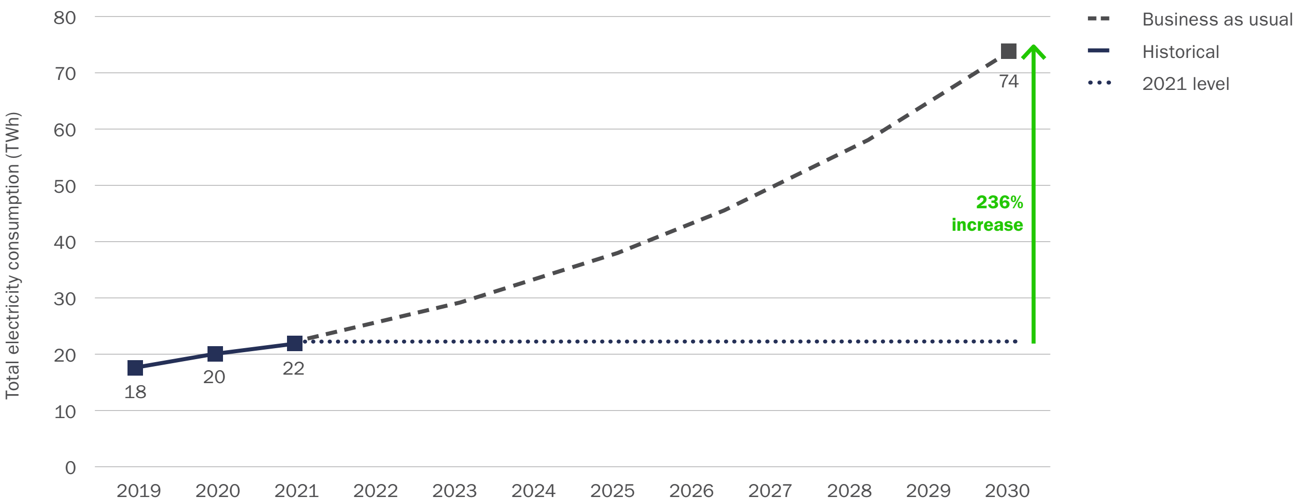
35 International Energy Agency (2023). New Zealand data explorer. Retrieved March 22, 2023, from https://www.iea.org/countries/new-zealand

Figure 19. Historical (2019-2021) data from Taiwan's semiconductor manufacturing sector's GHG emissions by company and its projections (2022-2030) under "commitments delivered" scenario.



Source: Authors' analysis.

Figure 20. Historical (2019-2021) data from Taiwan's semiconductor manufacturing sector's electricity consumption and its projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.[36]

36 Data scope: companies' manufacturing sites in Taiwan.

Impact of companies with high emissions

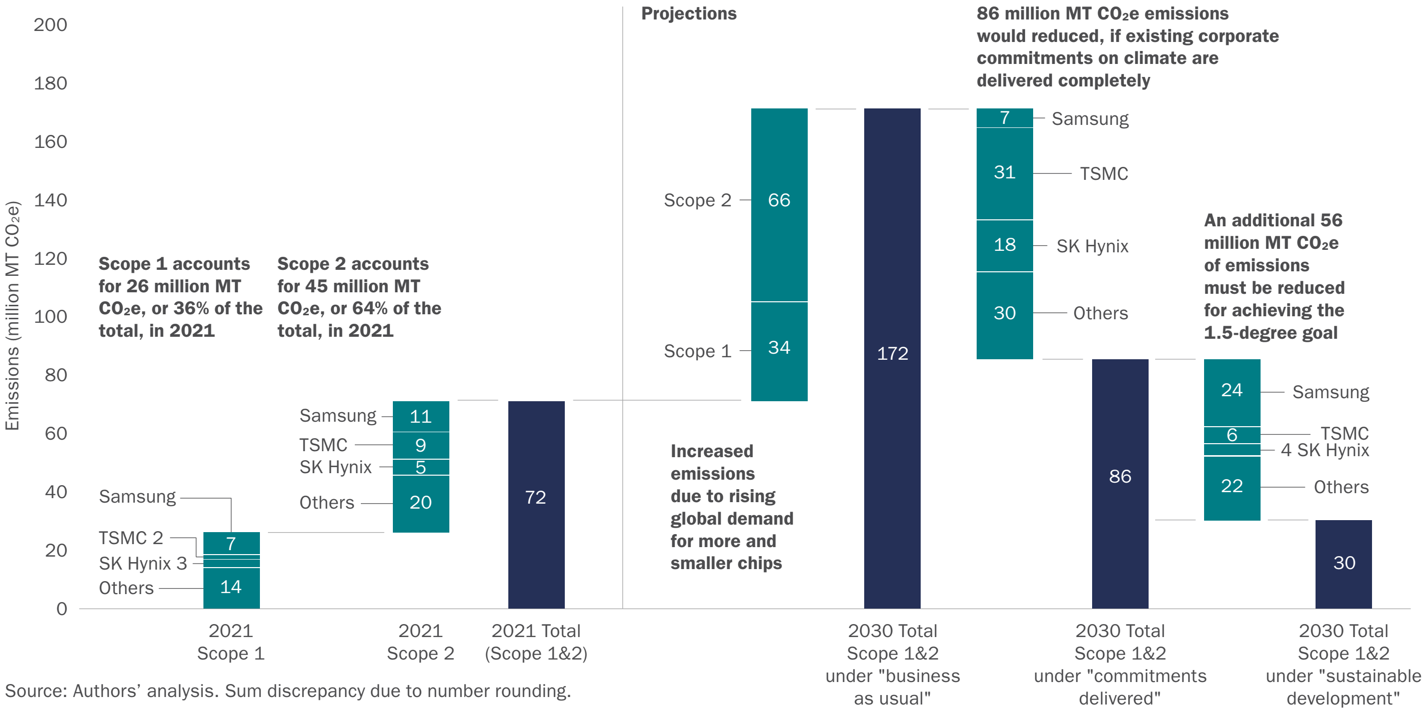
In 2021 scope 2 emissions were 45 million metric tons of CO_2e, accounting for 64% of total emissions by the sector. The remaining 26 million metric tons of CO_2e, or 36%, of total emissions were scope 1. By 2030, under the "business as usual" scenario, total scope 1 and scope 2 emissions of the industry will increase by 34 million metric tons of CO_2e and 66 million metric tons of CO_2e in 2030, respectively.

In 2021 Samsung Electronics, TSMC, and SK Hynix collectively emitted 52% of all emissions from the companies included for this research, with 25 million metric tons in scope 2 and 12 million metric tons of CO_2e of scope 1, equivalent to the emissions produced by nearly 10 coal-fired power plants.[37]

While overall emissions would be reduced to 86 million metric tons of CO_2e in 2030 under a "commitments delivered" scenario, Samsung Electronics only needs to reduce less than 7 million metric tons of CO_2 from its "business as usual" scenario. This is disproportionately smaller than TSMC and SK Hynix as well as others.

According to the IPCC and SBTi, to achieve the 1.5 degree Celsius goal, companies need to halve their emissions by 2030 compared with a 2019 baseline, which means an additional 56 million metric tons of CO_2e must be reduced. TSMC, Samsung Electronics and SK Hynix must reduce another 34 million metric tons of CO_2 on top of their current commitments to meet the 1.5 degrees target.

Figure 21. Emissions pathways of the global semiconductor manufacturing sector from 2021 to 2030.

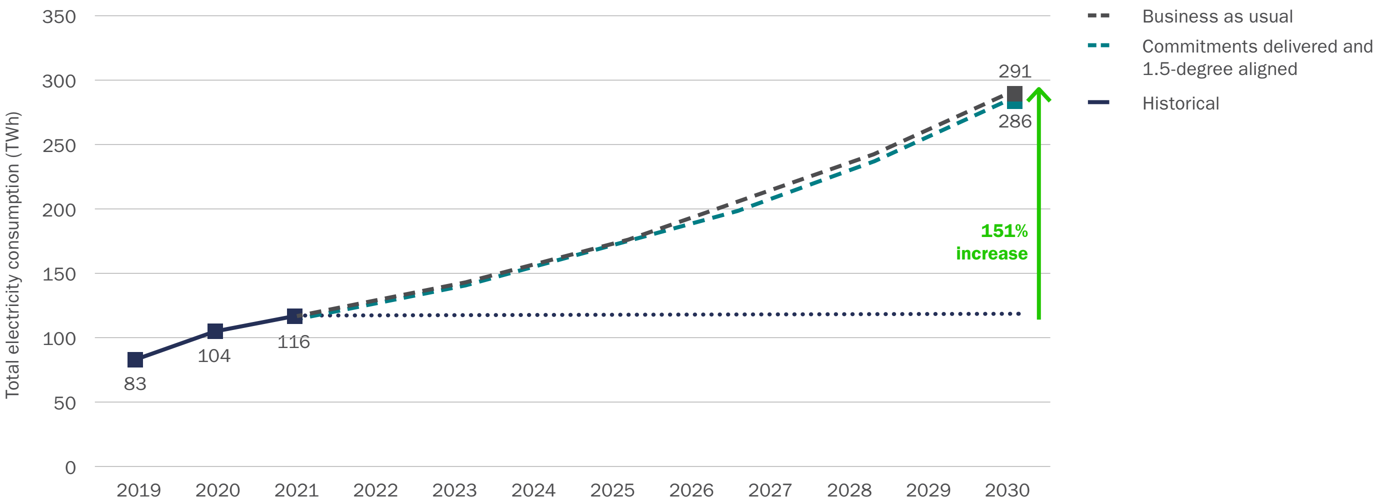


Source: Authors' analysis. Sum discrepancy due to number rounding.

37 Environmental Protection Agency (2022). Greenhouse Gas Equivalencies Calculator. Retrieved March 22, 2023, from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator#results

The increase in electricity consumption over the decade as demand for chip production and as smaller node technology comes into production over time is shown in Figure 22. Electricity consumption is likely to reach 286 terawatt hours (TWh) by 2030 under the “commitments delivered” and “consistent with 1.5 degrees Celsius” scenarios. Under a business as usual scenario, 2030 electricity consumption would be 291 TWh, a 151% increase.

Figure 22. Historical (2019-2021) global semiconductor manufacturing sector electricity consumption and its projections, shown in dashed lines (2022-2030).



Source: Authors’ analysis.

Renewable energy is essential for the semiconductor sector to reduce emissions. About 50% of industry emissions can be reduced by adopting renewables.[38] To meet the 1.5 degree requirement by 2030 – cutting emissions by 50% including all 3 scopes – companies must adopt 100% renewable energy by 2030.

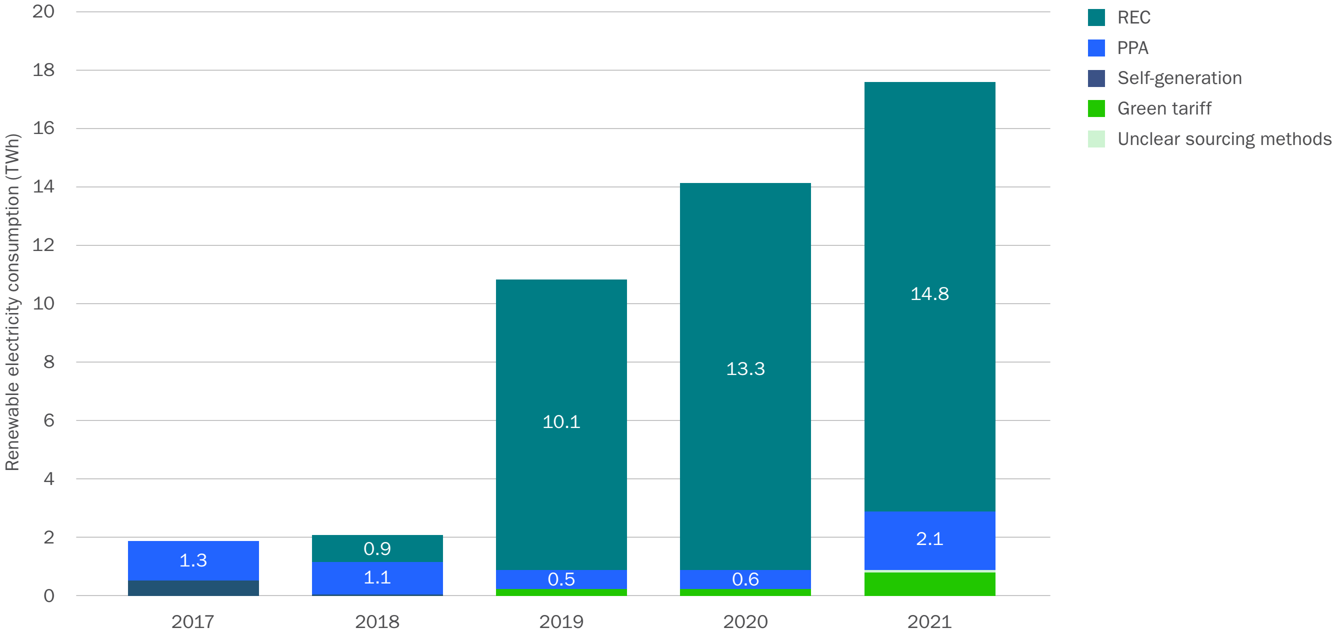
To achieve 100% renewable energy, companies’ sourcing methods are essential. High impact sourcing methods, such as onsite generation, renewable energy power station investment and PPAs can add additional renewables to the grid to contribute to the overall development of renewable energy. On the other hand, RECs are credits that can be purchased to offset electricity emissions from fossil fuels. Offsetting matters because, in most cases, RECs add no additional renewable energy production and due to the double counting, the effectiveness of emissions reduction through RECs is often not as clear as other sourcing methods.[39]

38 McKinsey Company (2022). Sustainability in semiconductor operations: Toward net-zero production. Retrieved March 22, 2023, from https://www.mckinsey.com/industries/semiconductors/our-insights/sustainability-in-semiconductor-operations-toward-net-zero-production

39 Anders Bjørn, Shannon M. Lloyd, Matthew Brander & H. Damon Matthews (2022). Renewable energy certificates threaten the integrity of corporate science-based targets. Nature Climate Change, 12, 539–546. https://www.nature.com/articles/s41558-022-01379-5

Historical data on how the 12 companies included in this research pursued renewable energy sourcing from 2017 to 2021 is shown in Figure 23. RECs accounted for 84% of all renewable energy sourced by the semiconductor manufacturing industry in 2021, with PPAs as a distant second largest contributor. Due to the high risk of double counting and low additionality, companies' scope 2 trajectory will no longer be aligned with the 1.5 degree target and will only achieve the 2 degree goal of the Paris agreement.[40]

Figure 23. The global semiconductor manufacturing sector's renewable energy sourcing amount by method.



Source: aggregations of CDP disclosure data of 12 companies, including Analog Devices, GlobalFoundries, Intel, Kioxia, Micron Technology, Samsung Electronics, SK Hynix, STMicroelectronics, Texas Instruments, TSMC, UMC, and Western Digital.

40 Anders Bjørn, Shannon M. Lloyd, Matthew Brander & H. Damon Matthews (2022). Renewable energy certificates threaten the integrity of corporate science-based targets. Nature Climate Change, 12, 539–546. https://www.nature.com/articles/s41558-022-01379-5

Decarbonisation status of the electronics supply chain by company

TSMC

TSMC has committed to peak its emissions by 2025 and to take 2030 emissions levels back to the 2020 level through purchasing renewable energy certificates (RECs) and increasing their gas abatement scale, among other solutions. This commitment is a mid-term goal of its ultimate 2050 carbon neutrality target.

To deliver the 2030 commitment, TSMC will need to reduce at least 32 million metric tons of CO_2e.

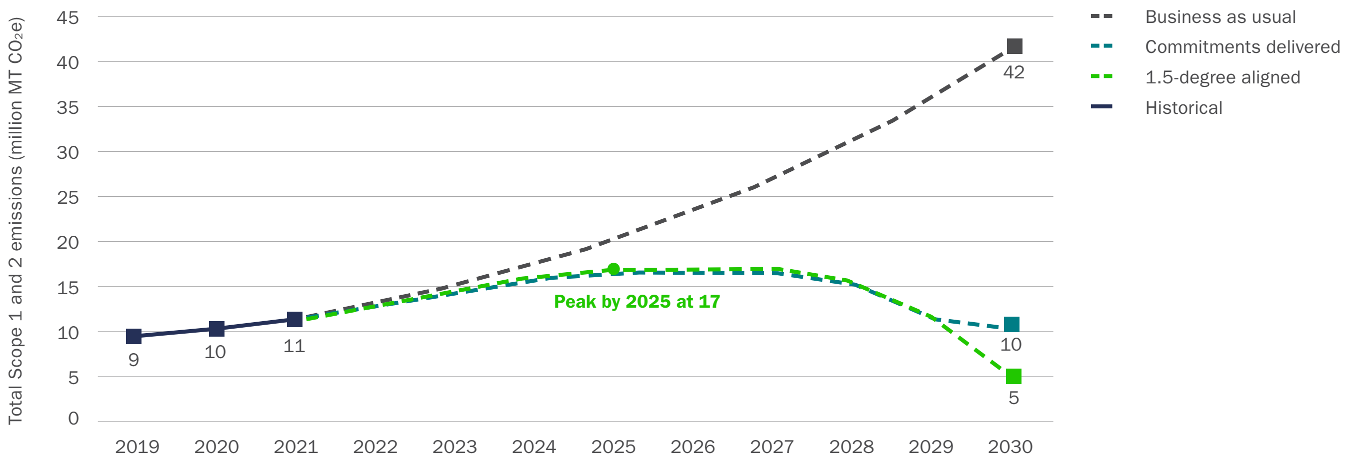
To fit the “consistent with a 1.5 degrees Celsius” scenario, TSMC needs to reduce another 5 million metric tons of CO_2e by 2030 – totaling a reduction of 37 million metric tons of CO_2e by the end of the decade.

TSMC’s emissions rose steadily from 2019 to 2021 from 9 million metric tons of CO_2e to 11 million metric tons CO_2e, as shown in Figure 24.

In a business as usual scenario, TSMC’s emissions would reach 42 million metric tons of CO_2e – with 32 million metric tons of CO_2e in scope 2 and 8 million metric tons of CO_2e in scope 1, as shown in Figure 25.

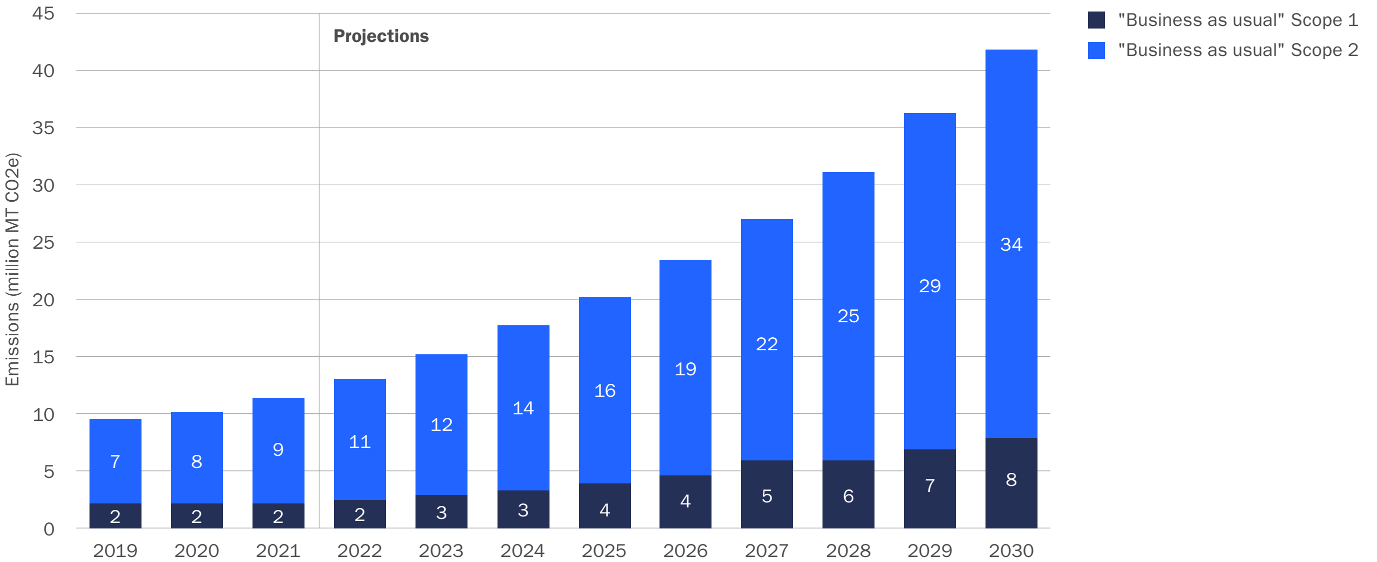
Electricity demand is projected to grow 267% by 2030, from 18 TWh in 2021 to 66 TWh in 2030, as illustrated in Figure 26. In 2021, TSMC sourced over 1 TWh of RECs, as shown in Figure 27, which accounts for around 58% of its total renewable energy use. The rest comes from PPAs.

Figure 24. Historical (2019-2021) TSMC GHG emissions and its projections, shown in dashed lines (2022-2030).



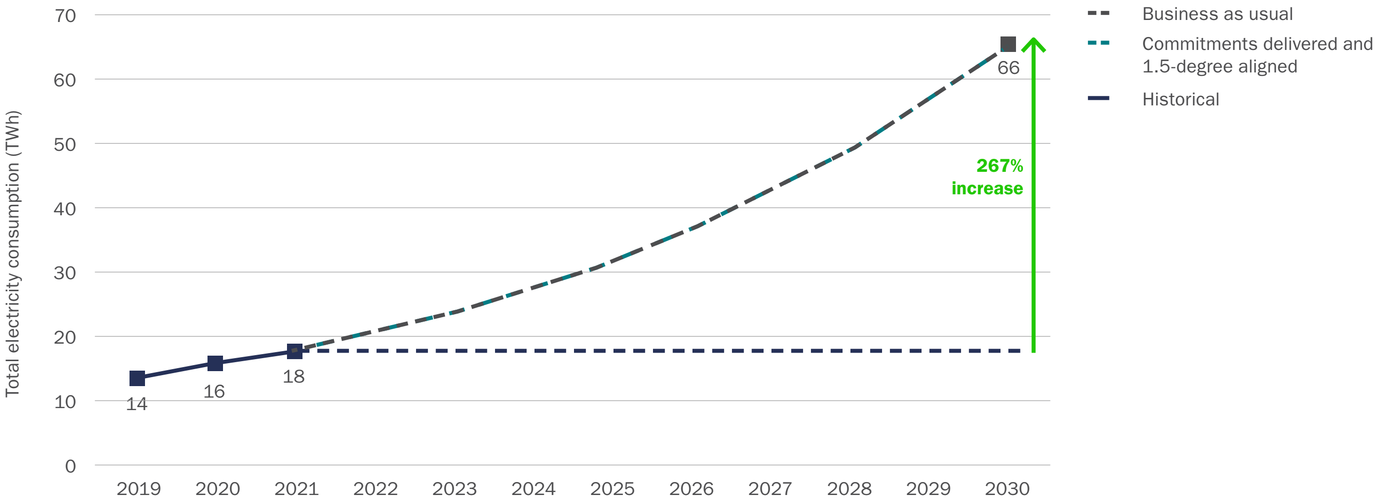
Source: Authors’ analysis.

Figure 25. Historical (2019-2021) TSMC and its business as usual projected (2022-2030) emissions by scope.



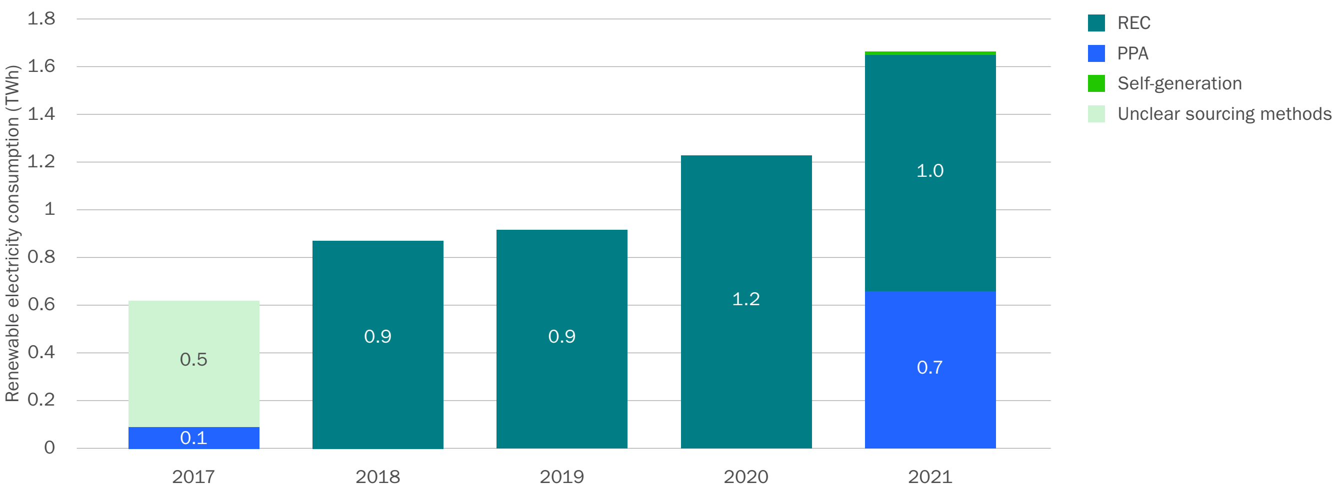
Source: Authors' analysis.

Figure 26. Historical (2019-2021) TSMC electricity consumption and its projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.

Figure 27. 2017-2021 TSMC renewable energy sourcing amount by method.



Source: Authors' analysis.

Samsung Electronics

Samsung has pledged to achieve net zero emissions by 2050, and has committed to 100% renewable energy for all facilities outside South Korea by 2027 and for all facilities inside South Korea by 2050. Samsung in particular lacks mid- or near-term targets for facilities inside of South Korea.

Samsung has targeted 100% renewable energy for its facilities outside of South Korea by 2027, meaning that those facilities would have zero scope 2 emissions by 2027. Samsung's emissions rose steadily from 2019 to 2021, from 16 million metric tons of CO_2e in 2019 to 18 million metric tons of CO_2e in 2021.

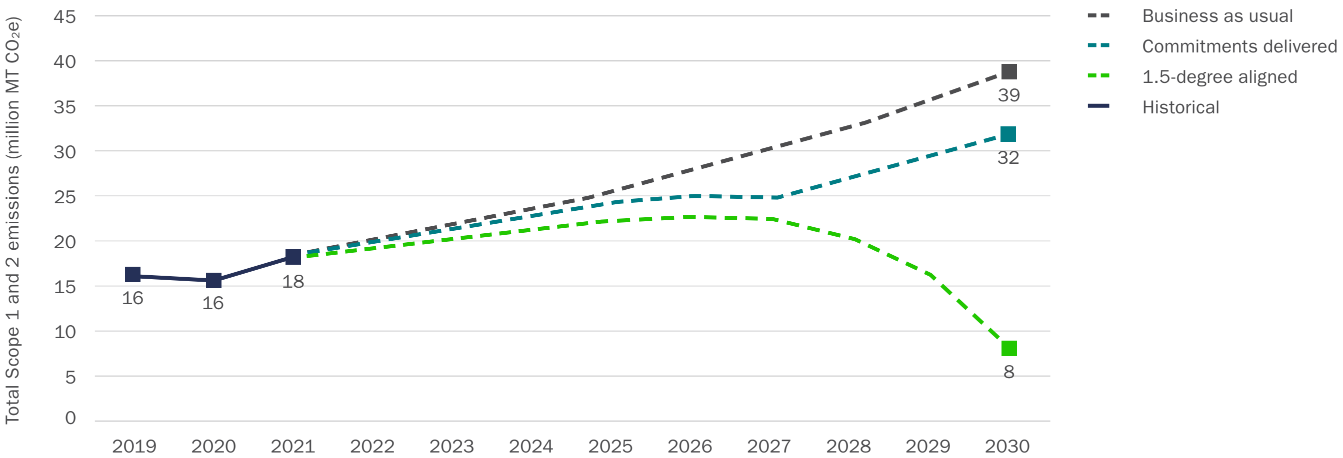
Under a "business as usual" scenario, Samsung's emissions would reach 39 million metric tons of CO_2e, including 23 million metric tons in scope 2 and 16 million metric tons CO_2e in scope 1, as illustrated in Figure 29.

Under a "commitments delivered" scenario, Samsung's emissions curve flattens before 2027, as shown in Figure 28, due to emissions reductions in facilities outside of South Korea. After 2027, the curve climbs upward again as domestic facilities drive significant increases in overall emissions.

Under the current "commitments delivered" scenario, Samsung's emissions are not likely to peak before 2030.

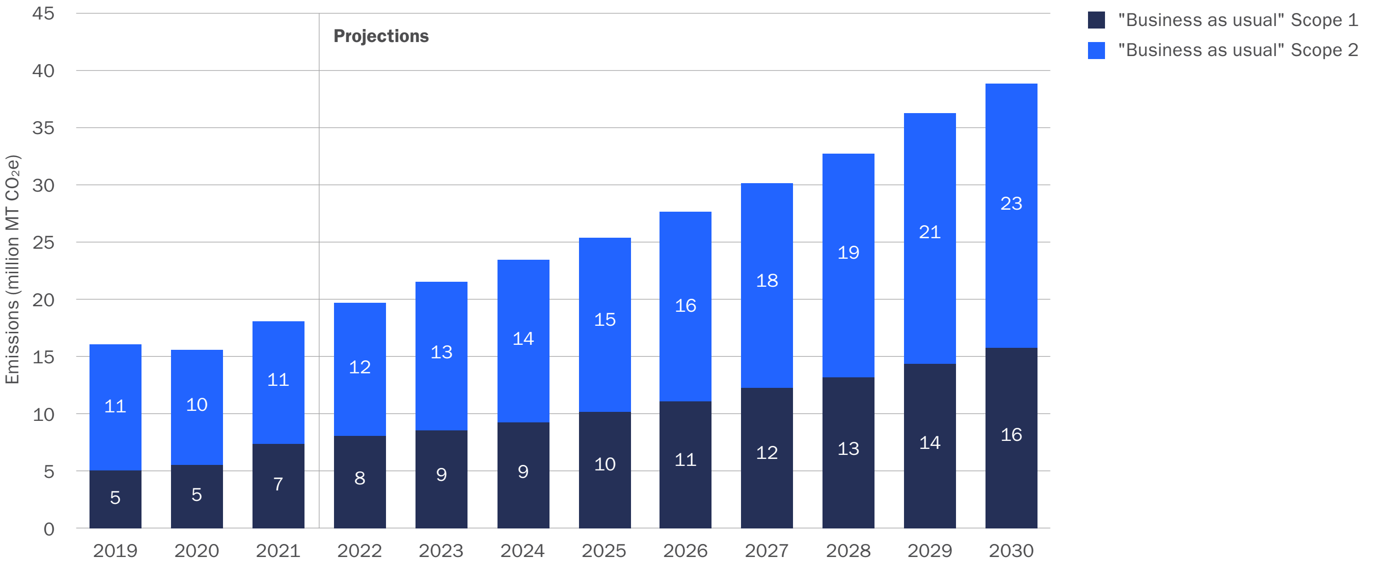
Electricity consumption is projected to grow more than 112%, from 26 TWh in 2021 to 55 TWh in 2030, as shown in Figure 30. RECs accounted for almost 90% of all of Samsung's renewable energy sourcing in 2021, as shown in Figure 31. PPAs and self-generation together accounted for 2%.

Figure 28. Historical (2019-2021) Samsung Electronics GHG emissions and projections, shown in dashed lines (2022-2030).



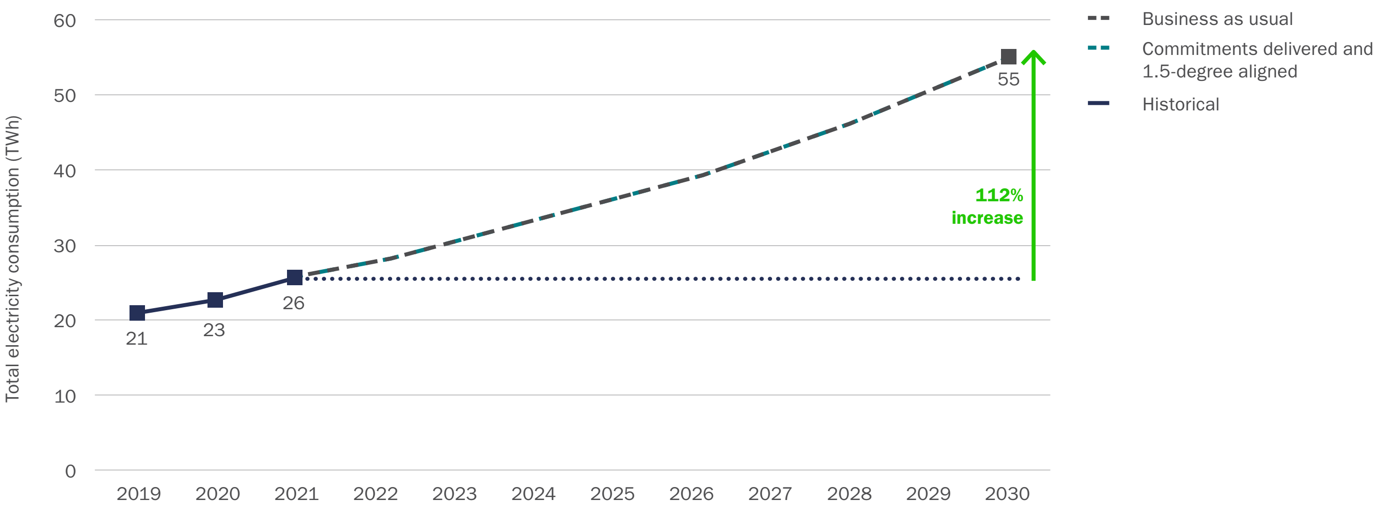
Note: Only the semiconductor division (DS) of Samsung Electronics are included in our modeling for Samsung. The other division, DX, was taken out, using emissions breakdowns provided by Samsung for its business divisions.
Source: Authors' analysis.

Figure 29. Historical (2019-2021) data from Samsung Electronics and its "business as usual" projected (2022-2030) emissions by scope.



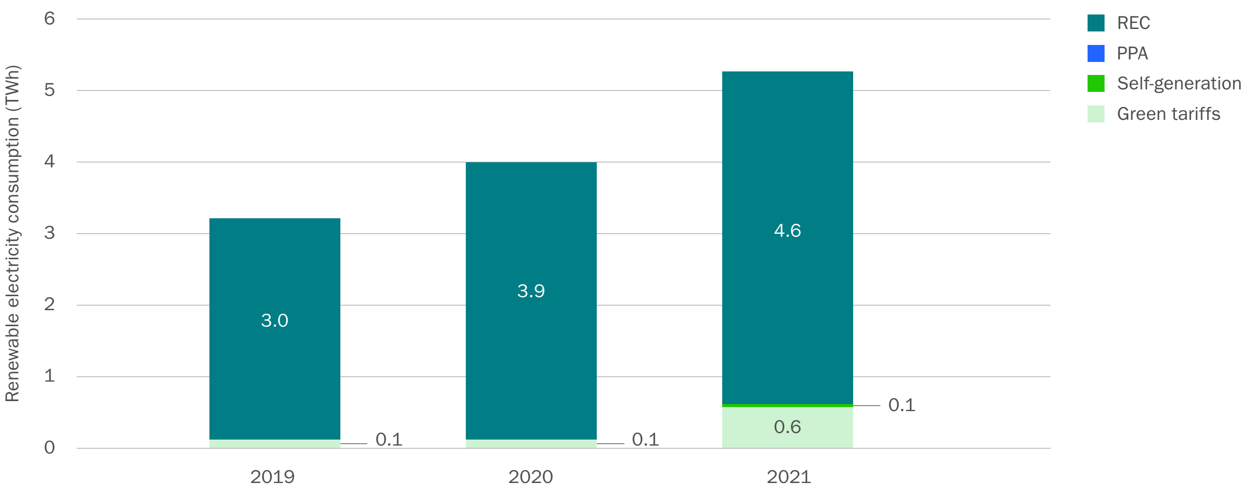
Source: Authors' analysis.

Figure 30. Historical (2019-2021) data from Samsung Electronics showing electricity consumption and projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.

Figure 31. Samsung Electronics renewable energy sourcing amount by method.



Source: Authors' analysis.

SK Hynix

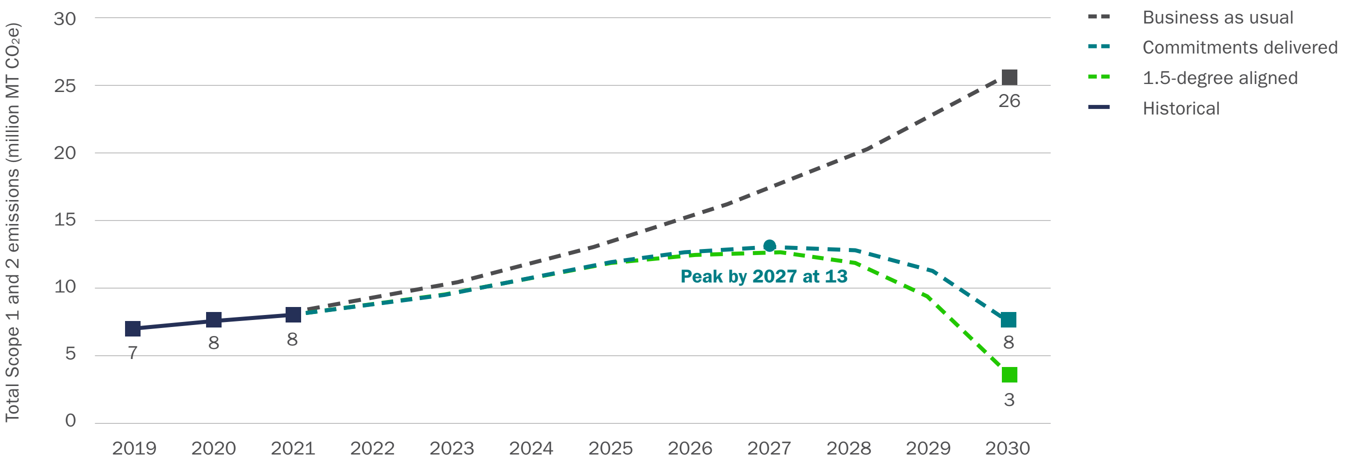
SK Hynix has committed to return 2030 emissions to the 2020 level as a mid-term goal in its 2050 net zero pledge.

SK Hynix's emissions rose steadily from 7 million metric tons of CO_2e in 2019 to 8 million metric tons in 2021. Under a "business as usual" scenario, SK Hynix's emissions would reach 26 million metric tons of CO_2e in 2030, with 17 million metric tons of CO_2e in scope 2 and 8 million metric tons of CO_2e in scope 1, as shown in Figure 33.

SK Hynix's emissions are likely to peak in 2027 under a "commitments delivered" scenario, at 13 million metric tons of CO_2e, as shown in Figure 32. There are no specific commitments for scope 2 or scope 1 emissions reductions from SK Hynix, so this emissions peak contour assumes that they would both be reduced to their individual 2020 levels.

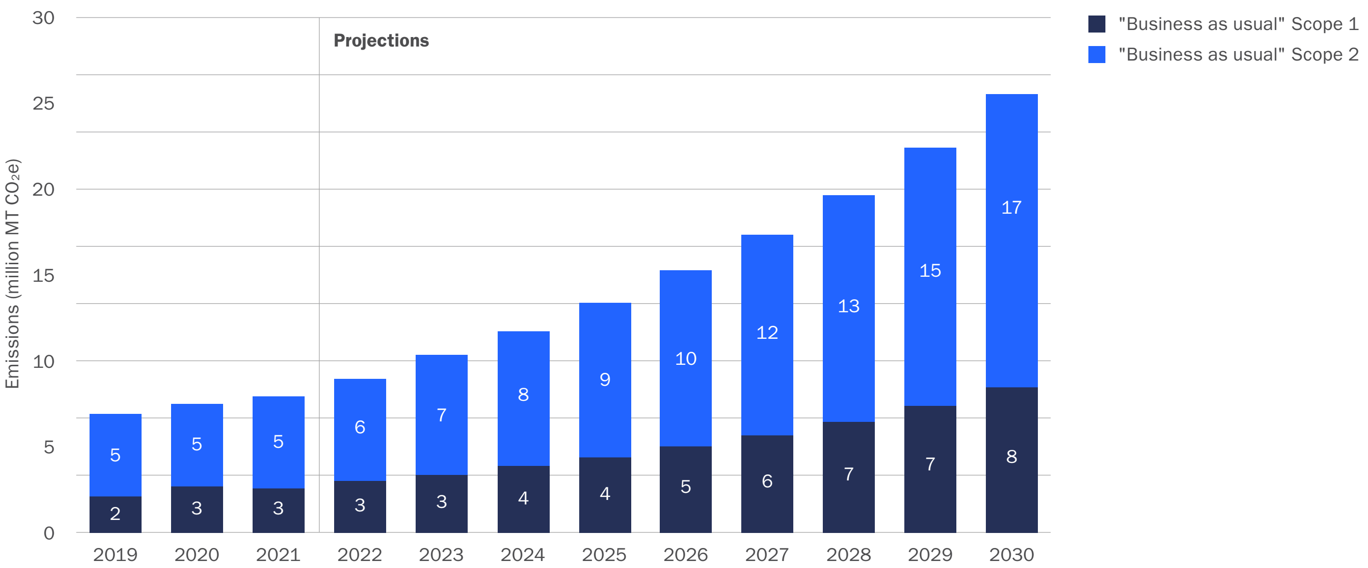
Electricity consumption is projected to increase by 215% by 2030, from 27 TWh in 2021 to 85 TWh in 2030, as shown in Figure 34. About 50% of SK Hynix's renewable energy came from PPAs in 2021, as shown in Figure 35, and the other half came from paying green tariffs.

Figure 32. Historical (2019-2021) data from SK Hynix showing GHG emissions and projections, shown in dashed lines (2022-2030).



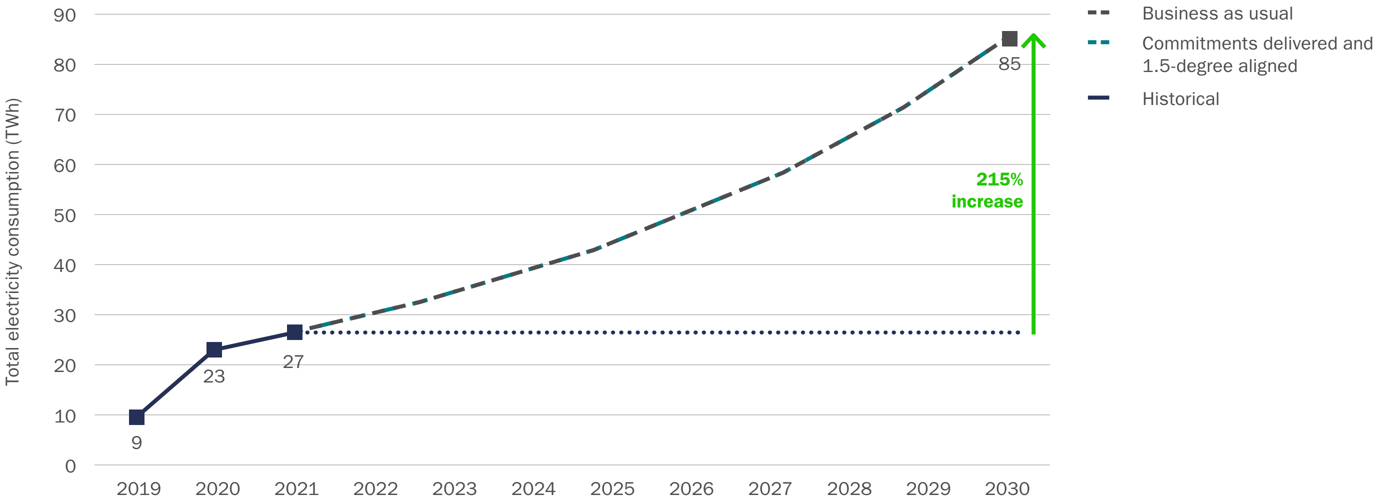
Source: Authors' analysis.

Figure 33. Historical (2019-2021) data from SK Hynix showing "business as usual" and projected (2022-2030) emissions by scope.



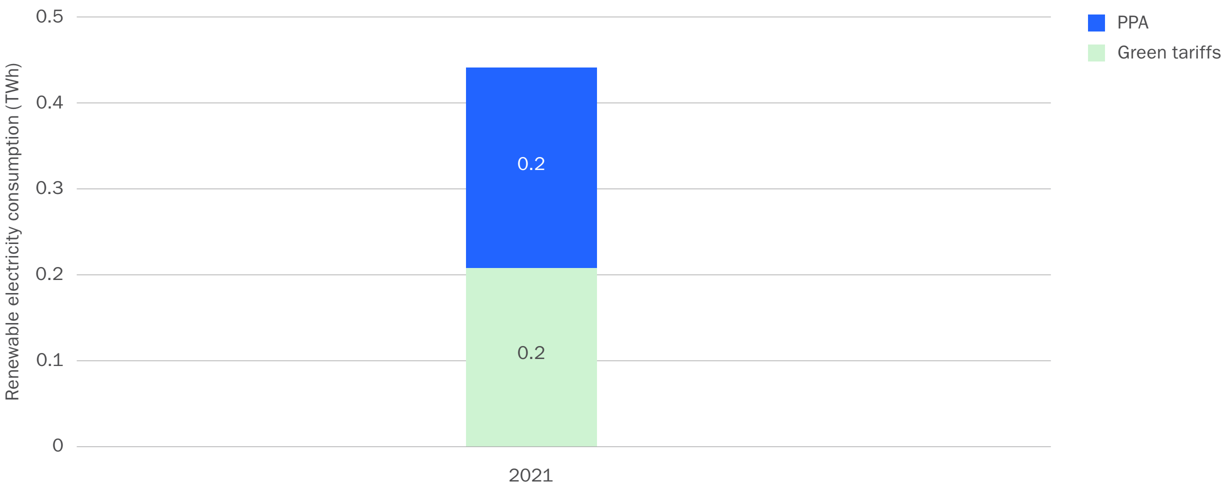
Source: Authors' analysis.

Figure 34. Historical (2019-2021) data from SK Hynix showing electricity consumption and projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.

Figure 35. 2017-2021 SK Hynix renewable energy sourcing amount by method.



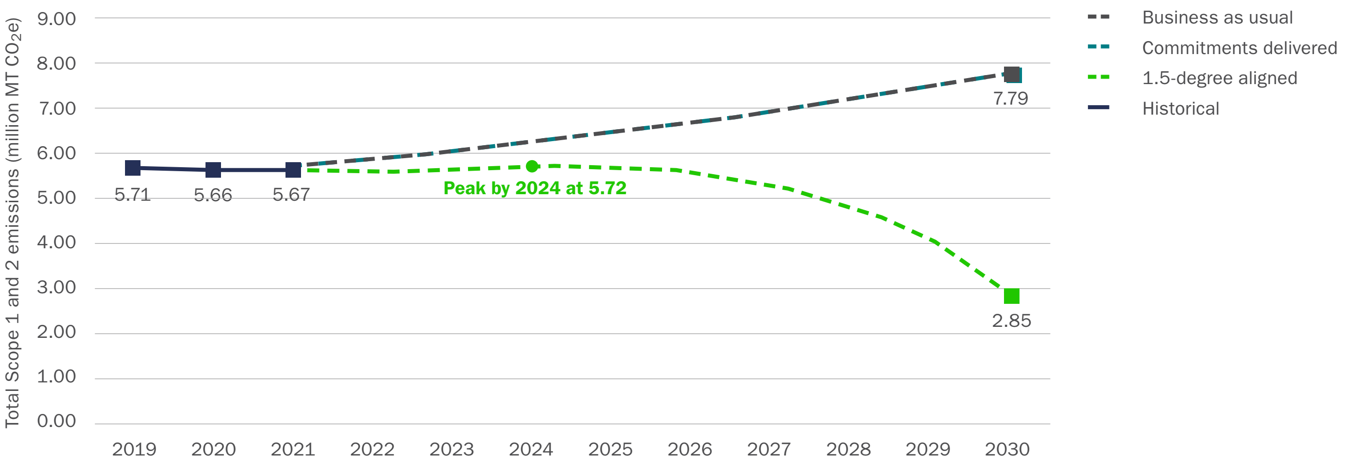
Source: Authors' analysis.

Samsung Display

Samsung Display has announced its carbon neutrality goal for 2050, but has made no clear short- or medium-term targets or emissions reduction pathways. Samsung Display's emissions decreased from 5.71 million metric tons CO_2e in 2019 to 5.67 million metric tons in 2021, as shown in Figure 36, due to its emissions reduction efforts including treatment of process gas and use of renewable energy. As illustrated in Figure 37, Samsung's scope 1 emissions rose from 1.1 million metric tons CO_2e in 2019 to 1.4 million metric tons CO_2e in 2021, while its scope 2 reduced from 4.6 million metric tons CO_2e to 4.3 million metric tons CO_2e over the same period. The decrease in scope 2 emissions was likely the result of reduced electricity consumption (Figure 38) paired with the use of renewable energy.

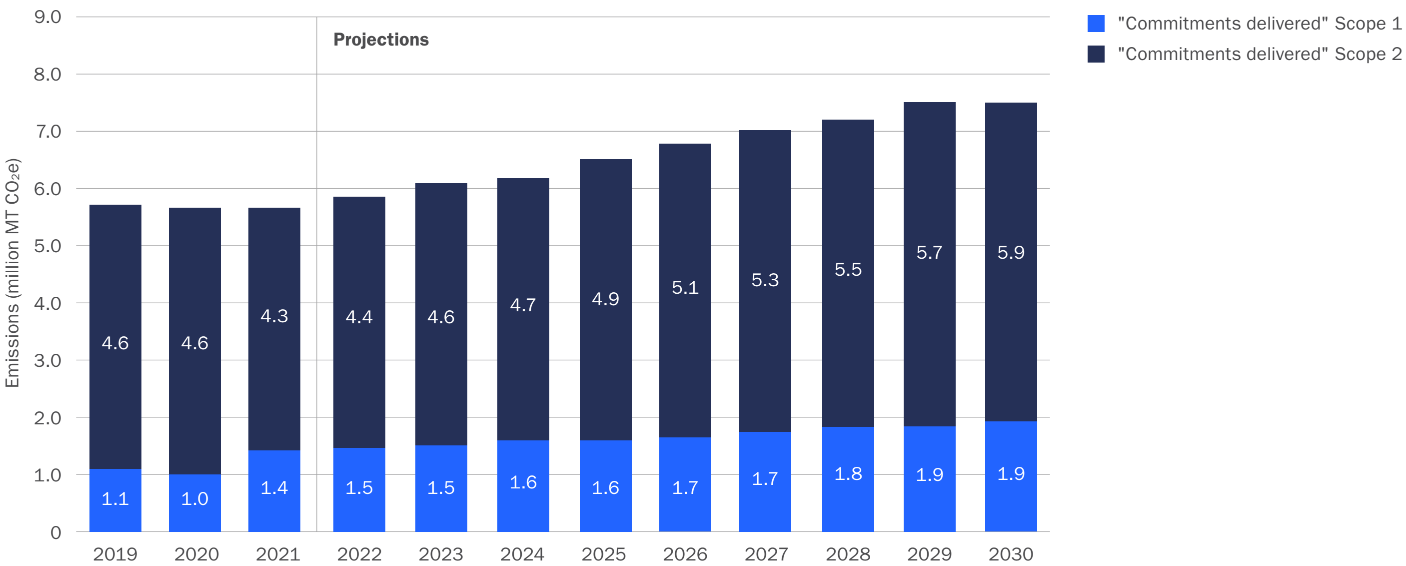
Additionally, given the lack of specific short- or medium-term targets, we weren't able to incorporate any emission reductions under the "commitments delivered" scenario. Its emissions can rise to 7.8 million metric tons CO_2e, under a business as usual scenario (Figure 36). Under the "1.5 degrees" scenario, Samsung Display could expect a peak in its emissions by 2024 at 5.7 million metric tons CO_2e, and reach 2.9 million metric tons CO_2e by 2030, half of its 2019 level. Without any further evidence/target on power consumption reduction, Samsung Display's electricity consumption is likely to increase by 37%, from 8.3 TWh in 2021 to 11.4 TWh in 2030.

Figure 36. Historical (2019-2021) data from Samsung Display showing GHG emissions and projections, shown in dashed lines (2022-2030).



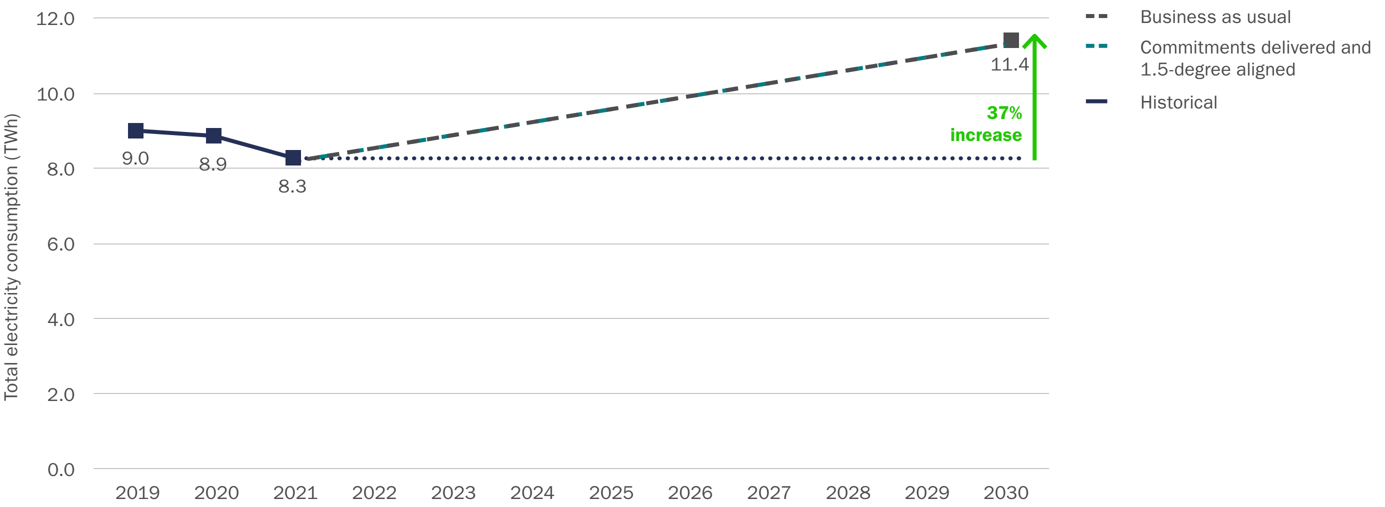
Source: Authors' analysis.

Figure 37. Historical (2019-2021) data from Samsung Display and its "commitments delivered" projected (2022-2030) emissions by scope.



Source: Authors' analysis.

Figure 38. Historical (2019-2021) data showing Samsung Display electricity consumption and its projections (2022-2030).



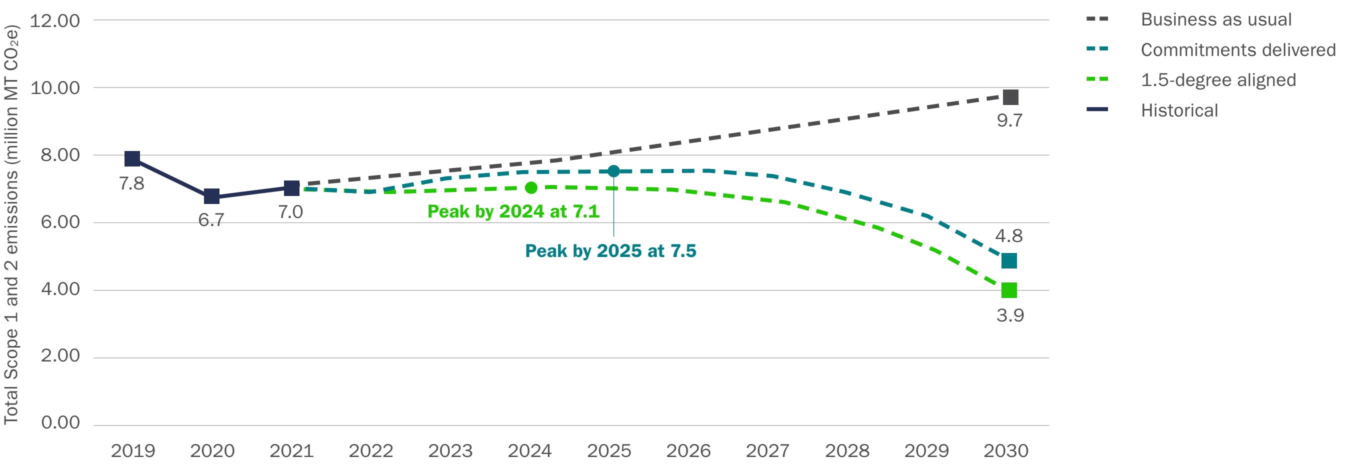
Source: Authors' analysis.

LG Display

LG Display has set emissions reduction goals of 40% by 2030 and 90% by 2050 compared to the baseline year, 2014. LG's total CO_2e emissions of scope 1 and 2 decreased from 7.8 million metric tons in 2019 to 6.7 million metric tons in 2020, but the emissions increased to 7 million metric tons in 2021, as illustrated in Figure 39. If we look at scope 1 and 2 emissions separately in Figure 40, scope 1 emissions declined, while scope 2 has a V-shaped trend that largely aligns with the electricity consumption trend (Figure 41).

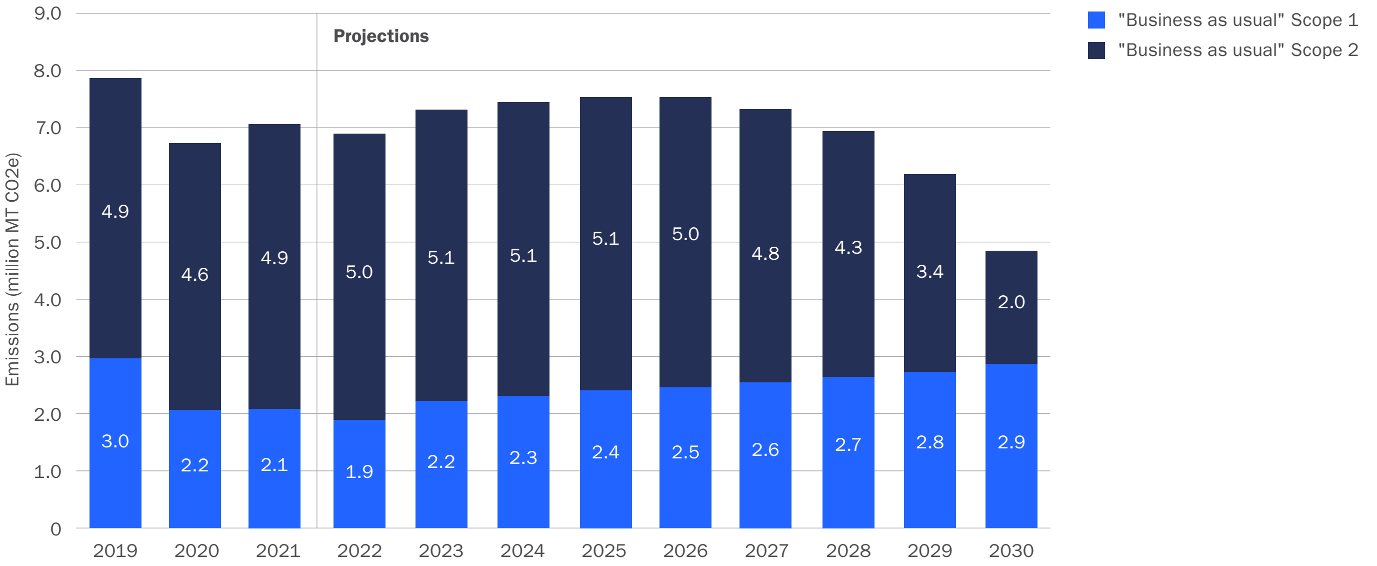
LG Display's 2030 CO_2e targets (60% of its 2014 levels) of scope 1 and 2 are 2.94 million metric tons and 1.98 million metric tons, respectively. As shown in Figure 40, LG Display achieved its scope 1 target in 2021. Under the "commitments delivered" scenario, LG Display can reduce its total emissions of scope 1 and 2 to 4.8 million metric tons CO_2e by 2030. If LG Display can reduce another 1.1 million metric tons CO_2e by 2030, its reduction efforts would align with IPCC and SBTi recommendations for achieving the 1.5 degree goal. While emissions decrease, LG Display's electricity consumption is expected to rise to 26.5 TWh by 2030 from 19.3 TWh in 2021.

Figure 39. Historical (2019-2021) data from LG Display showing GHG emissions and projections, shown in dashed lines (2022-2030).



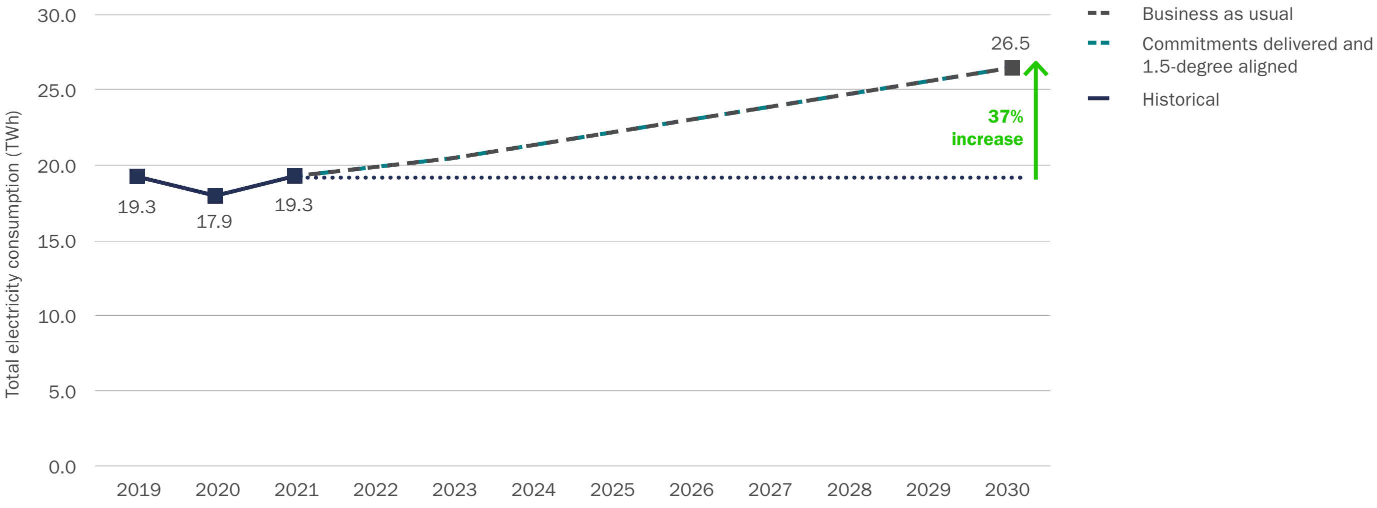
Source: Authors' analysis.

Figure 40. Historical (2019-2021) data showing LG Display "commitments delivered" and projected (2022-2030) emissions by scope.



Source: Authors' analysis.

Figure 41. Historical (2019-2021) data showing LG Display electricity consumption and its projections, shown in dashed lines (2022-2030).



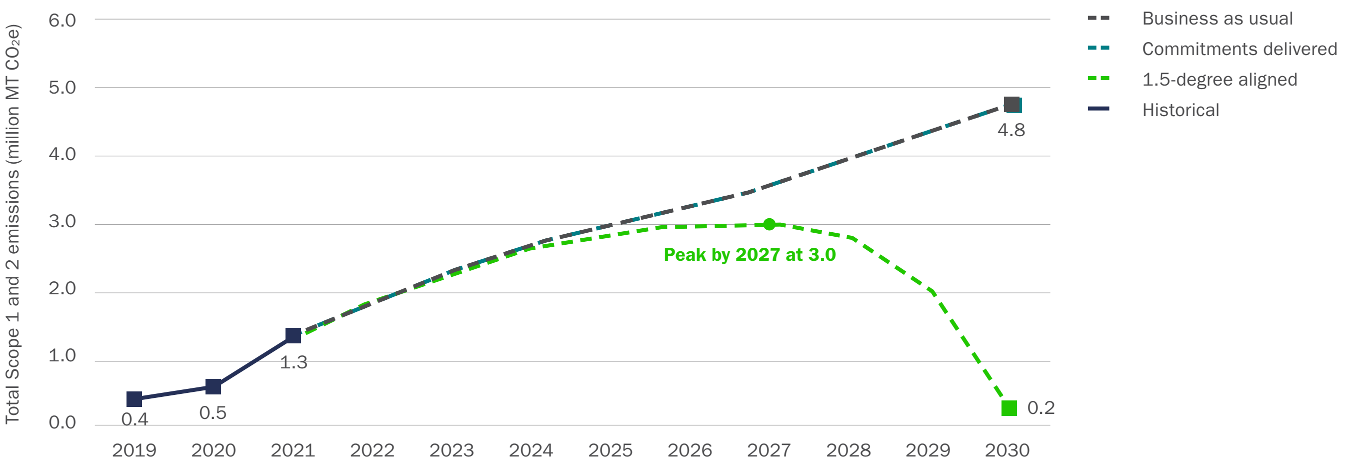
Source: Authors' analysis.

Luxshare Precision

Luxshare has announced its carbon neutrality goal by 2050, but made no clear short- or medium-term targets or pathways to reduce emissions. Luxshare's emissions rose significantly from 0.4 million metric tons CO_2e in 2019 to 1.3 million metric tons in 2021, as shown in Figure 42, driven by rapid expansion in production. As illustrated in Figure 43, Luxshare's scope 2 emissions account for almost all emissions of the company.

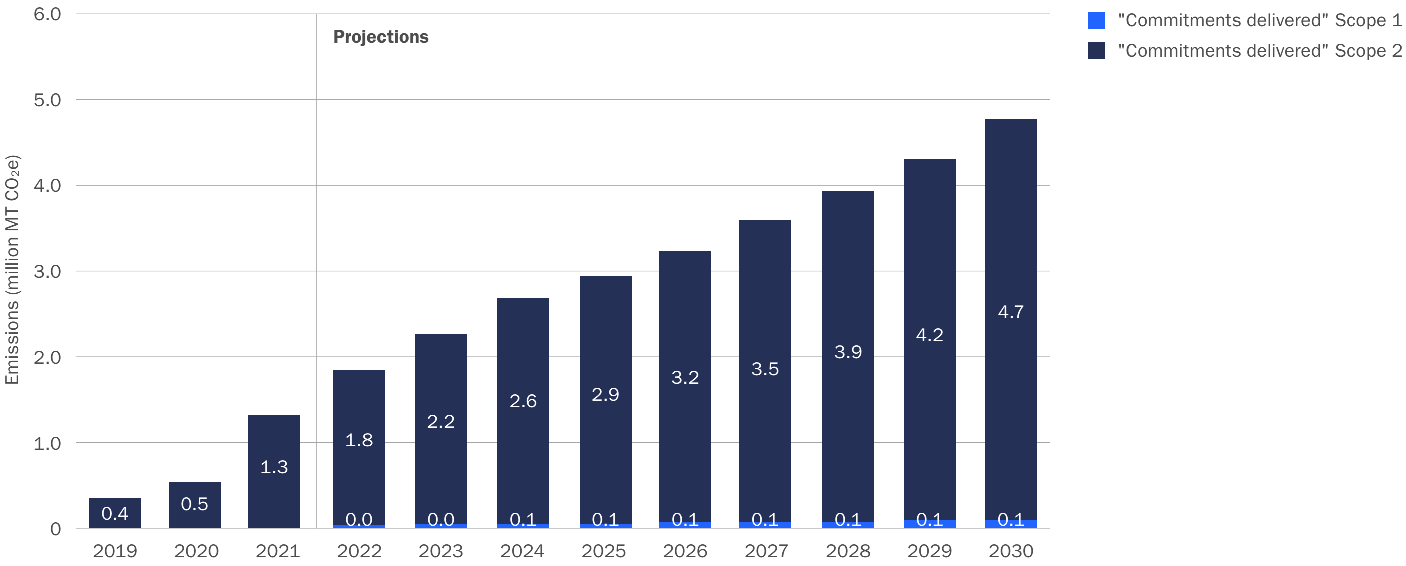
Due to the lack of specific short- or medium-term targets, we weren't able to incorporate any emission reductions under the "commitments delivered" scenario in the modeling calculations. Under a business as usual scenario, Luxshare's emissions can rise to 4.8 million metric tons (Figure 42). Under the "1.5 degrees" scenario, Luxshare could expect a peak in its emissions by 2027 at 3.0 million metric tons, and be further reduced to 0.2 million metric tons by 2030. Without any further evidence/target on power consumption reduction, Luxshare's electricity consumption is likely to increase by 270%, from 2 TWh in 2021 to 7.4 TWh in 2030.

Figure 42. Historical (2019-2021) Luxshare GHG emissions and its projections, shown in dashed lines (2022-2030).



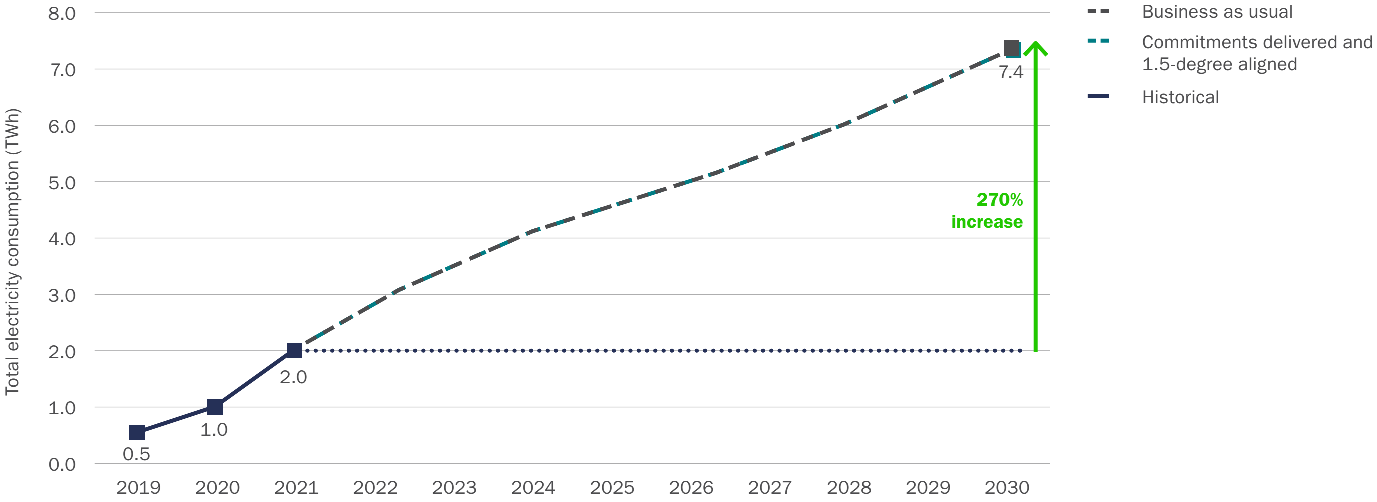
Source: Authors' analysis.

Figure 43. Historical (2019-2021) data from Luxshare and its "commitments delivered" projected (2022-2030) emissions by scope.



Source: Authors' analysis.

Figure 44. Historical (2019-2021) data showing Luxshare electricity consumption and its projections, shown in dashed lines (2022-2030).



Source: Authors' analysis.

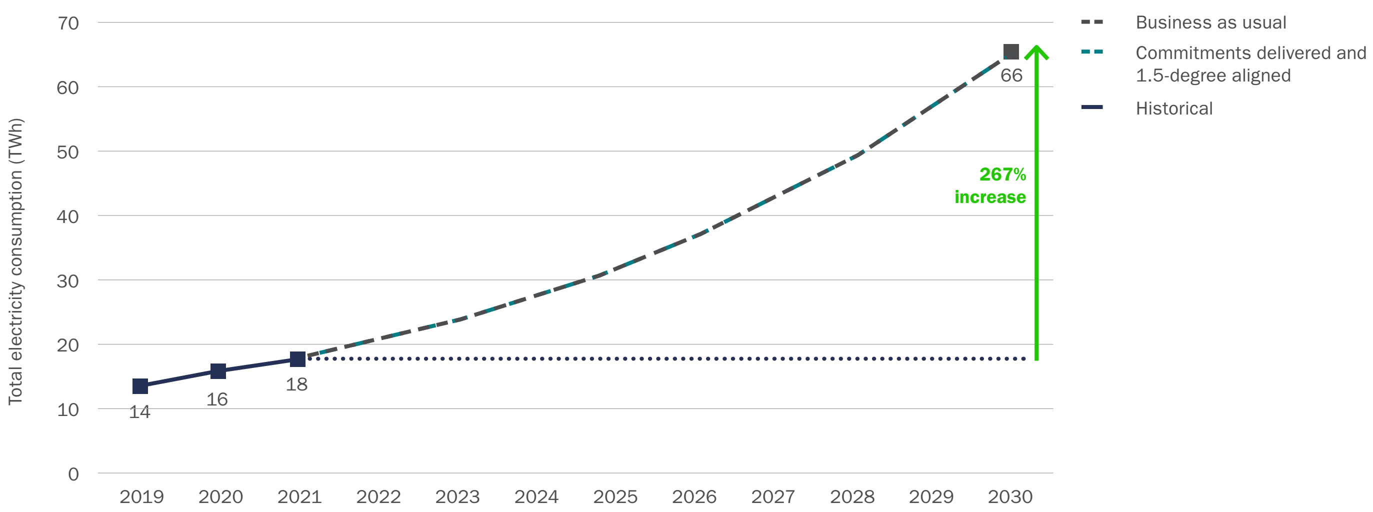
Recommendations

1. Companies need to cut emissions by at least 50% by 2030. To achieve this, 100% renewable energy by 2030 should be a priority.
2. Companies need to prioritize using power purchase agreements, onsite solar and investment to achieve a 100% renewable energy target by 2030.

Company portfolios

Company: TSMC

Transition progress[41, 42]:
Behind
Climate risk and the action being taken by the company
The climate crisis has led to an increased risk of droughts, floods, and storms in many global regions. TSMC's infrastructure is facing severe damage risk – the company's facilities in Tainan have a high flooding potential because the land is below sea level. TSMC has committed to net zero emissions by 2050. With a 62% of emissions coming from its electricity usage, TSMC designed the goal to achieve 100% renewable energy by 2050. However, by 2021, the company's renewable energy ratio was only 9%. TSMC plans to spend 6800 million TWD to purchase renewable energy, mainly through RECs and existing PPAs. TSMC's renewable energy ambition and action are too low and passive compared to its industry-leading position.
Electricity forecast



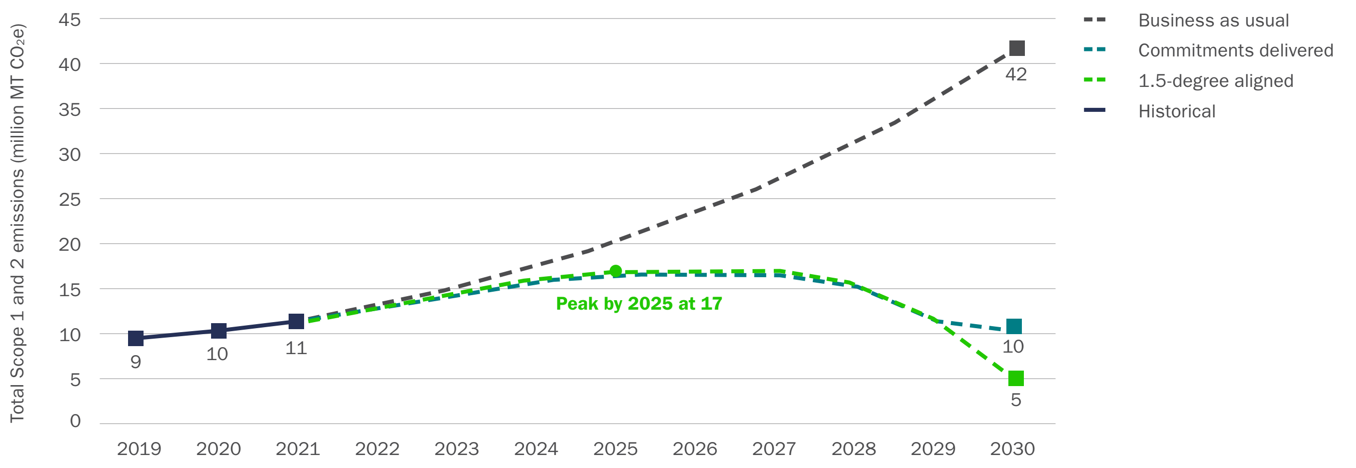
41 Referring company's own target achieving progress

42 Source: Bloomberg Finance L.P

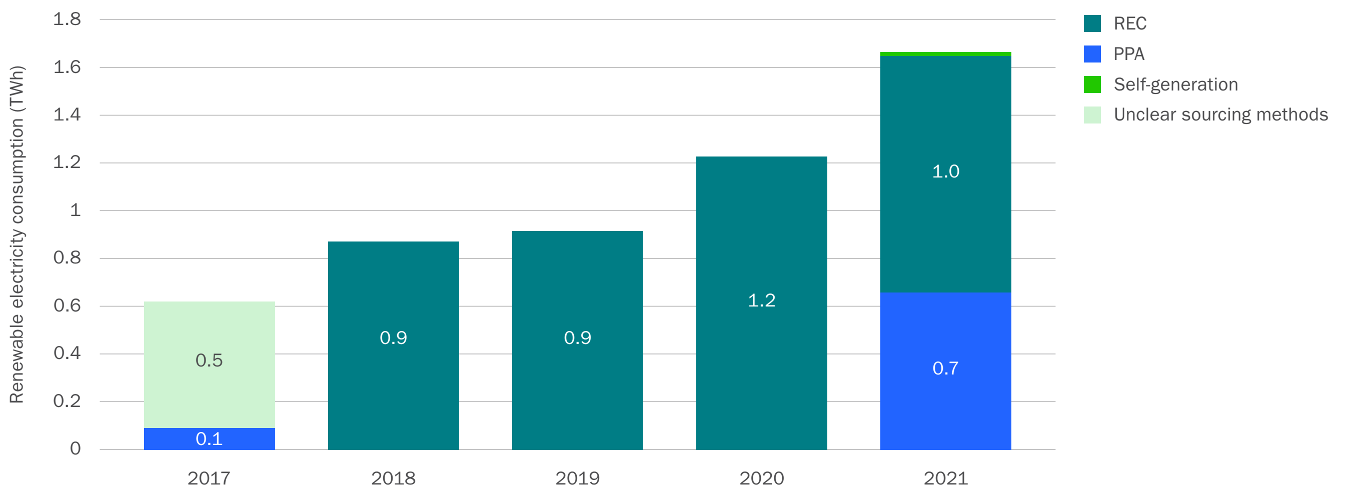
43 TSMC 2022 climate change cdp disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=966944&locale=en&organization_name=Taiwan+Semiconductor+Manufacturing+Company%2C+Ltd.&organization_number=18280&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F207189&survey_id=78646008

44 ESG 今周刊 (2022, March 23).「很多人抱怨，台積電把台灣的綠能買光了」何麗梅：其實台積是這樣想的…… Retrieved March 22, 2023, from https://esg.businesstoday.com.tw/article/category/180694/post/202203230072/

Emissions forecast



Renewable sourcing



Temperature alignment[45] (scope 1 and 2)

- 2025: 3.2 degrees (referring to when there is no target).
- 2030: 3.2 degrees (referring to when there is no target).
- 2050: 1.63 degrees.

Pathways to 100% renewable energy by 2030

- Actively participate in RE site development and communication.
- Prioritize high-impact RE (self-generation and corporate PPAs. Prioritize roof-top solar and other renewable options that cause less ecological impact).
- Diversify RE sources.

45 Source: Bloomberg Finance L.P

Company: Samsung Electronics

Transition progress[46]
No targets

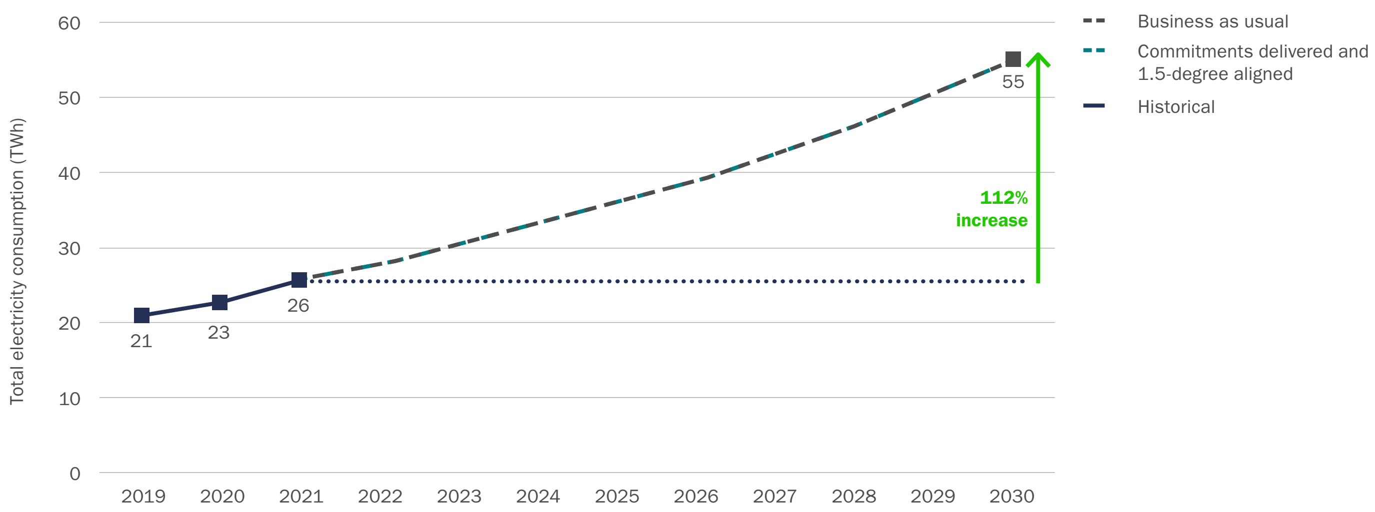
Climate risk and the action being taken by the company

According to the Korea Meteorological Administration, amongst the 22 typhoons in 2021, three affected Korean soil. The semiconductor production sites at Giheung, Hwaseong, and Pyeongtaek are particularly sensitive to changing weather conditions, making them vulnerable to quality losses in production.

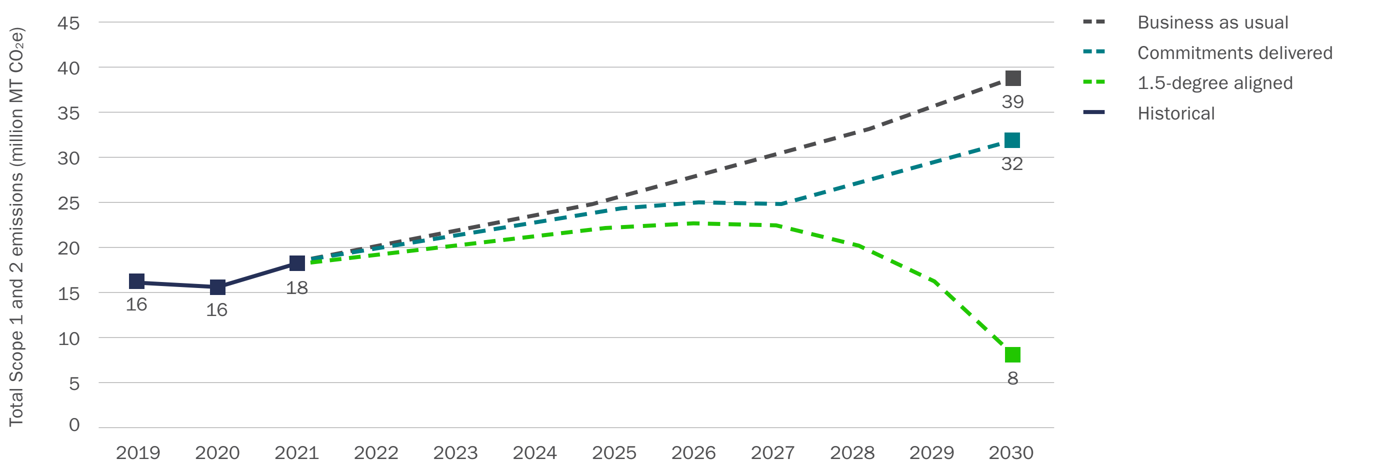
Eight production sites run by Samsung Electronics are at high risk of being affected by natural disasters, such as typhoons and cyclones. In 2018, the Pyeongtaek site experienced 30 minutes of power-outage and it is expected that the revenue loss due to that one incident accumulates to 50 billion KRW.[47]

In 2022, the company announced achieving carbon neutrality and 100% renewable energy by 2050. However, Samsung Electronics lacks solid and ambitious targets to actively seek solutions to the climate risks.

Electricity forecast



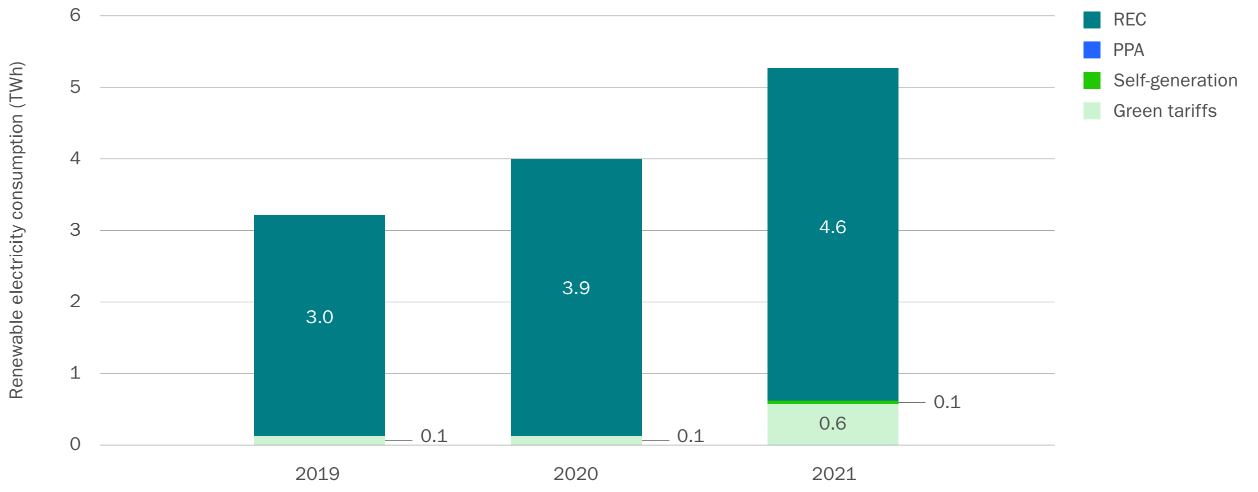
Emissions forecast



46 Source: Bloomberg Finance L.P

47 Samsung Electronics 2022 climate change cdp disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=966788&locale=en&organization_name=Samsung+Electronics&organization_number=16191&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F186996&survey_id=78646008

Renewable sourcing



Temperature alignment (scope 1 and 2)

Samsung has not disclosed a detailed emissions reduction plan for its scope 1 and 2.

Pathways to 100% renewable energy by 2030

- Accelerate the transition to 100% renewable energy by 2030 and apply it to their global operations as soon as possible.
- Set ambitious 100% renewable energy targets for its manufacturing supply chain (existing and new suppliers), including preferential policies to provide economic incentives.
- Select effective renewable energy procurement methods (such as PPAs and direct investment) that align with the basic procurement principles of locality, additionality, and advocacy.
- Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

Company: SK Hynix

Transition progress

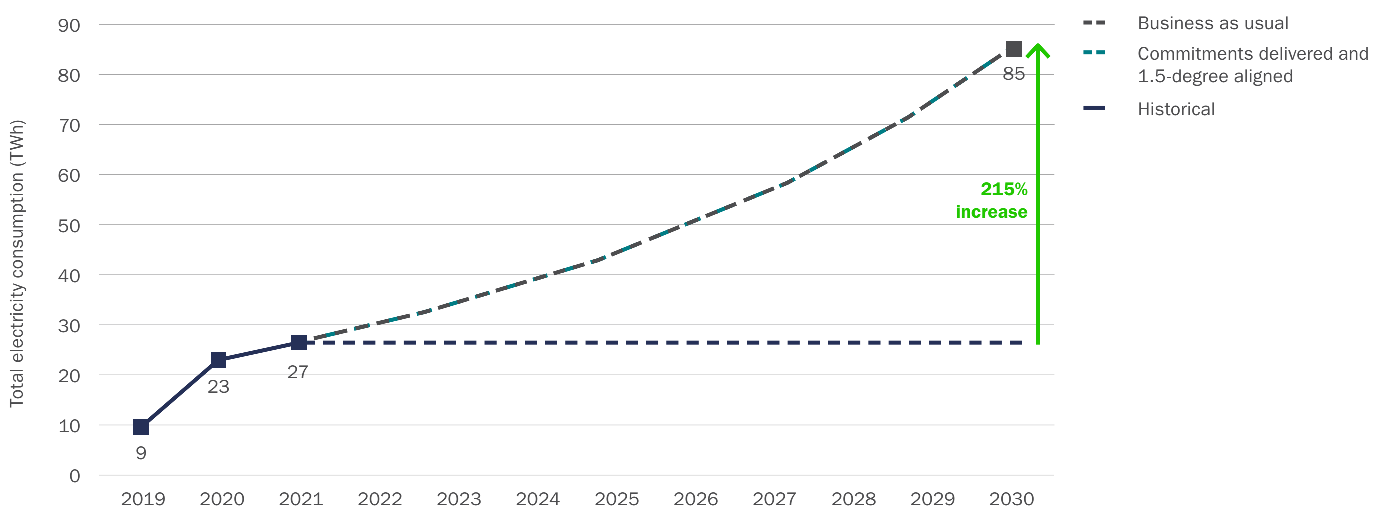
Behind

Climate risk and the action being taken by the company

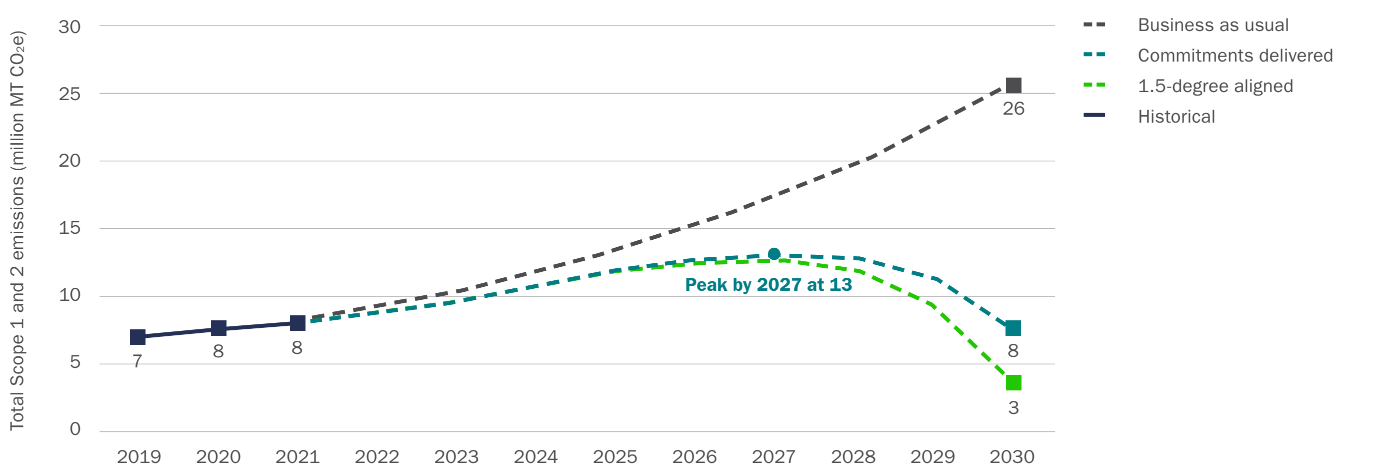
The increased risk of frequency and duration of extreme weather events such as heatwaves and heavy rain due to climate change places a potential financial burden on companies. SK Hynix faces increasing costs to maintain its semiconductor manufacturing facilities because extreme rainfall can have an adverse effect on the yield of semiconductor production, leading to problems in product quality of precision instruments.[48]

SK Hynix announced its goal to maintain greenhouse gas emissions at the 2020 level by 2030 to achieve 2050 net zero. The firm has also established a carbon management committee to focus on greenhouse gas issues and reflect them in its management strategy. The company established an intermediate goal of achieving more than 33% of renewable energy usage by 2030 and is carrying out activities to expand renewable energy, reduce energy, and improve efficiency. But SK Hynix's renewable energy ambition and action is low compared to its industrial position.

Electricity forecast

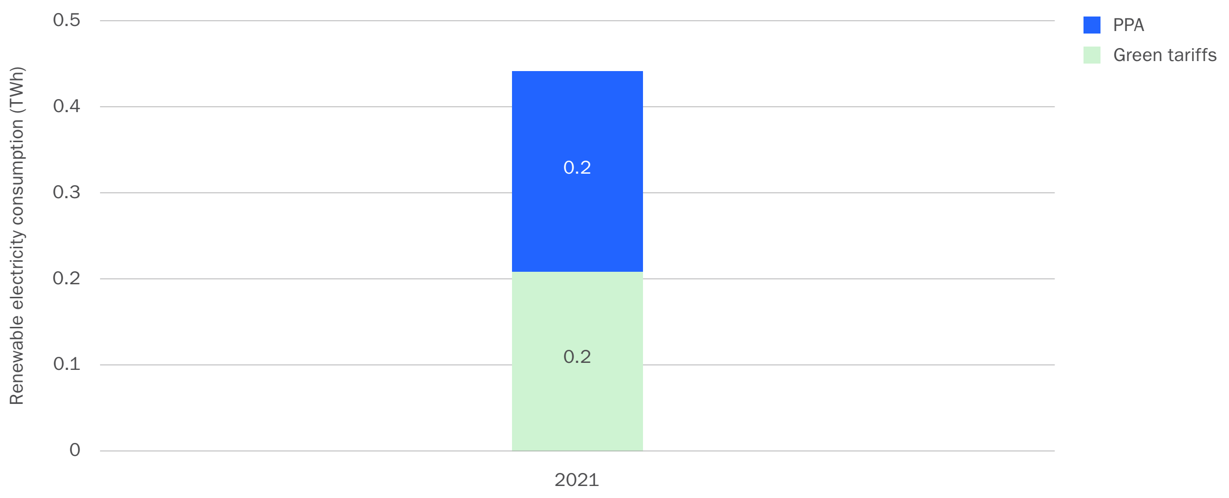


Emissions forecast



48 SK Hynix 2022 climate change CDP disclosure . Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=985284&locale=en&organization_name=SK+Hynix&organization_number=8663&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F212211&survey_id=78646008.

Renewable sourcing



Temperature alignment (scope 1 and 2)

- 2025: 2.57 degrees.
- 2030: 1.92 degrees.
- 2050: 1.5 degrees.

Pathways to 100% renewable energy by 2030

- Accelerate the transition to 100% renewable energy by 2030 and apply it to their global operations as soon as possible.
- Set ambitious 100% renewable energy targets for its manufacturing supply chain (existing and new suppliers), including preferential policies to provide economic incentives.
- Select effective renewable energy procurement methods (such as PPAs and direct investment) that align with the basic procurement principles of locality, additionality, and advocacy.
- Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

Company: Kioxia

Transition progress

No target

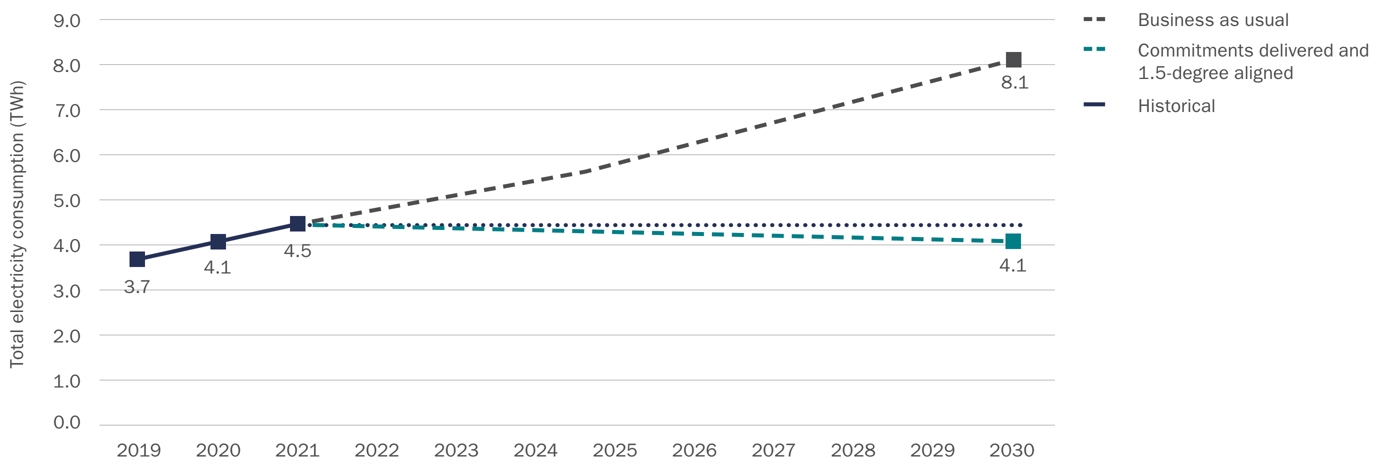
Climate risk and the action being taken by the company[49]

Kioxia’s factory is vulnerable to temporary or permanent closure in the event of extreme weather events, such as typhoons and floods that are exacerbated by climate change.

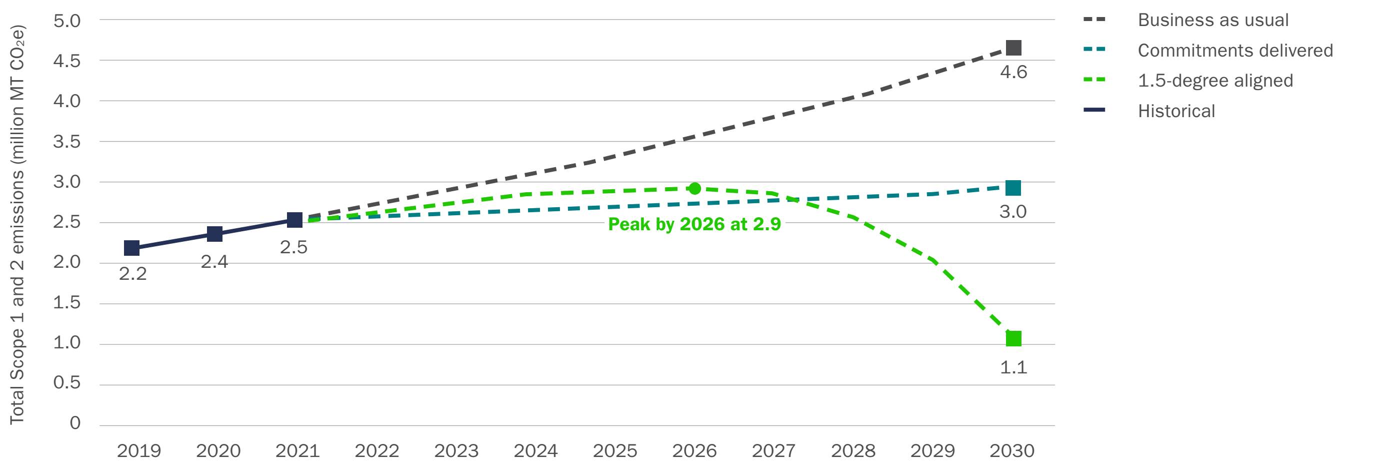
Kioxia has committed to reach 100% renewable energy by 2040, and the Kioxia Group is increasing the usage of renewable energy by installing large-scale solar power generation systems for the first time at its Kitakami Plant and Yokkaichi Plant. Installed on the rooftop of flash memory fabrication facilities, the new solar power systems will be the largest of their kind at any semiconductor plant in Japan. With a total generating capacity of about 7.5 megawatts (MW), the new solar power systems are expected to generate about 7,600 megawatt hours (MWh) of electricity annually for Kioxia and reduce carbon dioxide emissions by about 3,200 tons per year.[50]

The company's renewable energy use was less than 1% in 2021.

Electricity forecast



Emissions forecast



49 Kioxia 2022 climate change CDP disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=971726&locale=en&organization_name=Kioxia+Holdings+Corporation&organization_number=840012&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F219023&survey_id=78646008

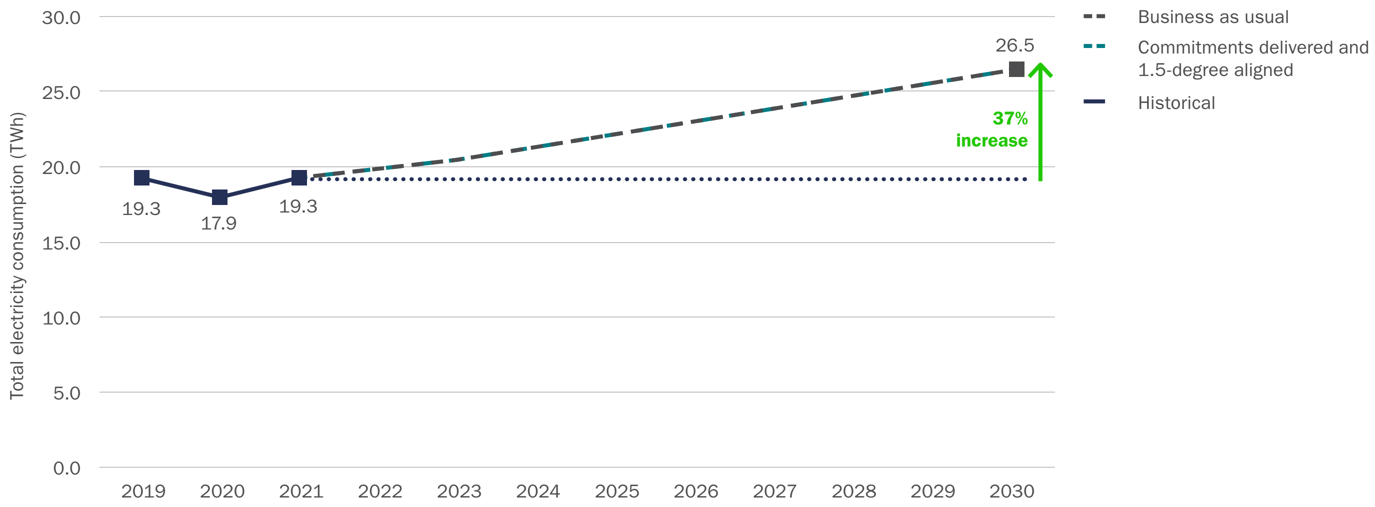
50 Kioxia Corporation (2023). Kioxia installs solar power generation systems at Kitakami and Yokkaichi Plants in Japan in major new sustainability initiative. Retrieved March 22, 2023, from https://www.kioxia.com/en-jp/about/news/2023/20230201-1.html

Renewable sourcing
N/a
Temperature alignment[51] (scope 1 and 2)
• 2025: 2.24 degrees. • 2030: 3.2 degrees (referring to when there is no target). • 2050: 3.2 degrees (referring to when there is no target).
Pathways to 100% renewable energy by 2030
• Set targets for energy efficiency improvements in operations and supply chains to improve energy consumption per material input. • Replace fossil fuel based electricity with renewable energy sources that meet; - additionality – new renewable energy power plants are opened (priority given to additional RE power plants over the use of credits from older RE power plants). - environmentally sound – the ecological and environmental impact of the construction and operation of RE power plants is minimized (e.g. not involving extensive deforestation, land modification or large emissions of carbon dioxide from the soil). - good for the community – the benefits and risks are disclosed to residents, including the environmental impact on the surrounding area and the impact on the livelihoods of local residents. The benefits are fully returned to the community through increased employment, tax revenues, industrial development, etc., and the majority of residents are not opposed to the project. - safety – safely installed and operated to prevent accidents which have an impact on the surrounding communities in case of natural disaster. • Replace other fossil fuel combustion needs with renewable alternatives (e.g. heat production, mobility). • Study and work together with and beyond industry groups to reduce greenhouse gas emissions from sources other than fossil fuel combustion. • Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

51 Source: Bloomberg Finance L.P

Company: LG Display

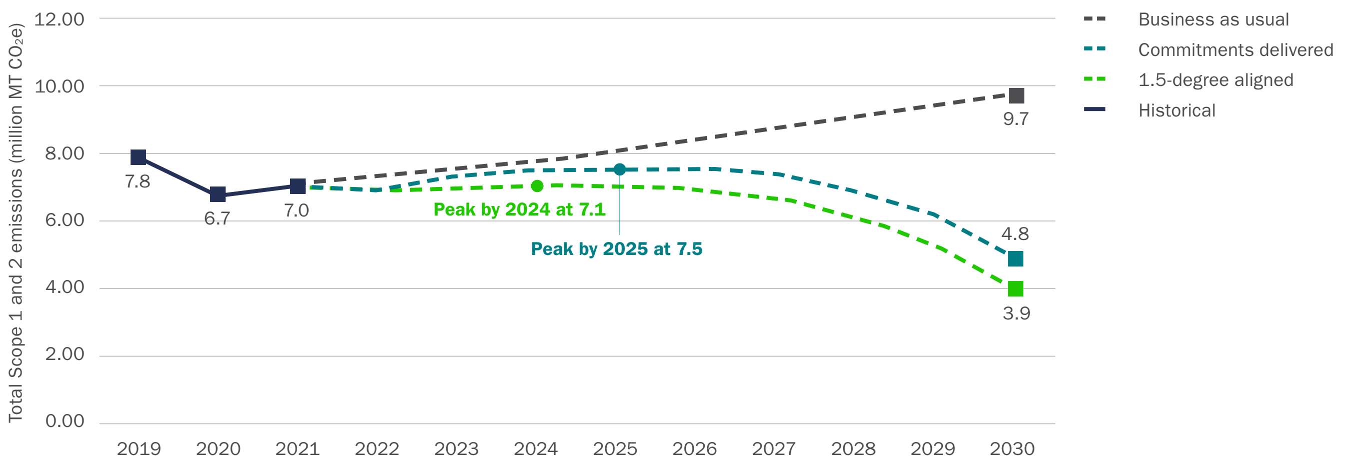
Transition progress[52]
Behind
Climate risk and the action being taken by the company[53]
The water supply by changes of annual precipitation from drought can influence productivity, and this is intimately related to LG Display's production and sales, and financial loss will be according to the reasons and the scale of damage. Changes in the average annual temperature due to climate change result in increased electricity use in other facilities, such as cleanrooms and freezers. The increase in energy consumption can lead to additional loads on the facilities. The steady increase in electricity costs due to the increased usage adds a financial burden on LG Display due to the increase in operating expenses. LG Display's energy costs are about 68% of the total management cost, so there is a continuing investment risk for energy saving. LG Display plans to purchase renewable energy through Green Premium to accelerate its renewable energy transition. The company is expecting to invest more than 1 trillion KRW to continue to purchase renewable energy by 2050. However, LG Display still lacks an ambitious 100% renewable energy commitment.
Electricity forecast



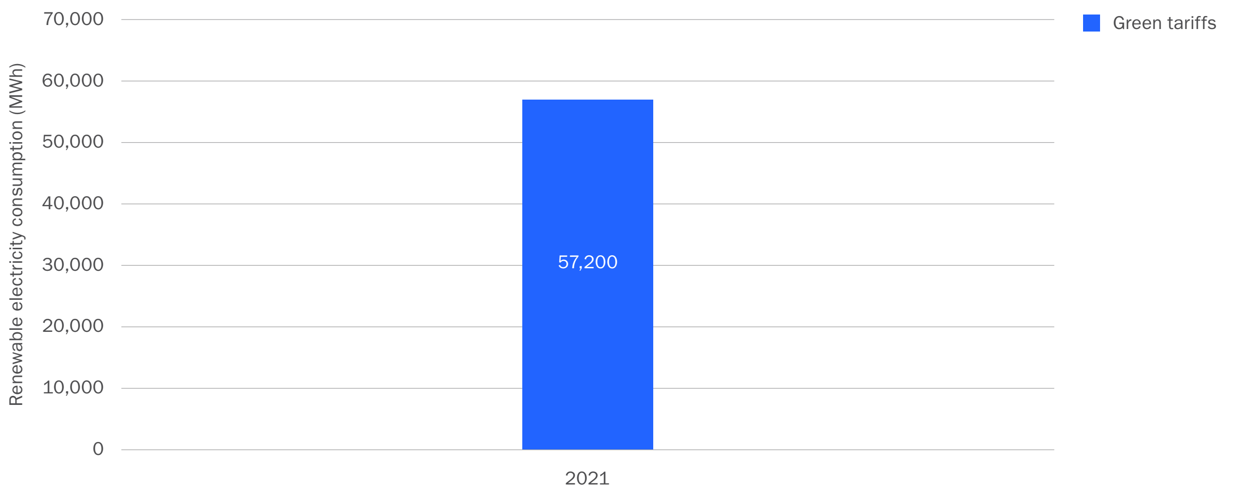
52 Source: Bloomberg Finance L.P

53 LG Display 2022 climate change CDP disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=996175&locale=en&organization_name=LG+Display&organization_number=23005&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F187878&survey_id=78646008

Emissions forecast



Renewable sourcing



Temperature alignment[54] (scope 1 and 2)

- 2025: 3.2 degrees (referring to when there is no target).
- 2030: 2.4 degrees.
- 2050: 1.83 degrees.

Pathways to 100% renewable energy by 2030

- Accelerate the transition to 100% renewable energy by 2030 and apply it to their global operations as soon as possible.
- Set ambitious 100% renewable energy targets for its manufacturing supply chain (existing and new suppliers), including preferential policies to provide economic incentives.
- Select effective renewable energy procurement methods (including PPAs and direct investment) that align with the basic procurement principles of locality, additionality, and advocacy.
- Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

54 Source: Bloomberg Finance L.P

Company: Samsung Display

Transition progress

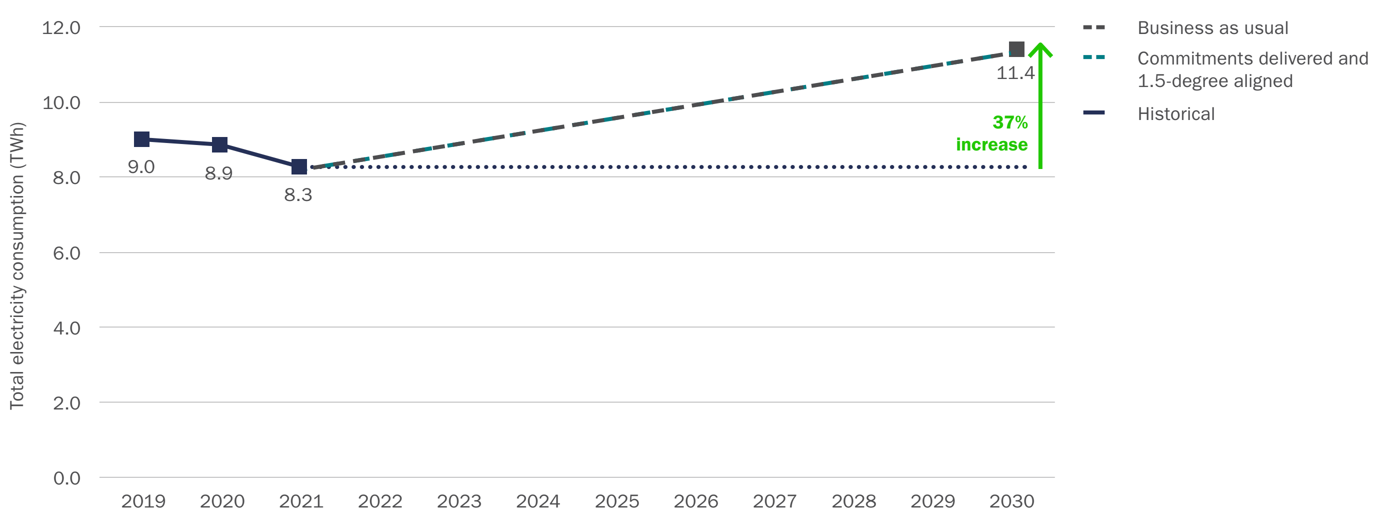
No target

Climate risk and the action being taken by the company[55]

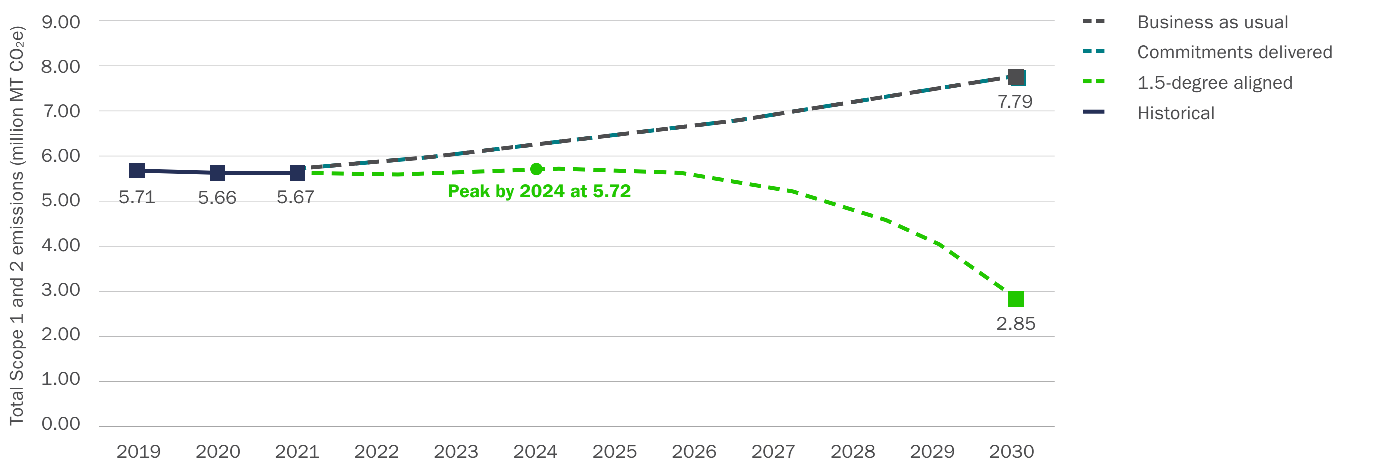
The increased risk in frequency of droughts and other extreme weather events as a result of climate change could have a negative impact on Samsung Display factories and operational facilities. Increased annual average temperatures could affect production at the company's facilities.

In 2022 September, Samsung Display committed to achieving carbon neutrality and transitioning to 100% renewable energy by 2050. Despite the lack of an ambitious timeline, the company has not set up concrete targets for its short and midterm emissions reduction.

Electricity forecast



Emissions forecast



55 Samsung Display 2022 climate change CDP disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=964730&locale=en&organization_name=Samsung+Display+Co.%2CLtd&organization_number=838364&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F206909&survey_id=78646008

Renewable sourcing
N/a
Temperature alignment
Samsung Display has not disclosed a detailed emissions reduction plan for its scope 1 and 2.
Pathways to 100% renewable energy by 2030
• Accelerate the transition to 100% renewable energy by 2030 and apply it to their global operations as soon as possible. • Set ambitious 100% renewable energy targets for its manufacturing supply chain (existing and new suppliers), including preferential policies to provide economic incentives. • Select effective renewable energy procurement methods (including PPAs and direct investment) that align with the basic procurement principles of locality, additionality, and advocacy. • Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

Company: BOE

Transition progress

No target

Climate risk and the action being taken by the company

BOE did not disclose the potential operational impact from climate change.

BOE did not set any climate targets.

Electricity forecast

N/a

Emissions forecast

N/a

Renewable sourcing

N/a

Temperature alignment

No target

Pathways to 100% renewable energy by 2030

- Steps towards 100% RE by 2030:
  1. Assess energy demand , energy consumption, and emission data. Establish a comprehensive, practical strategy plan for scaling up renewable energy procurement.
  2. Set a clear timeline for switching to 100% renewable energy across the supply chain, ideally by 2030, with short-term targets and sourcing methods identified.
  3. Publically announce the targets, and disclose regular, concrete updates of progress.
  4. Review and update targets and renewable energy sourcing methods at least every 5 years, regularly benchmarking with latest science and industry best practices.
- Principles to follow for renewable energy procurement
  - Have clear ownership of environmental attributes.
  - Procure renewable energy locally.
  - Prioritize newly commissioned renewable energy projects and set a commissioning date limit for old plants.
  - Adopt sourcing methods that can help increase new renewable energy installed capacity.

Therefore, we recommend corporations to prioritize green electricity trading, onsite generation and equity investment, instead of unbundled Renewable Energy Certificates (RECs).

Company: Japan Display

Transition progress
No target
Climate risk and the action being taken by the company
Production and operation will be suspended in the event of damage caused by extreme weather events.[56] Japan Display has not set any climate and 100% renewable energy targets. The renewable energy ratio is less than 1%.
Electricity forecast
N/a
Emissions forecast
N/a
Renewable sourcing
N/a
Temperature alignment
Japan Display has not disclosed a detailed emissions reduction plan for its scope 1 and 2.
Pathways to 100% renewable energy by 2030
• Set targets for energy efficiency improvements in operations and supply chains to improve energy consumption per material input. • Replace fossil fuel-based electricity with renewable energy sources that incorporate the following principles; - additionality – new renewable energy power plants are opened (priority given to additional RE power plants over the use of credits from older RE power plants). - environmental assessment – the ecological and environmental impact of the construction and operation of RE power plants is minimized (e.g. not involving extensive deforestation, land modification or large emissions of carbon dioxide from the soil). - community benefits – the benefits and risks are disclosed to residents, including the environmental impact on the surrounding area and the impact on the livelihoods of local residents. The benefits are fully returned to the community such as through increased employment, tax revenues, and industrial development, and the majority of residents agree with the project. - safety – safely installed and operated to prevent accidents which have an impact on the surrounding communities in case of natural disaster. • Replace other fossil fuel combustion needs with renewable alternatives (e.g. heat production, mobility). • Study and work together with and beyond industry groups to reduce greenhouse gas emissions from sources other than fossil fuel combustion. • Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

56 Japan Display climate change 2022 CDP. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=940994&locale=en&organization_name=Japan+Display+Inc.&organization_number=53586&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F202429&survey_id=78646008

Company: Sharp

Transition progress
Ahead
Climate risk and the action being taken by the company
Sharp recognizes that natural disasters such as typhoons and floods, which are increasing in frequency and magnitude due to climate change, are risks that require urgent adaptation strategies Sharp's white goods manufacturing base is located in a region of Thailand that experienced a large-scale flood in 2011, which had a huge impact on the company's logistics network. Sharp is aware that extreme rainfall events in Japan over the past few years have threatened the safety of its employees and caused loss of business opportunities.[57] Sharp aims to achieve net zero by 2050. However, the company has not set a 100% renewable energy target and the current renewable energy ratio is under 1%.
Electricity forecast
N/a
Emissions forecast
N/a
Renewable sourcing
N/a
Temperature alignment
• 2025: 3.2 degrees • 2030: 1.9 degrees • 2050: 3.2 degrees
Pathways to 100% renewable energy by 2030
• Set targets for energy efficiency improvements in operations and supply chains to improve energy consumption per material input • Replace fossil fuel based electricity with renewable energy sources that incorporate the following principles; - additionality – new renewable energy power plants are opened (priority given to additional RE power plants over the use of credits from older RE power plants). - environmental assessment – the ecological and environmental impact of the construction and operation of RE power plants is minimized (e.g. not involving extensive deforestation, land modification or large emissions of carbon dioxide from the soil). - community benefit – the benefits and risks are disclosed to residents, including the environmental impact on the surrounding area and the impact on the livelihoods of local residents. The benefits are fully returned to the community, such as through increased employment, tax revenues, and industrial development, and the majority of residents agree with the project. - safety – safely installed and operated to prevent accidents which have an impact on the surrounding communities in case of natural disaster. • Replace other fossil fuel combustion needs with renewable alternatives (e.g. heat production, mobility). • Study and work together with and beyond industry groups to reduce greenhouse gas emissions from sources other than fossil fuel combustion. • Engage with governments, utilities, affiliates, and other companies to advocate for renewable energy-friendly policies and investments.

57 Sharp climate change 2022 CDP. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=963924&locale=en&organization_name=3SHARP+LLC&organization_number=56951&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F190119&survey_id=78646008

Company: Luxshare Precision

Transition progress[58]

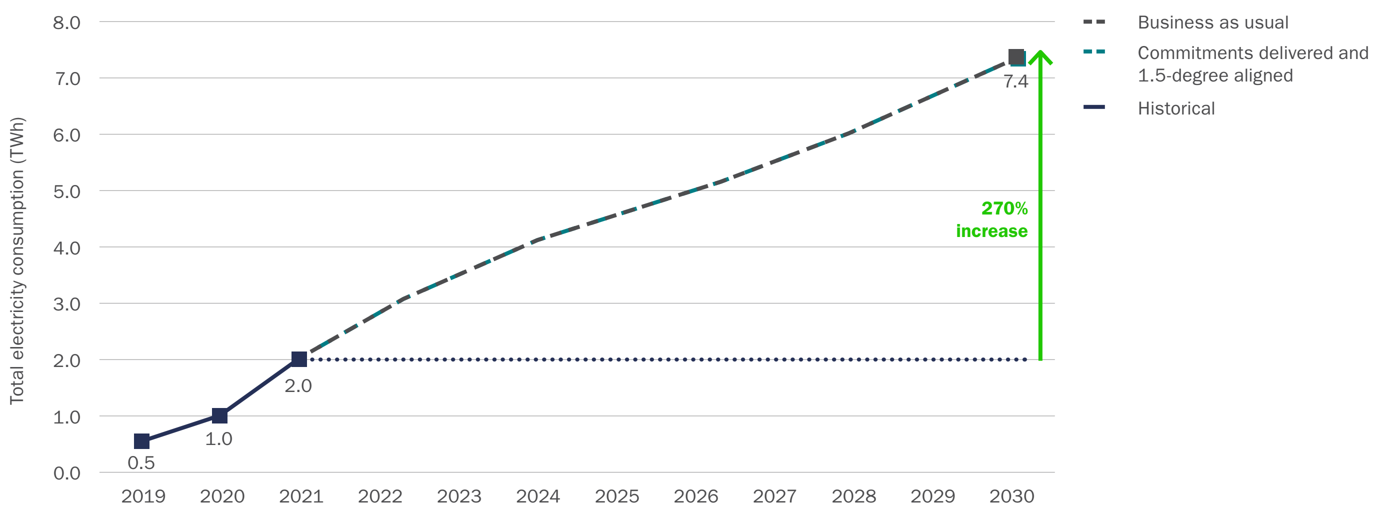
Behind

Climate risk and the action being taken by the company[59]

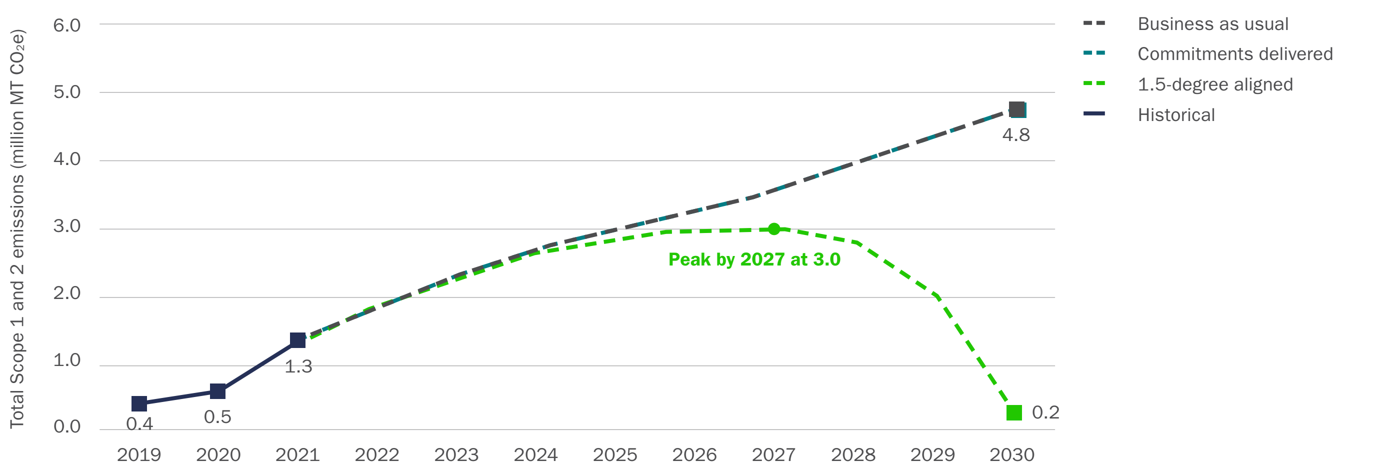
Luxshare Precision disclosed that the production and operational facilities might be affected due to extreme weather events caused by climate change.

Luxshare Precision aims to achieve carbon neutrality within its own operations by 2050 and has initiated an emissions reduction goal that is aligned with the 1.5 degree target as per the Paris agreement. To showcase its determination and commitment, Luxshare Precision must prioritise the transition to 100% renewable energy and set a 100% renewable energy target.

Electricity forecast



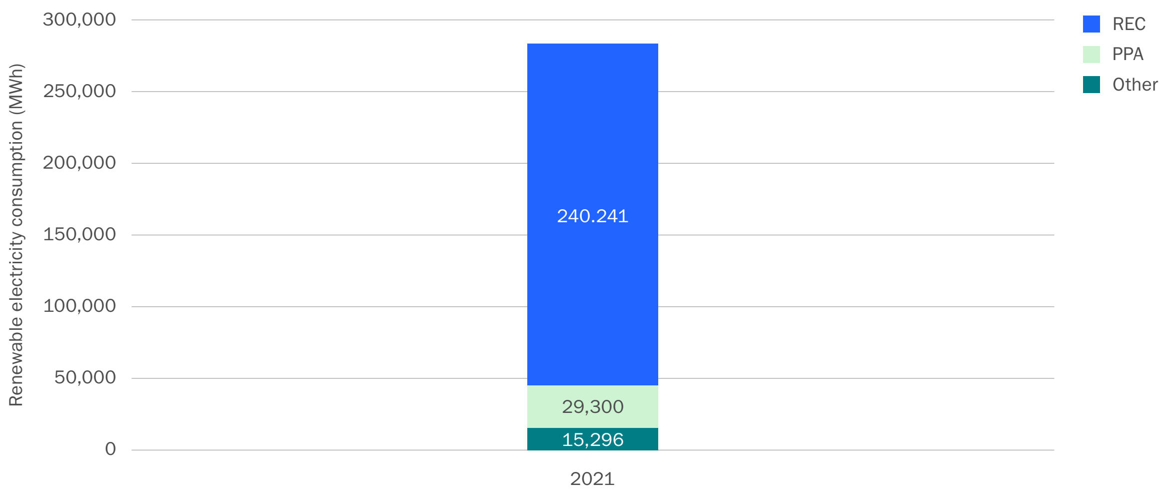
Emissions forecast



58 Source: Bloomberg Finance L.P

59 Luxshare Precision 2022 climate change CDP disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=994232&locale=en&organization_name=Luxshare+Precision+Industry&organization_number=51312&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F209358&survey_id=78646008

Renewable sourcing



Temperature alignment[60]

- 2025: 2.17 degrees.
- 2030: 3.2 degrees (referring to when there is no target).
- 2050: 3.2 degrees (referring to when there is no target).

Pathways to 100% renewable energy by 2030

- Steps towards 100% RE by 2030:
  1. Assess energy demand, energy consumption, and emission data. Establish a comprehensive, practical strategy plan for scaling up renewable energy procurement.
  2. Set a clear timeline for switching to 100% renewable energy across the supply chain, ideally by 2030, with short-term targets and sourcing methods identified.
  3. Publically announce the targets, and disclose regular, concrete updates of progress.
  4. Review and update targets and renewable energy sourcing methods at least every 5 years, regularly benchmarking with latest science and industry best practices.
- Principles to follow for renewable energy procurement
  - Have clear ownership of environmental attributes.
  - Procure renewable energy locally.
  - Prioritize newly commissioned renewable energy projects and set a commissioning date limit for old plants.
  - Adopt sourcing methods that can help increase new renewable energy installed capacity.

Therefore, we recommend corporations to prioritize green electricity trading, onsite generation and equity investment, instead of unbundled Renewable Energy Certificates (RECs).

60 Source: Bloomberg Finance L.P

Company: Hon Hai

Transition progress
No target
Climate risk and the action being taken by the company[61]
Hon Hai/Foxconn has global subsidiaries. Some of the company's facilities are in regions that experience extreme weather events such as earthquakes, floods, and typhoons that can damage equipment, interrupt operations, and affect the delivery of raw materials and shipment of finished products. In 2021, the "July 20th Zhengzhou exceptionally heavy rain" caused the box transformer, inverter, combiner box, photovoltaic module and other equipment in the company's rooftop photovoltaic area to be vulnerable to typhoons and heavy rains. In future decades, the increased risk of more frequent extreme weather events could mean that the operation and maintenance costs of equipment will increase. The company has set a goal to achieve carbon neutrality by 2050 but has not yet clarified its renewable energy target. Hon Hai's current renewable energy ratio is 5%.
Electricity forecast
N/a
Emissions forecast
N/a
Renewable sourcing
N/a
Temperature alignment
No target
Pathways to 100% renewable energy by 2030
• Actively participate in RE site development and communication. • Prioritize high-impact RE (self-generation and corporate PPAs. Also prioritize roof-top solar and ways that cause less ecological impact). • Diversify RE sources.

61 Hon Hai 2022 climate change CDP disclosure. Retrieved March 22, 2023, from https://www.cdp.net/en/formatted_responses/responses?campaign_id=79520704&discloser_id=943933&locale=en&organization_name=Hon+Hai+Precision+Industry&organization_number=21422&program=Investor&project_year=2022&redirect=https%3A%2F%2Fcdp.credit360.com%2Fsurveys%2F2022%2F6wz4wms4%2F217726&survey_id=78646008

Company: Goertek

Transition progress
No target
Climate risk and the action being taken by the company
Goertek did not disclose the potential operational impact from climate change. Goertek did not set any climate targets.
Electricity forecast
N/a
Emissions forecast
N/a
Renewable sourcing
N/a
Temperature alignment
No target
Pathways to 100% renewable energy by 2030
• Steps towards 100% RE by 2030: 1. Assess energy demand, energy consumption, and emission data. Establish a comprehensive, practical strategy plan for scaling up renewable energy procurement. 2. Set a clear timeline for switching to 100% renewable energy across the supply chain, ideally by 2030, with short-term targets and sourcing methods identified. 3. Publically announce the targets, and disclose regular, concrete updates of progress. 4. Review and update targets and renewable energy sourcing methods at least every 5 years, regularly benchmarking with latest science and industry best practices. • Principles to follow for renewable energy procurement - Have clear ownership of environmental attributes. - Procure renewable energy locally. - Prioritize newly commissioned renewable energy projects and set a commissioning date limit for old plants. - Adopt sourcing methods that can help increase new renewable energy installed capacity. Therefore, we recommend corporations to prioritize green electricity trading, onsite generation and equity investment, instead of unbundled Renewable Energy Certificates (RECs).

Company: Pegatron

Transition progress
No target
Climate risk and the action being taken by the company[62]
Despite the severe climate event that has been addressed by Pegatron on CDP disclosure, the company has taken sufficient steps to contribute to the change of the circumstances. Pegatron has not issued any carbon neutrality or 100% renewable energy targets. Furthermore, the company appeared to take no action towards changing to renewable energy in 2021.
Electricity forecast
N/a
Emissions forecast
N/a
Renewable sourcing
N/a
Temperature alignment
No target
Pathways to 100% renewable energy by 2030
• Actively participate in RE site development and communication. • Prioritize high-impact RE (self-generation and corporate PPAs). Prioritize roof-top solar and pathways that cause less ecological impact. • Diversify RE sources.

62 Pegatron 2022 climate change CDP disclosure

Limitations

Wafer size

1. Wafer size can affect the electricity consumption of a fab, both in terms of unit-production energy and carbon intensity. Additional research is needed to quantify those correlations.

Data

1. Due to lacking historical data and accurate market analysis, this report does not cover the emissions and electricity projections of industrial projection for the display manufacturing and final assembly.
2. Due to a lack of useful data, national/regional grid emission factors were not incorporated in the final modeling.

Companies reporting

1. Some companies' carbon commitments are defined less precisely than others', leaving the interpretation and quantitative translation sometimes more uncertain.
2. The global warming potential factors companies used for their GHG accounting are not always the same, which can introduce inconsistency to the baselines.

Appendix

The abbreviations used in this report

CO_2e	Carbon dioxide equivalent
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
MT	Metric tons
PPAs	Power Purchase Agreements
RECs	Renewable Energy Certificates
SBTi	Science Based Targets initiative
TWh	terawatt hours (1TWh=1000GWh=10^6 MWh=10^9 kWh)
WSTS	World Semiconductor Trade Statistics