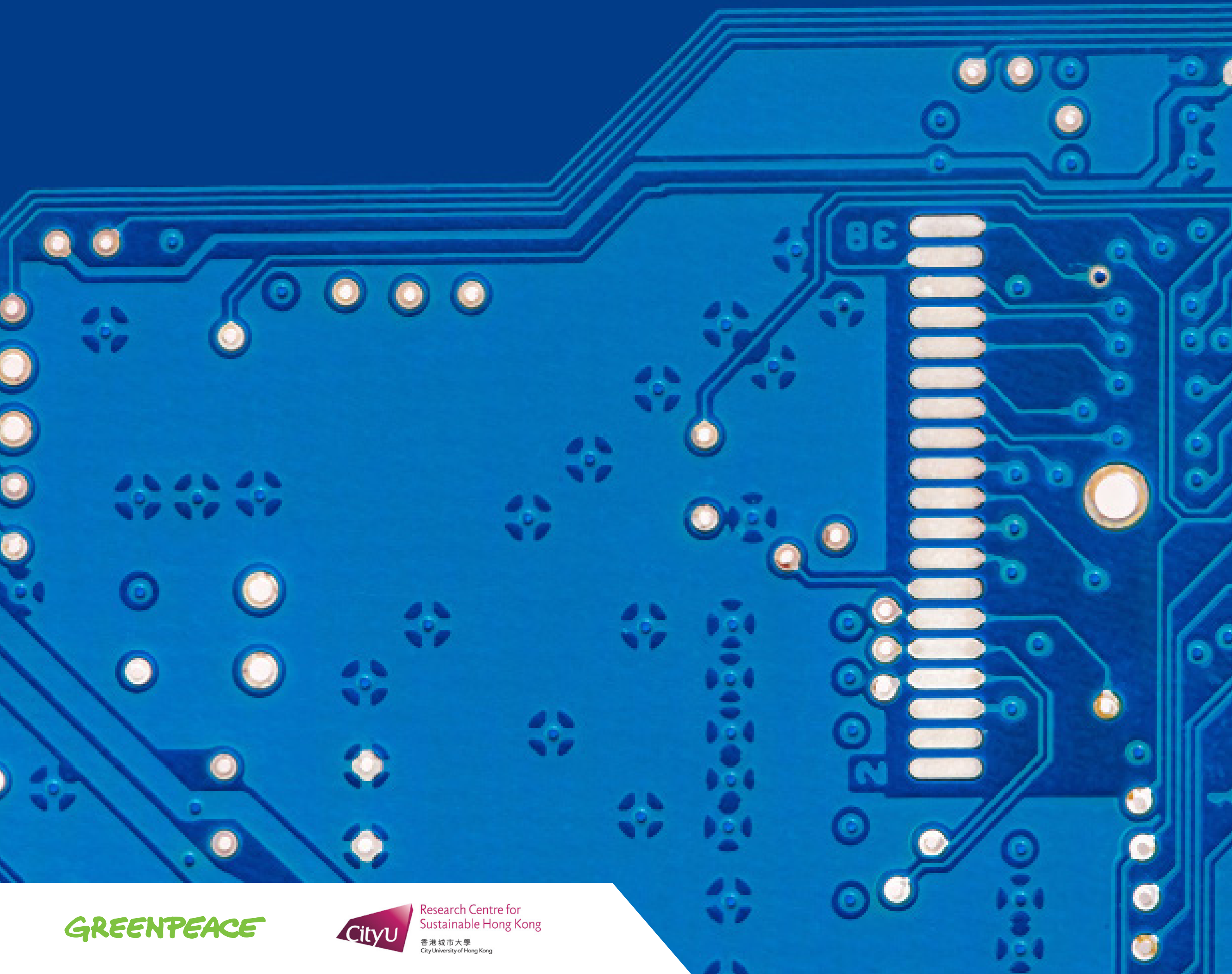
Powering Ahead

A Cost–Benefit Analysis of Renewable Energy Adoption Across the Electronics Supply Chain in East Asia



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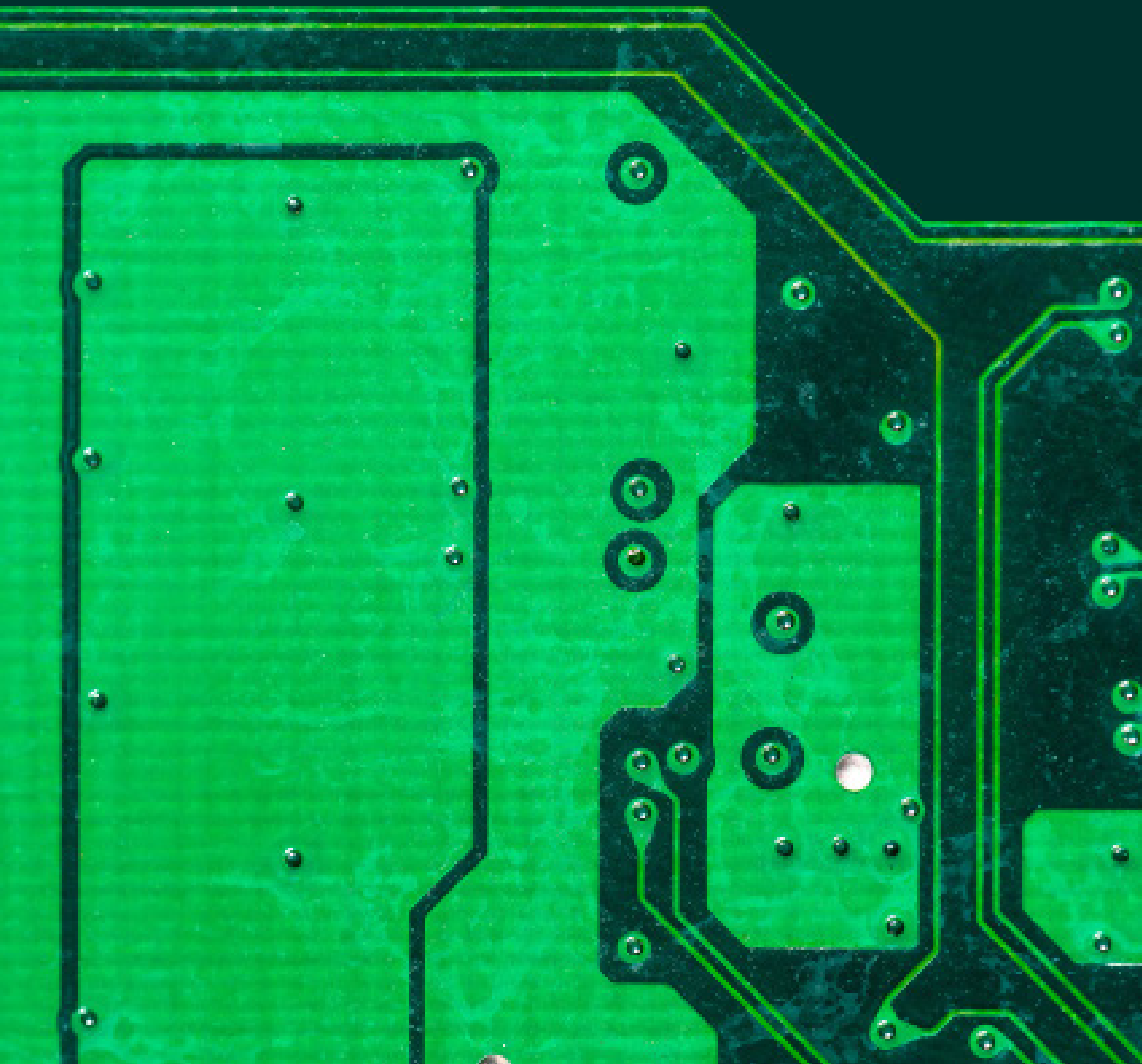


Introduction

In recent years, carbon emissions from the electronics supply chain have skyrocketed. Due to artificial intelligence, advanced chipmaking and the Internet of Things, the electronics industry has become one of the fastest growing sources of electricity consumption worldwide.[1] By 2030, semiconductor manufacturing alone is on track to consume 237 terawatt hours (TWh) of electricity globally, which is a value that is close to Australia's annual electricity consumption.[2,3]

In response to the industry's outsized carbon footprint, consumer electronics brands and suppliers are beginning to commit to powering their operations with 100% renewable energy. However, a disparity has emerged in the ambition date of different companies to meet the 100% renewable energy target. While consumer-facing brands such as Apple, Microsoft[4] and Google have already achieved 100% renewable energy across their own operations, critical electronics suppliers, such as TSMC, Foxconn and Samsung, have issued much less ambitious targets, pledging to achieve 100% renewable energy worldwide by 2040 at the earliest.[5]

Historically, there has been a widespread perception that ambitious climate targets conflict with business objectives.[6] However, by incorporating an analysis of energy, carbon and pollution costs through 2050, a more complete picture emerges. Projected increases in the cost of fossil fuels challenge the assumption that climate targets threaten economic competitiveness. The findings of this study indicate that electronics manufacturers that are able to reach 100% renewable energy by 2030 would achieve a competitive edge compared to their peers.

The scope of this report

In this study, we perform a cost–benefit analysis of the renewable energy pathway for 13 leading electronics companies in East Asia (TSMC, Samsung Electronics, SK Hynix, Luxshare Precision, Goertek, Foxconn, Pegatron, Samsung Display, LG Display, AUO, BOE, UMC and Innolux). The year 2022 was set as a baseline, a firm's committed renewable energy target was employed as a business as usual (BAU) scenario,[7] and a target of 100% renewable energy by 2030 was set as the renewable energy (RE) scenario. The cost–benefits under the two scenarios were compared. Carbon mitigation and cost reduction effects were analyzed under the advanced transition scenarios to 100% renewable energy.

1 Greenpeace (2023). Supply Change. Retrieved May 20, 2024, from https://www.greenpeace.org/static/planet4-eastasia-stateless/2023/04/620390b7-greenpeace_energy_consumption_report.pdf?_ga=2.13781943.1429922343.1696731374-156585249.1681783107

2 Based on Australia's 2021 electricity consumption. International Energy Agency (2023). Australia data explorer. Retrieved May 20, 2024, 2023, from https://www.iea.org/countries/australia

3 Based on Australia's 2021 electricity consumption, ibid.

4 Microsoft (2024). 2024 Environment Sustainablity Report. Retrieved May 20, 2024, from https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RW1lhhu

5 Greenpeace (2022). Supply Change. Retrieved May 20, 2024, from https://www.greenpeace.org/static/planet4-eastasia-stateless/2022/10/89382b33-supplychange.pdf

6 Ip (2023). Why No One Wants to Pay for the Green Transition. Retrieved May 20, 2024, from https://www.wsj.com/business/autos/why-no-one-wants-to-pay-for-the-green-transition-aed6ba74

7 For companies that had not issued a global 100% renewable energy target as of May 2024, their renewable energy ratio in 2022 or mid-renewable energy target was applied in the 2050 scenario.

Key findings

This study finds that major electronics suppliers in East Asia would achieve a competitive edge by transitioning to 100% renewable energy by 2030. If the 13 electronics suppliers in the study were each to achieve 100% renewable energy by 2030, they could earn financial benefits of between 87.42 million USD and 12.45 billion USD per company in 2030. The savings would result from avoiding the rising price of fossil energy and environmental costs, including potential carbon taxes and emissions-related fines.

The companies would also benefit from the decreasing cost of renewable electricity, and will benefit society by stopping the production of pollution and harmful emissions that negatively impact human health, agricultural productivity and biodiversity. The effects on the global climate and weather systems from centuries of burning fossil fuels include increased frequency and severity of extreme events such as floods, heatwaves and wildfires, which are expected to continue to be experienced in future decades. However, stopping burning coal, oil and gas by 2030 will help to mitigate the severity of future climate-related disasters.

A transition to renewable energy brings substantial environmental benefits. If all 13 manufacturers in the study were to achieve 100% renewable energy by 2030, their combined CO_2 emissions for the year 2030 could reduce by 231.6 million tonnes. The reduction in emissions would significantly exceed the total emissions of the Netherlands in 2022.[8]

A transition to renewable energy has the potential to bring financial benefits to suppliers. If all 13 manufacturers were to achieve 100% renewable energy by 2030, they could reduce their expenses by a combined 20.12 billion USD in 2030.

Of all the 13 firms analysed in this report, Samsung Electronics could achieve the most significant emissions reductions and financial savings by adopting renewables. By committing to 100% renewable energy by 2030, Samsung Electronics could reduce its carbon emissions in 2030 by 161.96 million tonnes, more than the total emissions of Chile in 2022.[9] By transitioning to 100% renewable energy by 2030, Samsung could save 12.45 billion USD in the year 2030 alone.

Among the 13 manufacturers, UMC currently has the lowest proportion of renewable energy usage, at 0.15% in 2022, and urgently needs to accelerate its adoption of renewable energy. UMC would save 195.15 million USD in 2030 by achieving 100% renewable energy by the end of the decade.

Table 1 shows the economic savings and emissions reduction potential for each of the 13 companies if they were each to achieve 100% renewable energy by 2030.

8 European Commission (2023). GHG emissions of all world countries. Retrieved May 20, 2024, from https://edgar.jrc.ec.europa.eu/report_2023

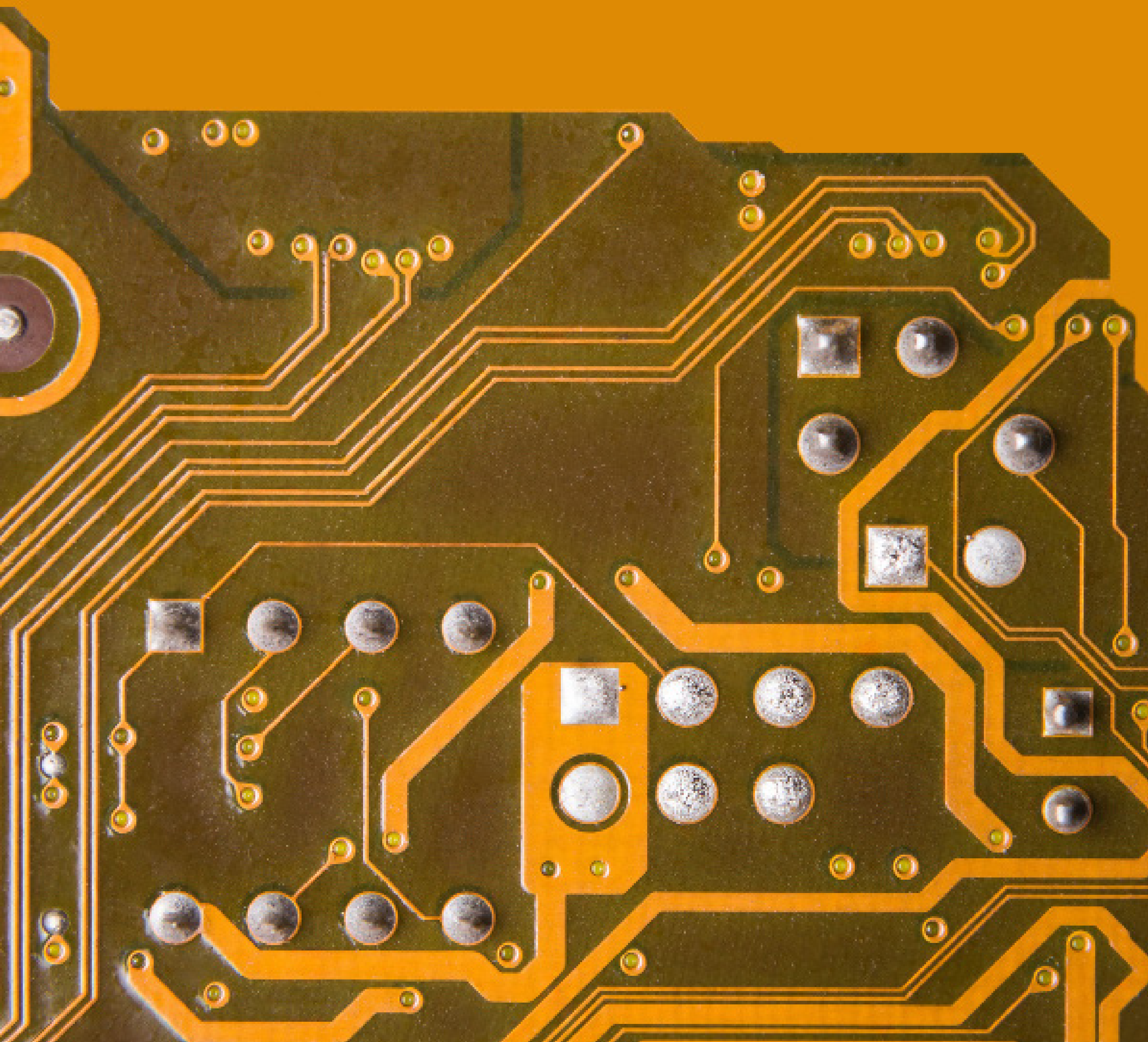
9 European Commission (2023). GHG emissions of all world countries. Retrieved May 20, 2024, from https://edgar.jrc.ec.europa.eu/report_2023

Table 1.

Summary of potential emissions and economic savings from companies by transitioning to 100% renewable energy in 2030.

Company	Emissions avoided (million tonnes of CO_2)	Economic saving (million USD)
tsmc	10.22	540.92
SAMSUNG	161.96	12445.09
SK hynix	12.80	1833.27
LUXSHARE ICT	5.27	351.98
Goertek	0.77	87.42
FOXCONN 鴻海科技集團	3.61	569.14
PEGATRON	0.55	127.37
SAMSUNG DISPLAY	10.90	1491.86
LG Display	6.47	1321.43
BOE	7.91	595.82
AUO	3.66	273.69
UMC	3.54	195.15
INNOLUX	3.94	294.93

The rising cost of fossil fuels



The rising cost of fossil fuels

Globally, renewable energy has become one of the cheapest forms of energy. In 2022, the levelized cost of electricity (LCOE) from newly commissioned utility-scale renewable energy projects decreased year on year.[10] In 2023, the LCOE for utility photovoltaic (PV) solar power dropped by an average of 23% across Asia Pacific, which in turn has put more pressure on the cost of fossil fuels, such as gas and coal.[11]

Further, carbon prices across multiple emissions trading systems worldwide are expected to increase during the period from 2026 to 2030, in comparison to the period from 2022 to 2026. The average European Union emissions trading system (EU ETS) carbon price is expected to be 84.4 euros per tonne of CO_2 during the period from 2022 to 2025, but is projected to rise to almost 100 euros per tonne of CO_2 during the period from 2026 to 2030.[12]

Regulatory pressure to reduce carbon emissions is intensifying globally as governments implement strict emissions regulations and provide incentives for the adoption of renewable energy. Companies that actively transition to renewable energy sources will be better able to comply with the new regulations, avoid potential fines, and benefit from government incentives, thereby improving their overall market competitiveness.

Figure 1 illustrates the anticipated surge in costs resulting from tightened environmental regulations on the electronics sector, specifically the carbon-related expenses stemming from projected carbon price hikes by 2050. A transition to renewable energy would assist firms in averting such costs, thereby optimizing their cost–benefit ratios.

10 Irena (2022). Renewable Power Generation Costs in 2022. Retrieved May 20, 2024, from https://www.irena.org/Publications/2023/Aug/Renewable-Power-Generation-Costs-in-2022#:~:text=For%20newly%20commissioned%20onshore%20wind,2022%20to%20USD%200.049%2FkWh.

11 Wood Mackenzie (2024). Solar inflation reverses as renewable costs in Asia reach all-time low. Retrieved May 20, 2024, from https://www.woodmac.com/press-releases/asia-lcoe/

12 Statistica (2024). Average carbon price expectations worldwide from 2022 to 2030, by trading system. Retrieved May 20, 2024, from https://www.statista.com/statistics/1334906/average-carbon-price-projections-worldwide-by-region/

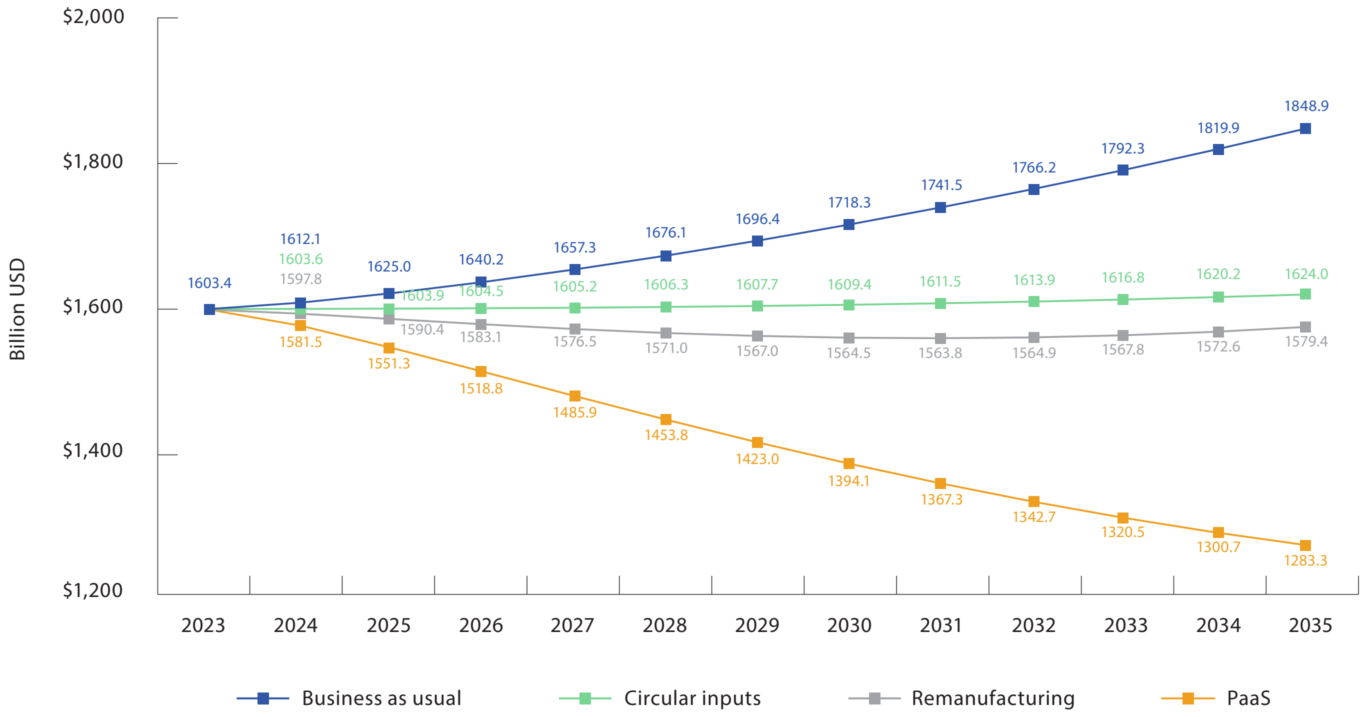


Figure 1.
The projected cost increase due to reinforced environmental regulation on the electronics industry. PaaS: product-as-a-service
Source: PWC, 2023.[13]

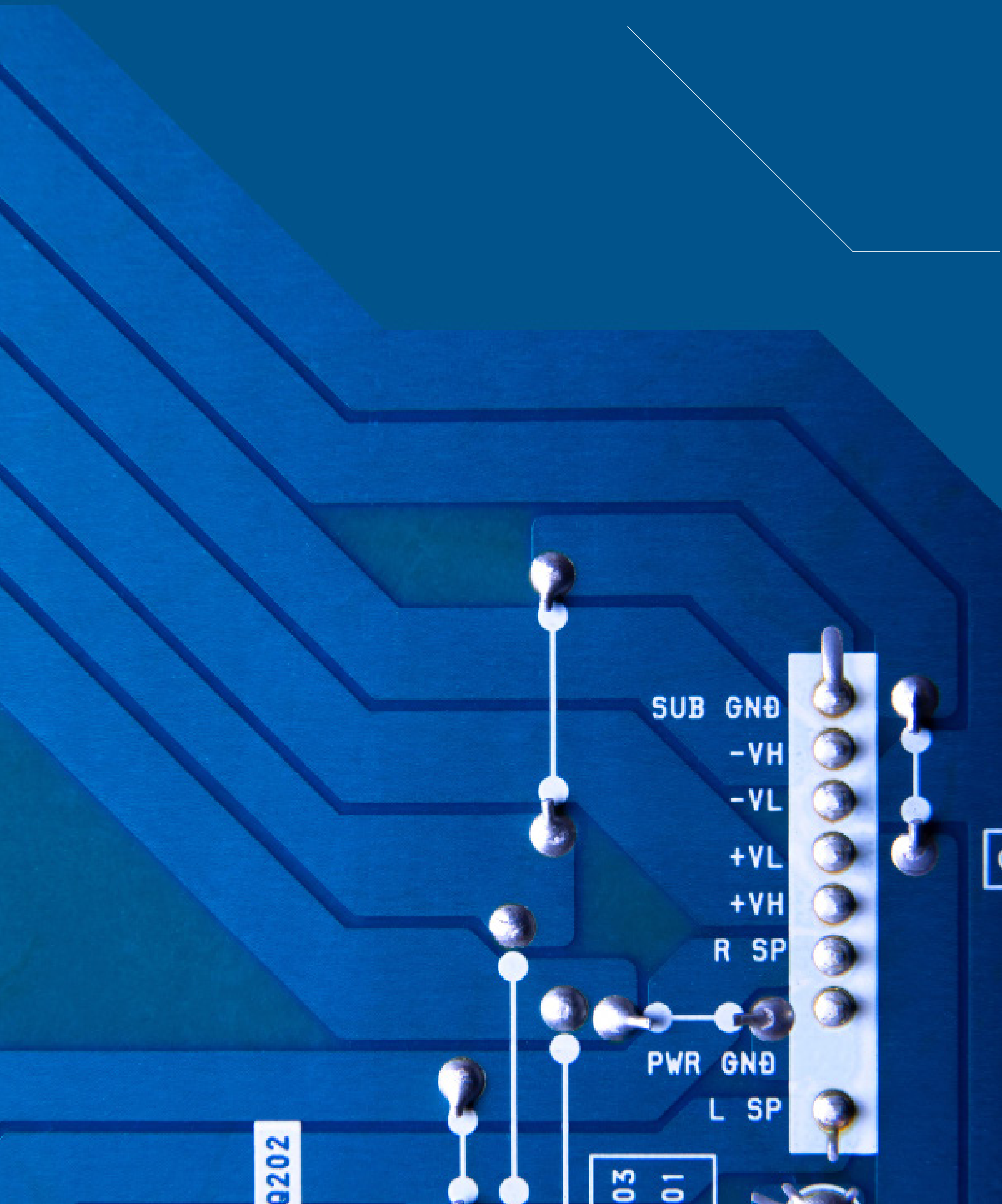
In addition, the reinforcement of disclosure and audit tools may potentially elevate the climate-related expenses incurred by electronics firms. There are increasing requirements from internationally respected environmental audits and initiatives for the electronics industry, such as:

- ISO 14001
- Global Reporting Initiative (GRI) G3 guidelines
- UN Global Compact
- SA 8000, for social responsibility
- Business Social Compliance Initiative's code of conduct
- Electronics Industry Citizenship Coalition (EICC)
- RE100
- TCFD Climate-related disclosures

As a result of rising costs from audits, disclosures and climate regulations, 100% renewable energy pledges can help to bolster economic competitiveness by avoiding regulatory costs and reducing energy-related costs.

13 PWC, 2023. Future Proofing the Electronics Industry: The case for circular business models

Methodology and data



Definition and indicators for supply chain environmental competitiveness

This study applies a cost–benefit analysis (CBA)[14] to present the competitiveness improvement from adopting a 100% renewable energy transition.

To provide concise and clear information to stakeholders and policymakers, this study defines the supply chain competitiveness as an equation, shown below, as the ratio between benefits and costs in the supply chain, with a focus on energy and related emissions and pollution.

$$\text{SC competitiveness} = \frac{\text{Benefits}}{\text{Cost}}$$

The costs and benefits can further be divided into two value categories: (i) economic; and (ii) environment and social. A valuation method was used to realize the valuation of different cost–benefit indicators.

- Economic
  For the economic benefit indicator, we select revenue as an indicator for the economic benefit of a company. For cost, we select energy purchase cost, including fossil fuel-based electricity and renewable energy electricity cost.
- Environment and social
  This study will refer to the environmental profit and loss (EP&L) mindset[15] approach to make the valuation on social costs from the impacts of environmental pollution and resource depletion. The social cost of pollutants and emissions, such as the emissions trading system (ETS) market price for CO_2 emissions, is applied to quantify the social cost derived from related environmental impacts. The major considerations are CO_2 emissions and air pollutants. The air pollutants are only considered where data are available.

Based on the above theory and indicators, we developed a supply chain environmental competitiveness index (SCEC) to illustrate the cost–benefit analysis associated with the renewable energy (RE) transition for companies. Table 2 summarizes the indicators used to calculate the SCEC index, along with their respective explanations and calculation methods. Our primary focus is on the cost–benefit analysis associated with materials consumption, energy consumption, CO_2 emissions, air pollutants, and revenue generated during the manufacturing stage of the selected companies. It is important to note that when a company engages in multiple markets, localized values will be considered for each indicator calculation.

14 Investopedia (2024). What Is Cost-Benefit Analysis, How Is it Used, What Are its Pros and Cons? Retrieved May 20, 2024, from https://www.investopedia.com/terms/c/cost-benefitanalysis.asp

15 Ecochain (2023).What's an Environmental Profit & Loss account? And how do companies use it?. Retrieved May 20, 2024, from https://ecochain.com/blog/what-is-an-environmental-profit-and-loss-account/

Table 2.
A summary of indicators for calculations on the supply chain environmental competitiveness index (SCEC).

Indicator	Unit	Source and calculation
Revenue (a)	Billion USD	Firm's sustainability report
Energy consumption (b)	GWh	Firm's sustainability report
Renewable energy used (c)	%	=RE consumption/ total electricity consumption
Fossil fuel Electricity price (d)	USD/MWh	Statistics or literature
Fossil fuel cost (e)	MUSD	=b*(1-RE%)*d
RE electricity cost (f)	USD/MWh	Statistics or literature
RE cost (g)	MUSD	=b*(RE%)*f
Total energy cost (h)	MUSD	=e+g
CO_2 emission (i)	t	=b*(1-RE%)* (emission/non RE energy consume)+ b*(RE%)*(emission per RE (ton/kWh))
CO_2 price (j)	USD/t	ETS market price (ETS market prices)
CO_2 cost (k)	MUSD	= i*j/1000000
Env-socio cost (m)	MUSD	=k
Revenue (a)	billion USD	=a
Total cost (TC)	billion USD	=(h+m)/1000
SCEC index	-	=a/TC

The carbon intensity of fossil fuel-based electricity (FE) or renewable energy-based electricity (RE) can be estimated based on the life cycle assessment of the power system (Figure 2) and the process balance model for calculating the inputs and outputs inventory for each process on life cycles (Figure 3).

The Appendix lists the carbon emission intensity of different electricity sources.

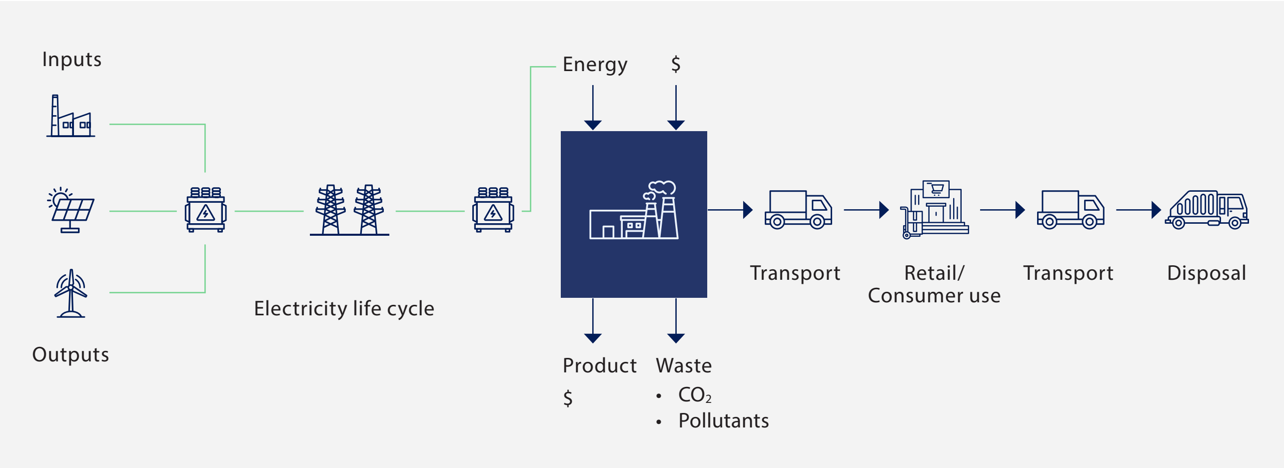
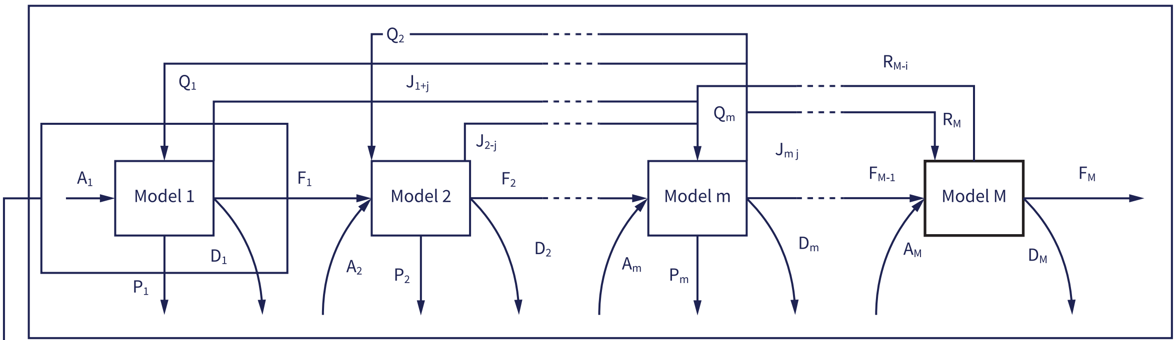
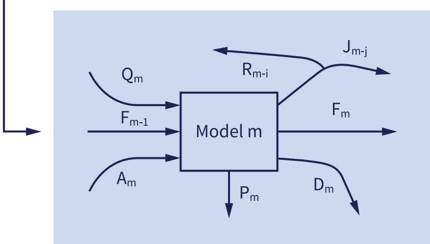


Figure 2.
The schematic shows the scope of this study under the life cycle of the electronics industry and the basis of the calculations for electricity carbon emissions.





$$A_m + Q_m + F_{m-1} = R_m + F_m + J_m + P_m + D_m$$

$$\sum A_m = \sum (D_m + P_m) + F_M$$

$$F_m = \sum_{1}^{t=m} A_t + \sum_{1}^{y=m} (\sum_{i}^{t} R_{y,m} + \sum_{1}^{t} J_{y,m}))w_m^F$$

Figure 3.
The process balance model used for calculating the values in life cycles.

Data and materials

Environmental data

The fossil fuel electricity prices and the renewable energy electricity prices in global regions by 2050 are summarized in the Appendix in Figures S-1 to S-4. We also summarize the lifecycle carbon emission intensity for fossil fuel and renewable electricity (Figure S-5) and the carbon prices, which were based on the global ETS market price at the time of writing (Figure S-3).

To better reflect market conditions, fossil fuel electricity prices and renewable electricity prices are treated as follows:

The by-region market prices are set as benchmark values. Levelized cost of energy (LCOE) trends of fossil and renewable electricity (PV and wind) are applied to reflect price changes in fossil fuel-based and renewable electricity prices by global region from 2022 to 2050.

Table 3.
Projected electricity prices by global region (USD/MWh).

		2022	2025	2030	2050
China mainland	Coal-fired	91	90	90	88
	Renewables	66	48	31	22
Japan & South Korea	Natural Gas	128	134	140	152
	Renewables	85	62	40	28
Europe	Natural Gas	190	200	207	226
	Renewables	52	36	24	17
North America	Natural Gas	67	70	73	80
	Renewables	50	37	24	17
Taiwan	Natural Gas	103	109	113	123
	Renewables	173	126	81	57
Rest of the world	Natural Gas	107	112	117	127
	Renewables	70	51	33	23

Table 4.
Projected carbon prices by region, USD/tonnes.

	2020	2025	2030	2040	2050
FU ETS	93	93	110	144	179
UK ETS	87	87	102	132	161
China ETS	30	30	45	73	102
New Zealand ETS	50	50	63	90	117
South Korea ETS	43	43	58	89	119
RGGI**	35	35	50	80	110
WCI (California-Quebec)	43	43	57	84	111
Global Emission Offsets (GEO)	22	22	32	52	72

Source: See the Appendix

Electronics firms

Thirteen of the biggest East Asian suppliers of the world's top consumer electronics brands (TSMC, Samsung Electronics, SK hynix, Luxshare Precision, Goertek, Foxconn, Pegatron, Samsung Display, LG Display, BOE, AUO, UMC and Innolux) were selected to calculate the SCEC index, with the emphasis on their manufacturing stage. Companies' Scope 3 emissions were also included in the calculation. Each company's sustainability report, ESG report or TCFD report was the major data source.[16,17] Data from 2022 were used as the baseline year for comparisons.

Renewable energy scenarios

Most of the 13 firms have joined RE100 initiatives and have committed to renewable energy targets, as summarized in Table 4. A detailed summary of the 100% renewable energy targets is summarized in Table 5.

As stated above, 2022 was set as the baseline year because some firms do not publish 2023 data until their 2024 reports. Each firm's committed renewable energy target was used as the business as usual (BAU) scenario, and an advanced 100% renewable energy target realized by 2030 was set as the advanced 100% RE scenario. The cost–benefits under the scenarios were compared. The values in 2022 were calculated based on each company's reported energy consumption condition.

Assumptions were made in the calculations for the BAU scenario:

(1) If a company had not issued a commitment to 100% renewable energy and/or a mid-term renewable energy target, then we assigned the renewable energy ratio of that company in the most recent year, 2022, to the future projection for 2050 and/or the mid-term renewable energy target.

(2) We assigned a mid-range target to 2050 for the companies that had issued a mid-term renewable energy target but did not issue a commitment to 100% RE.

16 Company data have been verified with the companies in this report.
17 BOE, Goertek and Foxconn did not respond to the data verification inquiry from Greenpeace East Asia

Table 5.
Summary of renewable energy scenarios for the 13 firms in the analysis.

Company	Baseline	BAU Scenario		100% RE scenario	
	2022	2030	2050	2030	2050
TSMC*	10%	60%	100%	100%	100%
Samsung Electronics	31%	31%**	100%	100%	100%
SK hynix	29.6%	33%	100%	100%	100%
Luxshare Precision	24%	50%***	50%	100%	100%
Goertek	6%	6%	6%	100%	100%
Foxconn****	8%	50%	100%	100%	100%
Pegatron	19%	50%	50%	100%	100%
Samsung Display	21%	21%	100%	100%	100%
LG Display	13%	13%	13%	100%	100%
BOE	0.98%	0.98%	0.98%	100%	100%
AUO	1.16%	30%	100%	100%	100%
UMC	0.15%	50%	100%	100%	100%
Innolux	0.4%	20%	20%	100%	100%

BAU, business as usual; RE, renewable energy.

* TSMC committed to realize 100% renewable energy by 2040. The baseline and BAU values are Taiwan sites. They realize 100% renewable energy for other sites.

** Samsung Electronics has not issued a global mid-term target for Samsung Electronics Group, although the company has targeted to achieve 100% renewable energy for its DX department which the ratio of electricity usage was 10% of the total electricity consumption of Samsung Electronics. The research applied its 2022 renewable energy ratio to its 2030 renewable energy target.

***Luxshare Precision aims to achieve 50% renewable energy by 2025. The company has not yet issued a 100% renewable energy target.

**** In April 2024, Foxconn updated its commitment to realize 100% renewable energy by 2040.

Revenue

Revenue is the basic value to determine the production volume and the associated energy consumption scenarios. According to multiple sources, the consumer electronics market is projected to experience an annual growth rate of 2.99% from 2024 to 2028 (CAGR 2024–2028). Details are displayed in the Appendix. Based on this percentage value, we set an annual market growth rate at 3% and used that value to estimate the revenue and energy consumed for each scenario with the following coefficients. We assume the same revenue and energy consumption growth for both BAU and RE scenarios.

Limitations of the research and uncertainty of the analytical results

- Scope 1,2,3 matching revenue

  This study employs a cost-benefit analysis to assess the competitiveness of the supply chain. Revenue and the costs associated with energy and emissions constitute two significant factors. To align with a company's revenue, we incorporate Scope 1, 2, and 3 emissions (encompassing the entire supply chain). These emissions are sourced from a company's disclosures, such as sustainability or ESG reports, and/or CDP reports. Using the 2022 emissions value as a benchmark, we simulate CO_2 emissions based on variations in energy consumption across different renewable energy (RE) scenarios. These simulated values represent an ideal scenario for CO_2 emissions reduction throughout the supply chain, facilitated by the energy transition.

- Scope 3 reporting

  We acknowledge the inherent limitations and uncertainties associated with our results. Scope 3 emissions disclosure remains limited across various industries, a widely recognized fact. This study exclusively utilizes reported emissions from companies with consultancy and verification. It lacks further detailed analysis on the categories of Scope 3 emissions and their justifications. Scope 3 emissions are typically underestimated in disclosures due to challenges in data collection. Another uncertainty arises from simulating the relationship between energy consumption and CO_2 emissions. Given the characteristics of the electronics industry, the primary energy consumption is electricity. Scope 2 emissions constitute a significant portion of the total emissions. Consequently, the simulation provides a reliable representation of the CO_2 emissions trend. However, the absolute value should be interpreted as an ideal reference point.

  There was an additional limitation in that practices for disclosure of scope 3 emissions varied across companies. Going forward, it is necessary to improve the transparency of corporate information disclosure through strengthening global climate disclosure regulations.

18 Foxconn (2024).Hon Hai Technology Group (Foxconn) Pledges 100% Renewable Electricity By 2040 and Joins RE100. Retrieved May 20, 2024, from https://www.foxconn.com/en-us/press-center/events/csr-events/1322

19 Statistica (2024).Consumer Electronics - Worldwide. Retrieved May 20, 2024, from https://www.statista.com/outlook/cmo/consumer-electronics/worldwide

Results by company

TSMC

TSMC has a target to achieve 100% renewable energy by 2040.

If TSMC were to achieve its current target – 100% renewable energy by 2040 – it could emit 10.47 million tonnes of CO_2 by 2030. By comparison, if TSMC were to achieve 100% renewable energy by 2030, 10.22 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy by 2030, TSMC could save 540.92 million USD by 2030. The savings would be largely from the avoidance of carbon tax and an increase in the price of fossil fuels.

If TSMC transitioned to 100% renewable energy by 2030, the SCEC index value could increase to 43 in 2030. The company's SCEC index was 28 in 2022.

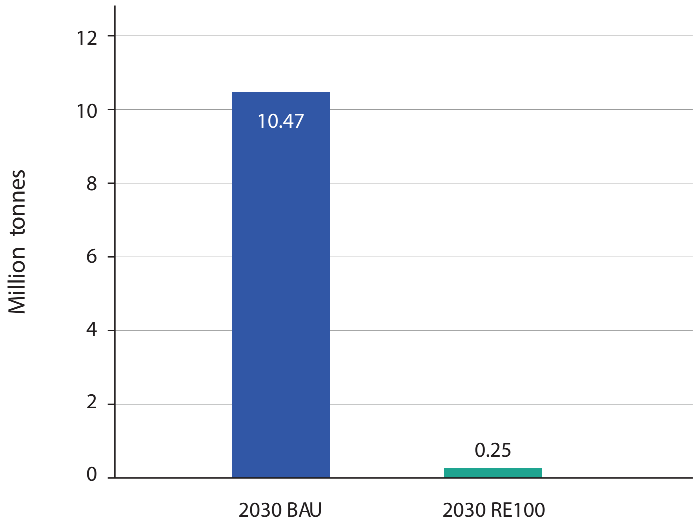


Figure 4.
The projected CO_2 emissions by TSMC in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

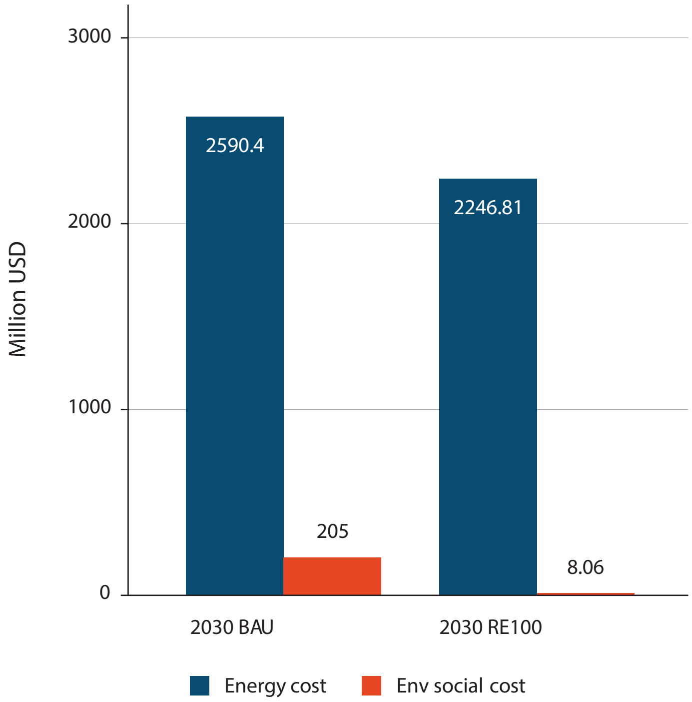


Figure 5.
The projected energy cost and environmental and social cost for TSMC under 100% renewable energy (RE100) scenarios in 2030.

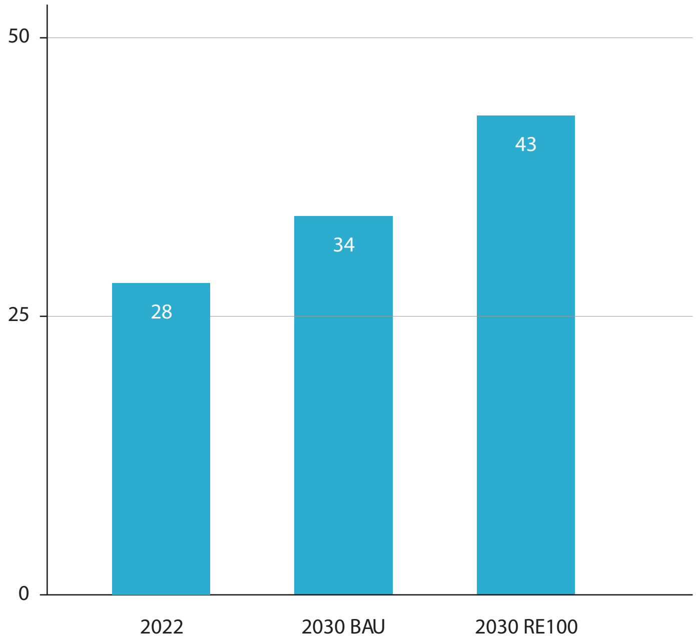


Figure 6.
The supply chain environmental competitiveness (SCEC) value trend for TSMC in 2022, and projected values for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Samsung Electronics

Samsung Electronics has a target to achieve 100% renewable energy by 2050.

If Samsung Electronics were to achieve its current target, it could emit 162.35 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 161.96 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy by 2030, Samsung Electronics could save 12.45 billion USD in 2030. The savings would largely be from the avoidance of carbon tax and the increase in the price of fossil fuels.

If Samsung Electronics could achieve 100% renewable energy by 2030, its supply chain environmental competitiveness (SCEC) value could significantly increase to 175.20 by 2030, which is 7.0 times its 2022 SCEC value.

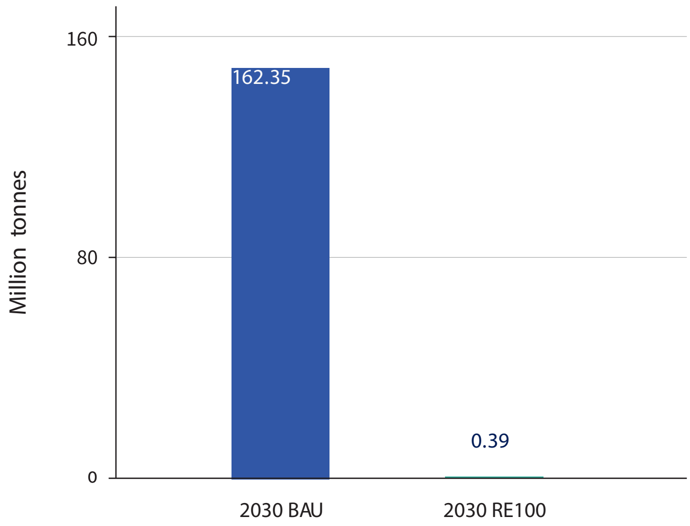


Figure 7.
The projected CO_2 emissions by Samsung Electronics in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

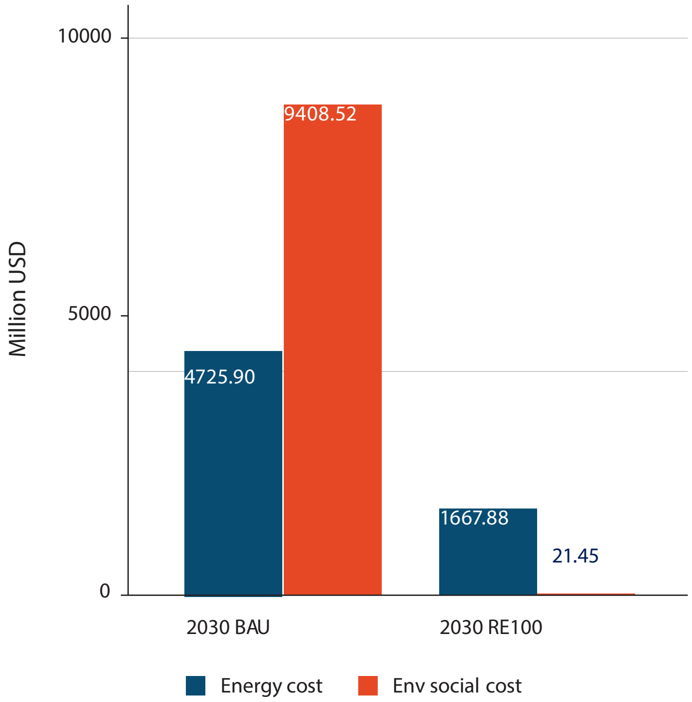


Figure 8.
The projected energy cost and environmental social cost for Samsung Electronics under business as usual (BAU) and 100% renewable energy (RE100) scenarios in 2030.

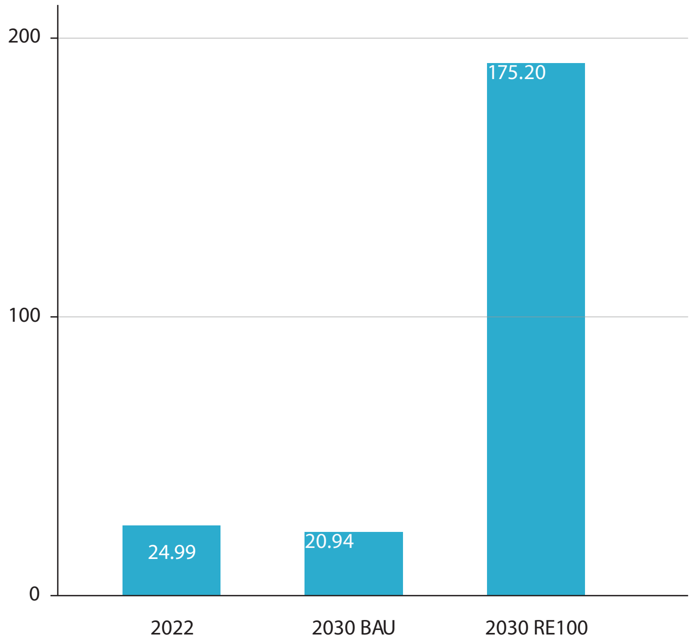


Figure 9.
The supply chain environmental competitiveness (SCEC) value trends for Samsung Electronics in 2022, and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

SK hynix

SK hynix has a target to achieve 100% renewable energy by 2050.

If SK hynix were to achieve its current target, it could emit 12.94 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 12.80 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, SK hynix could save 1.83 billion USD in 2030. The savings would be largely from the avoidance of carbon tax and the increase in the price of fossil fuels.

If SK hynix could achieve 100% renewable energy, the supply chain environmental competitiveness (SCEC) value could increase to 66.10 by 2030, which is 3.7 times the 2022 value.

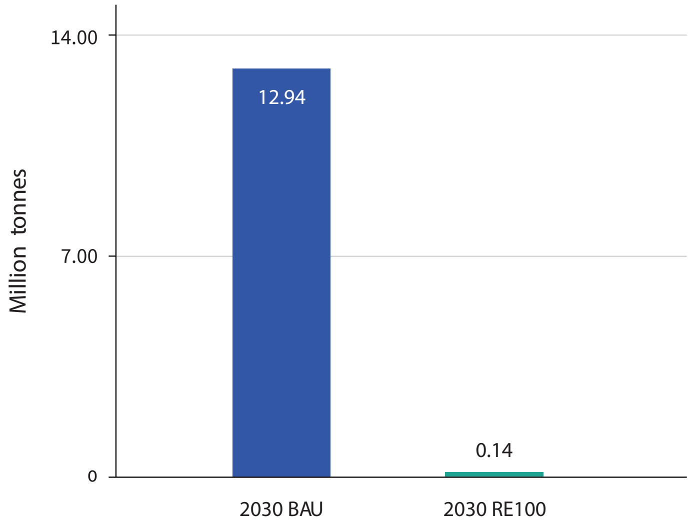


Figure 10.
The projected CO_2 emissions for SK hynix in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

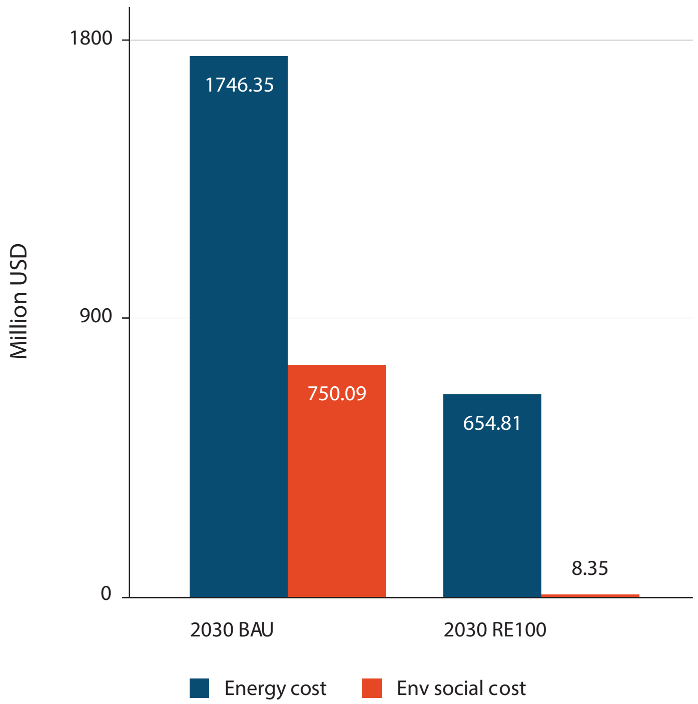


Figure 11.
The projected energy cost and environmental and social cost for SK hynix under business as usual (BAU) and 100% renewable energy (RE100) scenarios in 2030.

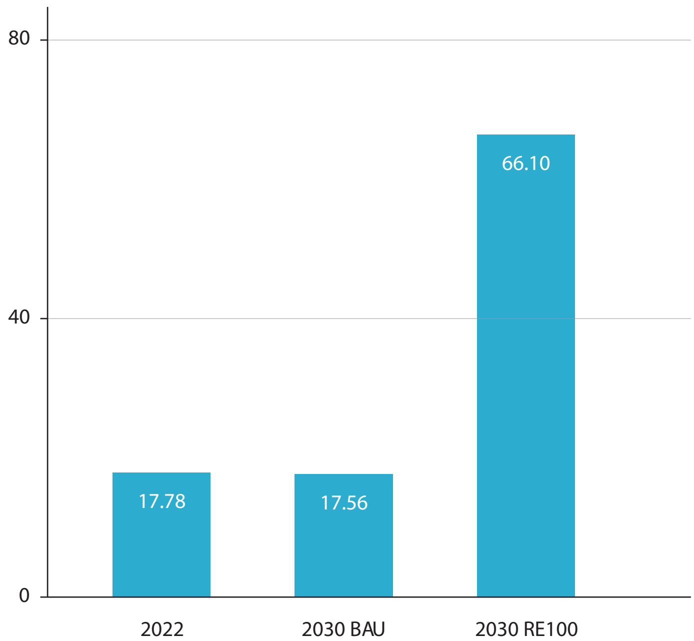


Figure 12.
The supply chain environmental competitiveness (SCEC) value trend for SK hynix in 2022, and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Luxshare Precision

Luxshare Precision has a target to achieve 50% renewable energy by 2025, but the company has not yet issued a 100% renewable energy target.

If Luxshare Precision were to maintain its current target to achieve 50% renewable energy by 2025, it could emit 5.30 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 5.27 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy by 2030, Luxshare Precision could save 351.98 million USD in 2030. The savings would be largely from the avoidance of carbon tax and an increase in the price of fossil fuels.

If Luxshare Precision could achieve 100% renewable energy by 2030, the supply chain environmental competitiveness (SCEC) value could significantly increase to 317.48, which is 4.7 times its 2022 SCEC value.

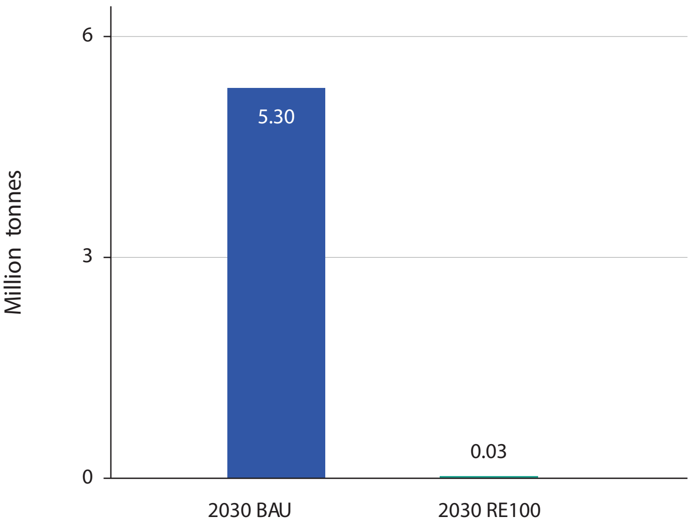


Figure 13.
The projected CO_2 emissions for Luxshare Precision in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

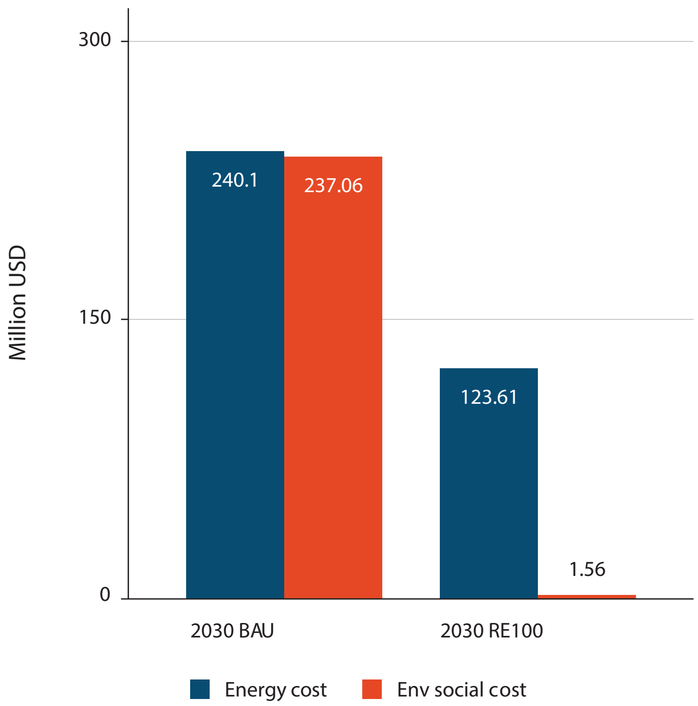


Figure 14.
The projected energy cost and environmental and social cost for Luxshare Precision in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

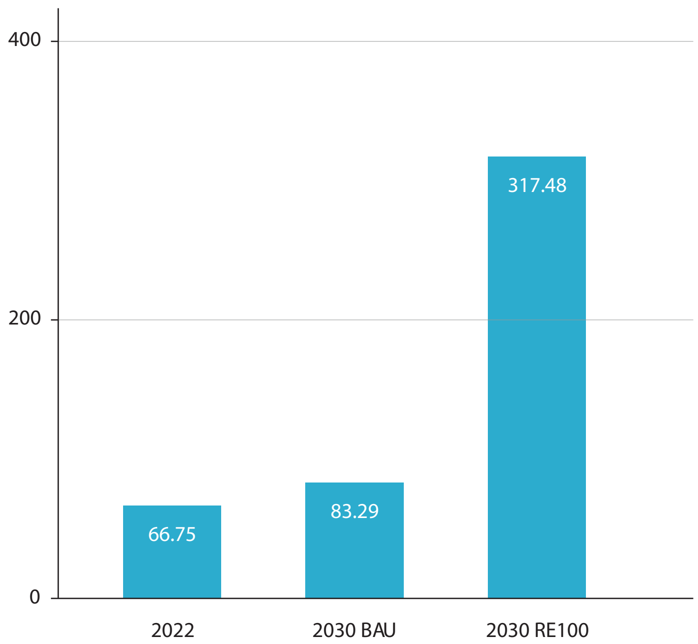


Figure 15.
The supply chain environmental competitiveness (SCEC) value trends for Luxshare Precision in 2022 and projections for 2030 under the business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Goertek

Goertek has not yet issued a 100% renewable energy target.

If Goertek were to achieve 100% renewable energy by 2050, the company could emit 0.78 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 0.77 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, Goertek could save 87.42 million USD in 2030. These savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The supply chain environmental competitiveness (SCEC) value could increase to 628.25 in the 2030 renewable energy (RE) scenario, which is 3.6 times its 2022 SCEC value.

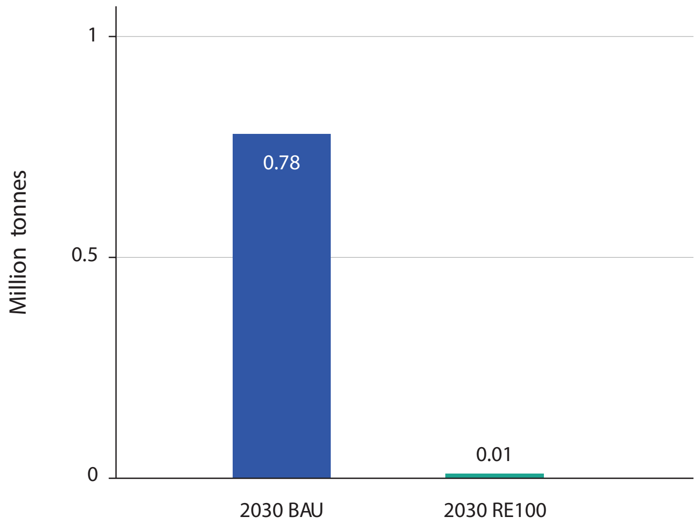


Figure 16.
The projected CO_2 emissions for Goertek in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

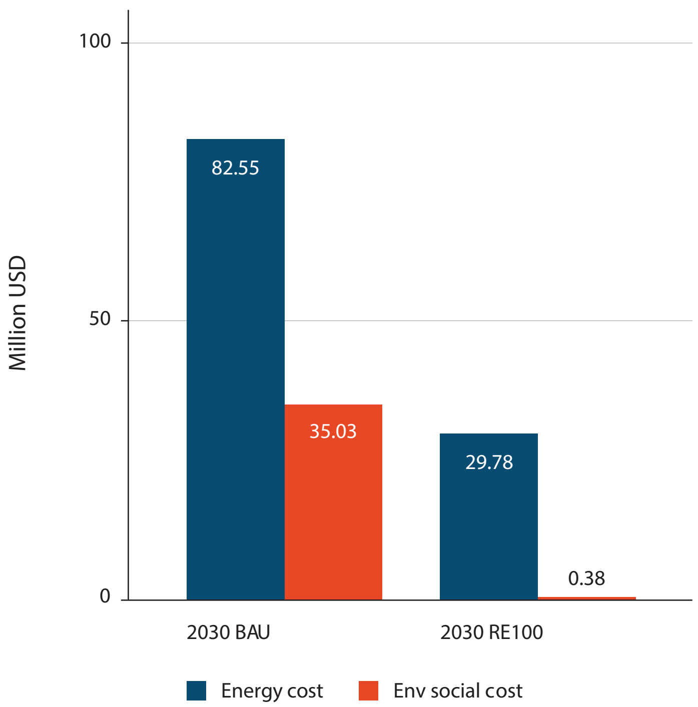


Figure 17.
The projections for Goertek for energy cost and environmental and social cost in 2030 under bus

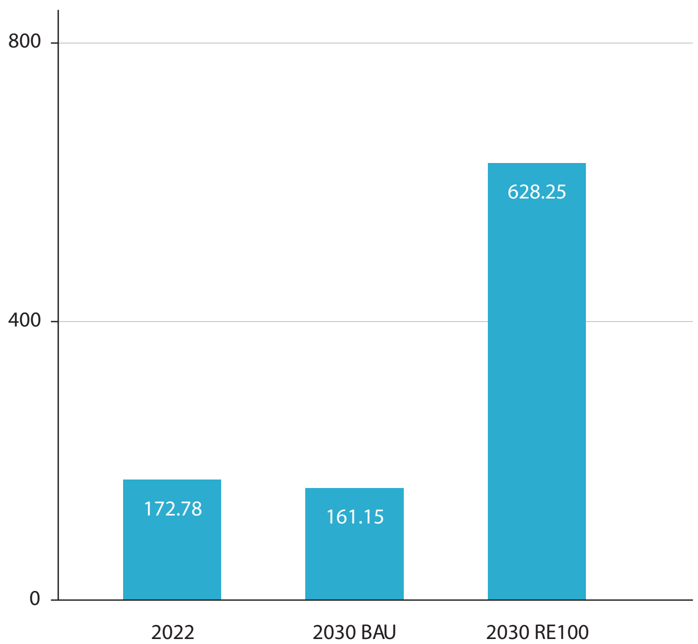


Figure 18.
The supply chain environmental competitiveness (SCEC) values for Goertek in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Foxconn

Foxconn has a target to achieve 100% renewable energy by 2040.

If Foxconn were to achieve its current target, it could emit 3.73 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 3.61 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, Foxconn could save 569.14 million USD in 2030. The savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

Foxconn's SCEC could increase to 605.88 in the 2030 100% RE scenario, which is 3.2 times its 2022 SCEC value.

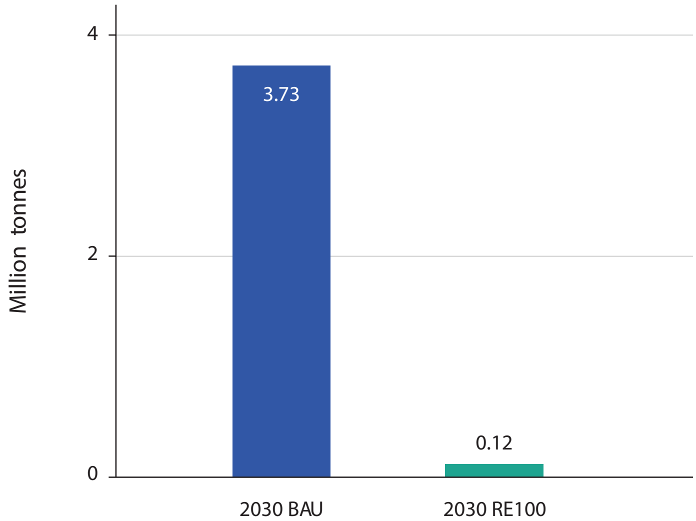


Figure 19.
The projected CO_2 emissions for Foxconn in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

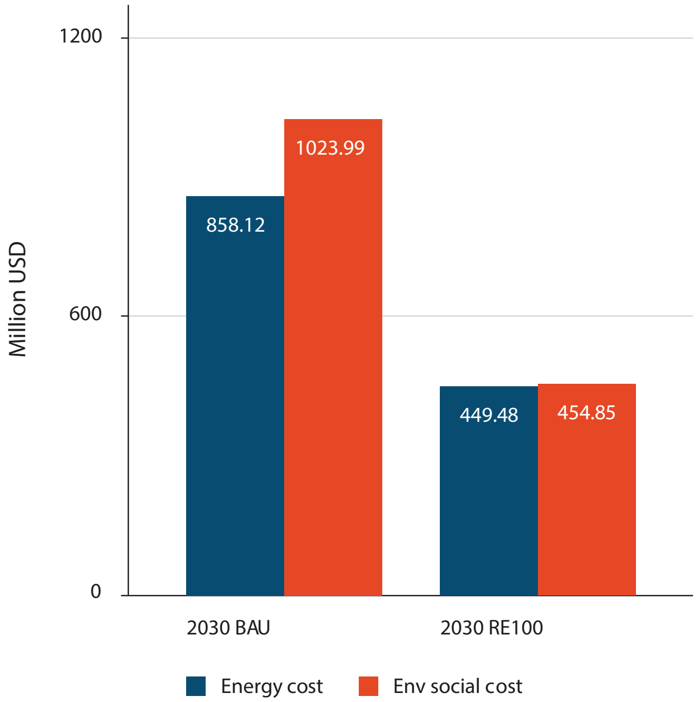


Figure 20.
The energy cost and the environmental and social cost projections for Foxconn in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

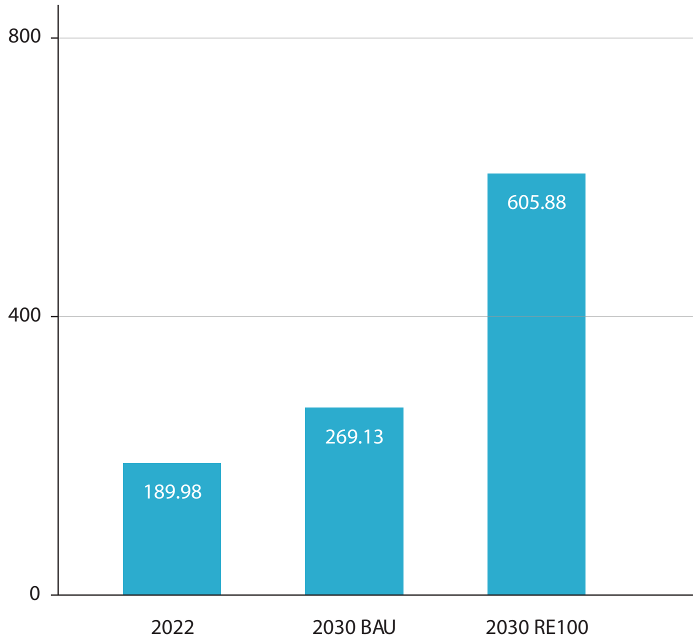


Figure 21.
The supply chain environmental competitiveness (SCEC) values for Foxconn in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Pegatron

Pegatron has not yet issued a 100% renewable energy target.

If Pegatron were to maintain its current renewable energy ratio, it could emit 0.56 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 0.55 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy by 2030, Pegatron could save 127.37 million USD in 2030. These savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC value could increase to 1,039.89 by 2030, which is 3.2 times its current SCEC value.

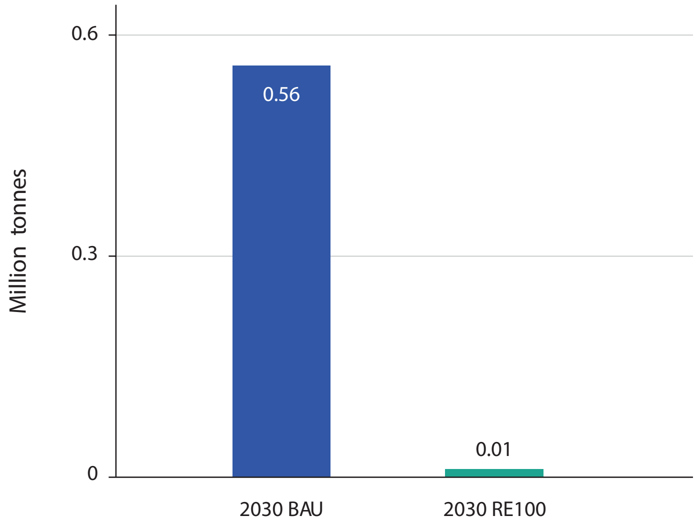


Figure 22.
The projected CO_2 emissions for Pegatron in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

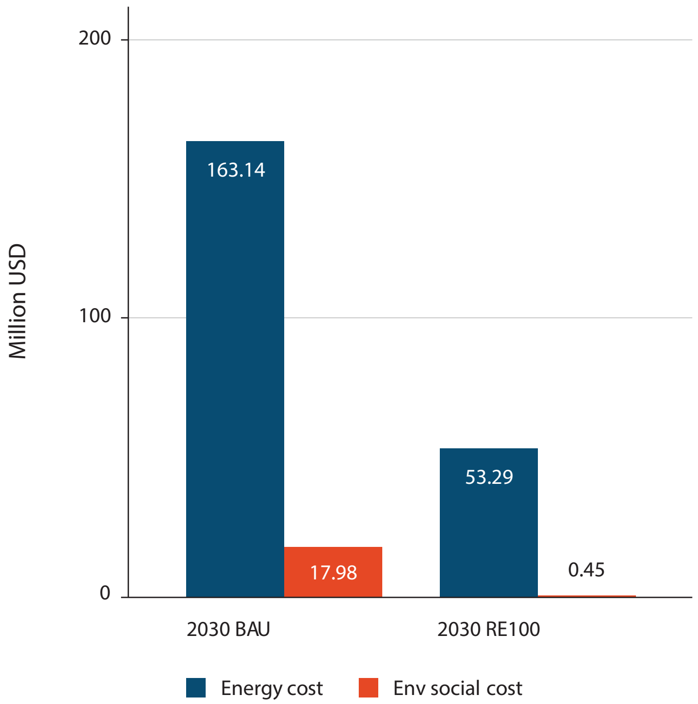


Figure 23.
The projected energy cost and environmental and social cost for Pegatron in 2030 under business as usual (BAU) 100% renewable energy (RE100) scenarios.

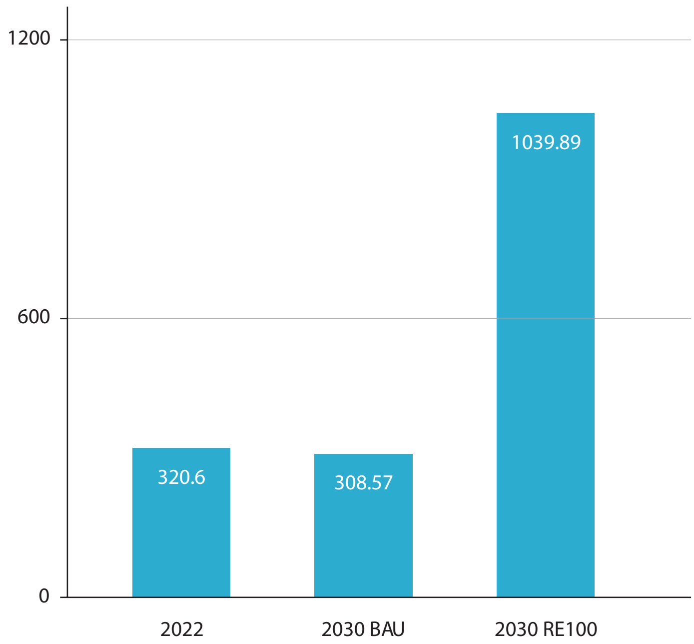


Figure 24.
The supply chain environmental competitiveness (SCEC) values for Pegatron in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Samsung Display

Samsung Display has a target to achieve 100% renewable energy by 2050.

If Samsung Display were to achieve its current target, it could emit 11 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 10.90 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, Samsung Display could save 1.49 billion USD in 2030. These savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC value could increase to 97.88 by 2030, which is 4.0 times its 2022 SCEC value.

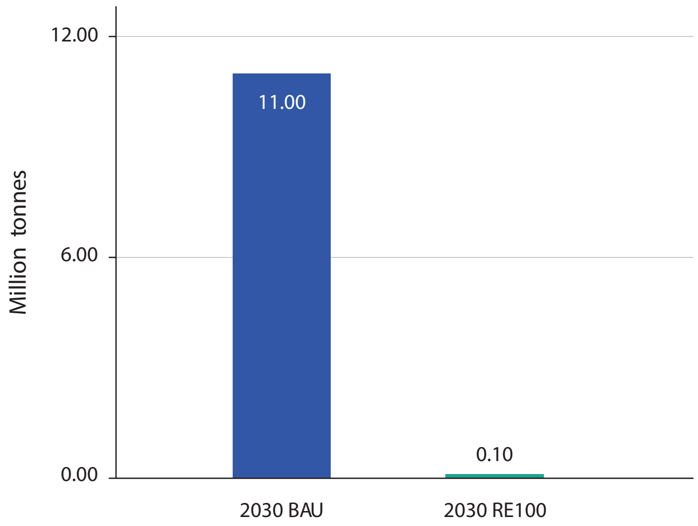


Figure 25.
The projected CO_2 emissions in 2030 for Samsung Display under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

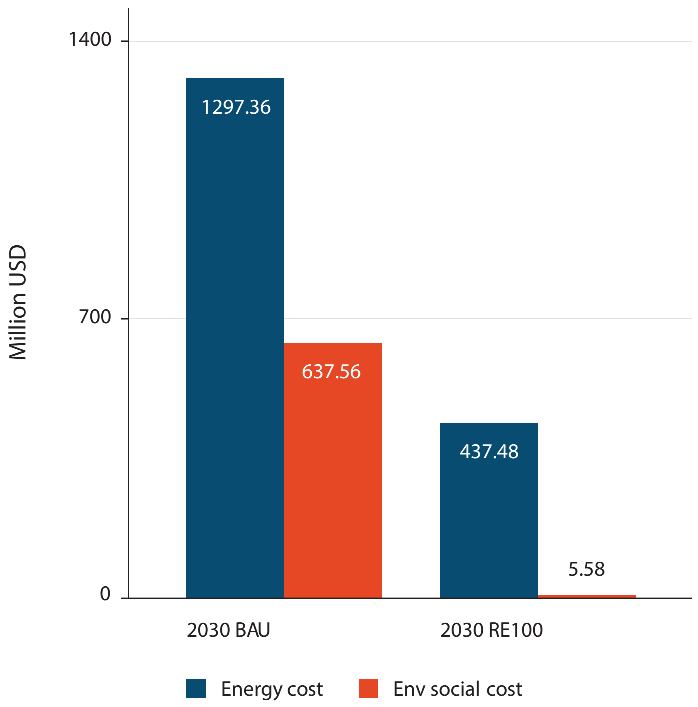


Figure 26.
The projected energy cost and environmental and social cost for Samsung Display under business as usual (BAU) and 100% renewable energy (RE100) scenarios in 2030.

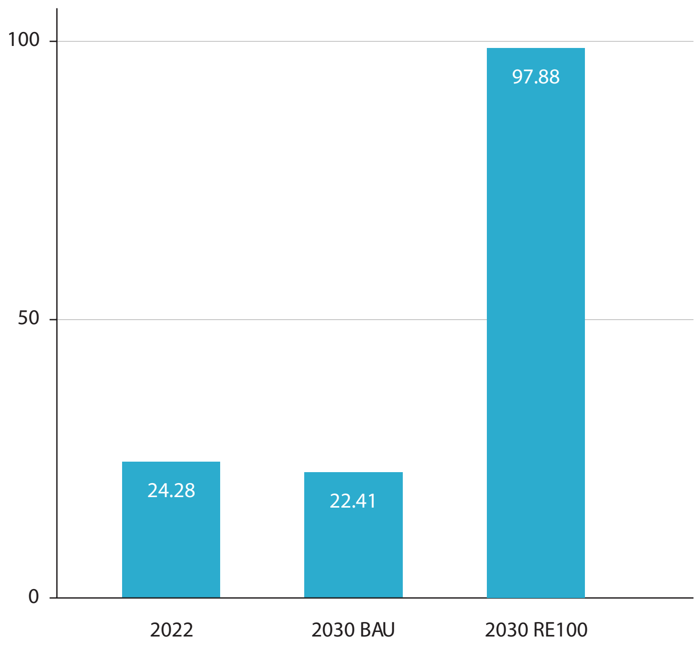


Figure 27.
The supply chain environmental competitiveness (SCEC) values for Samsung Display in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

LG Display

LG Display has not yet issued a 100% renewable energy target.

If LG Display were to maintain its current renewable energy ratio, it could emit 6.56 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 6.47 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, LG Display could save 1.32 billion USD in 2030. These savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC index value could increase to 57.93 by 2030, which is 3.7 times its 2022 SCEC value.

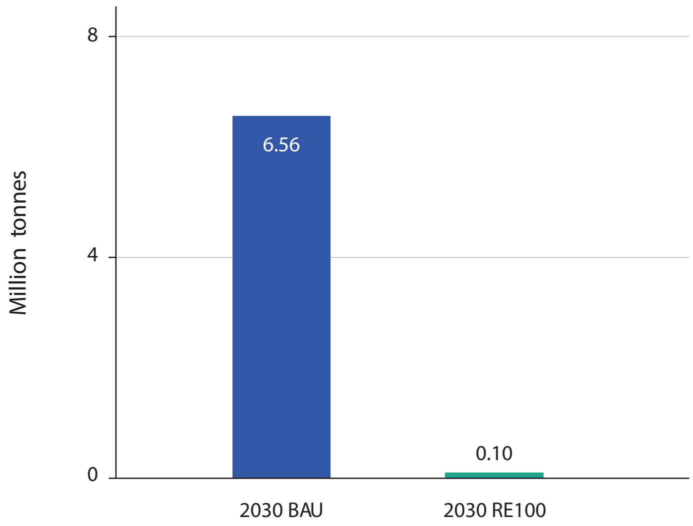


Figure 28.
The projected CO_2 emissions for LG Display in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

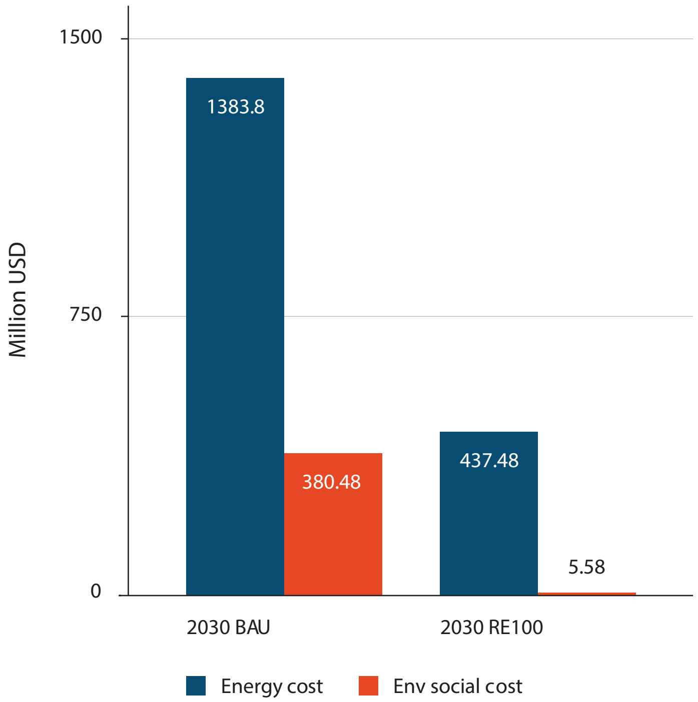


Figure 29.
The projected energy cost and environmental and social cost for LG Display in 2030 under business as usual (BAU) 100% renewable energy (RE100) scenarios.

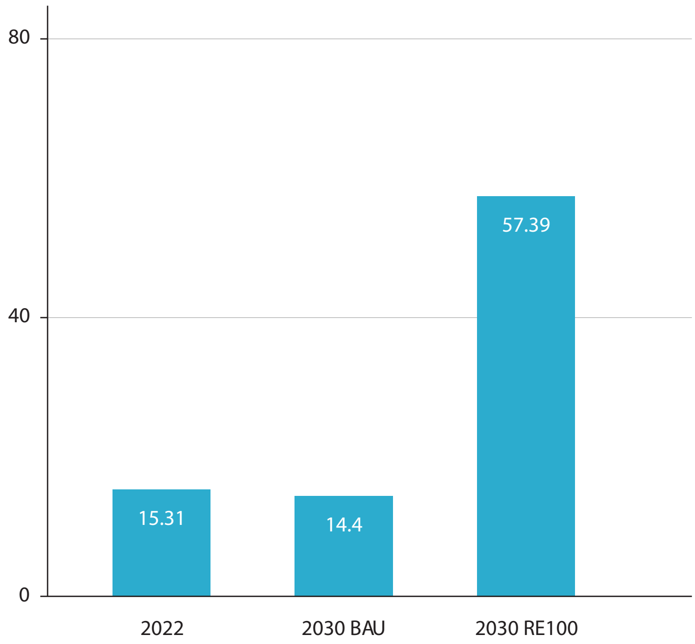


Figure 30.
The supply chain environmental competitiveness (SCEC) values for LG Display in 2022 and in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

BOE

BOE has not yet issued a 100% renewable energy target.

If BOE were to maintain its current renewable energy ratio, it could emit 8.18 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 7.91 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, BOE could save 595.82 million USD in 2030. These savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC value of the company could increase to 34.42 by 2030, which is 1.5 times its 2022 SCEC value.

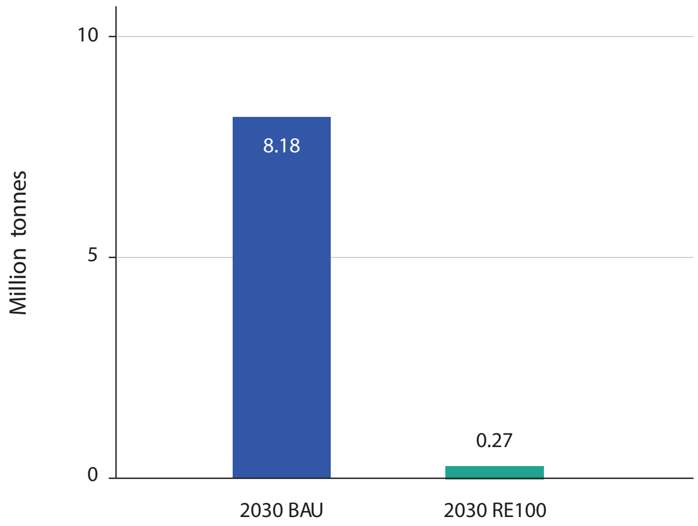


Figure 31.
The projected CO_2 emissions for BOE in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

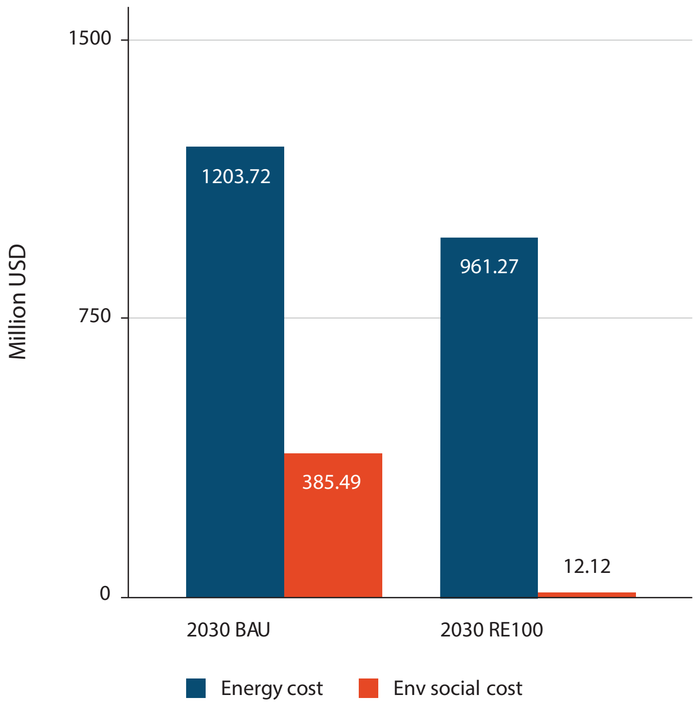


Figure 32.
The projected energy cost and environmental and social cost for BOE in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

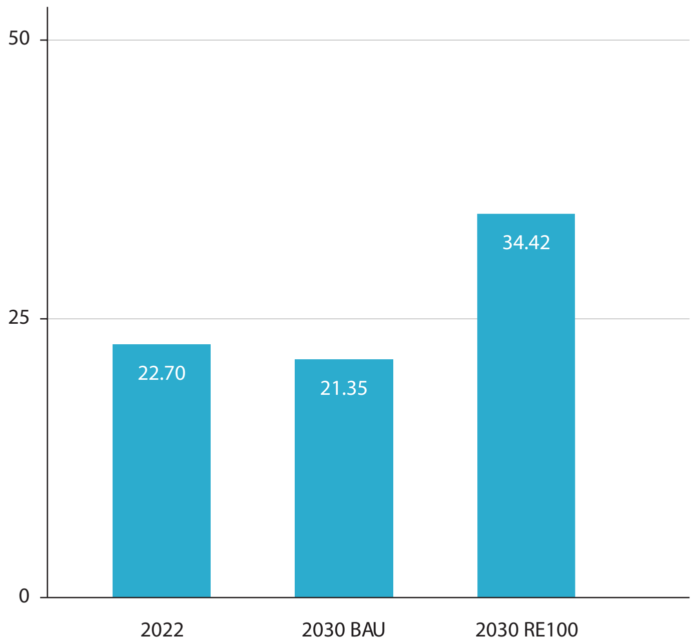


Figure 33.
The supply chain environmental competitiveness (SCEC) values for BOE in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

AUO

AUO has a target to achieve 100% renewable energy by 2050.

If AUO were to achieve its current target, it could emit 3.71 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 3.66 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, AUO could save 273.69 million USD in 2030. The savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC index of AUO could increase to 21.56 in 2030, which is 1.5 times its 2022 SCEC value.

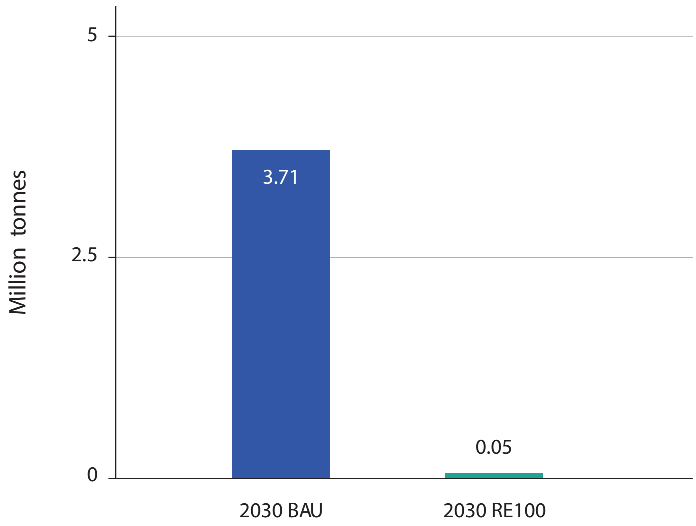


Figure 34.
The projected CO_2 emissions for AUO in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

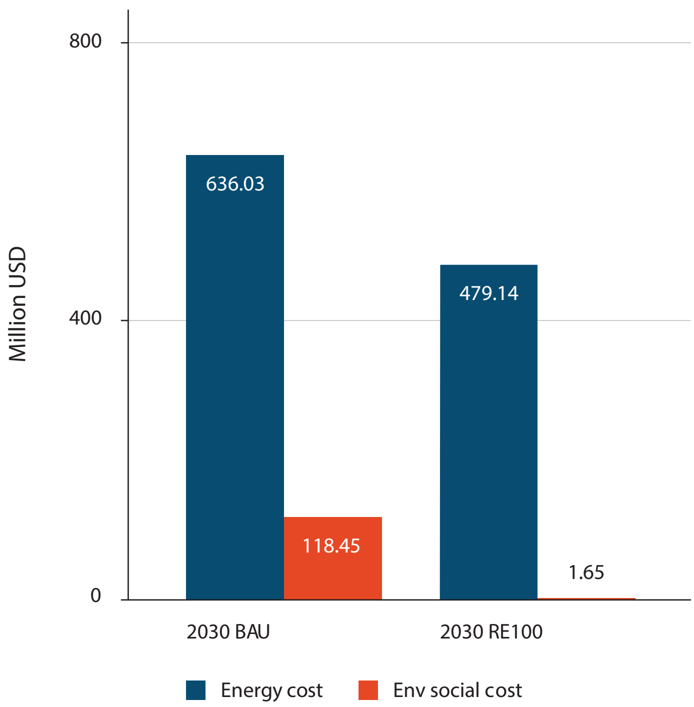


Figure 35.
The projected energy cost and environmental and social cost for AUO under business as usual (BAU) and 100% renewable energy (RE100) scenarios in 2030.

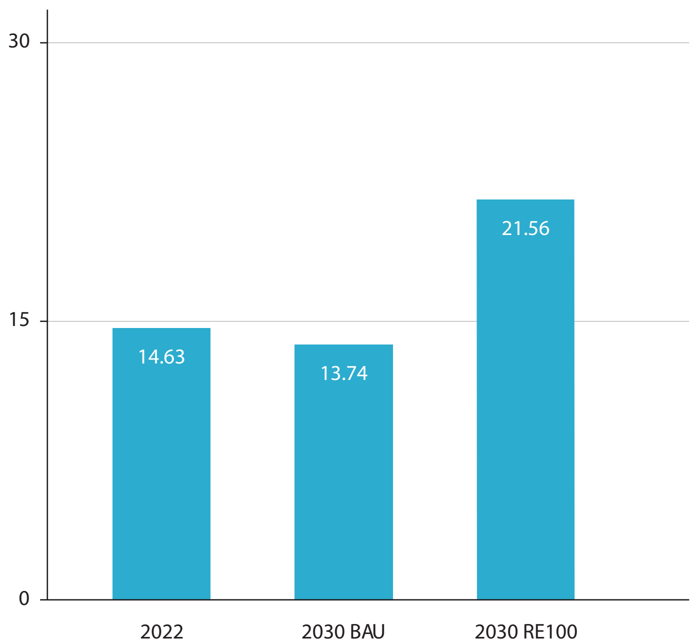


Figure 36.
The supply chain environmental competitiveness (SCEC) values for AUO in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

UMC

UMC has a target to achieve 100% renewable energy by 2050.

If UMC were to achieve its current target, it could emit 3.58 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 3.54 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, UMC could save 195.15 million USD in 2030. The savings would be largely from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC value of UMC could increase to 26.82 by 2030, which is 1.6 times its 2022 SCEC value.

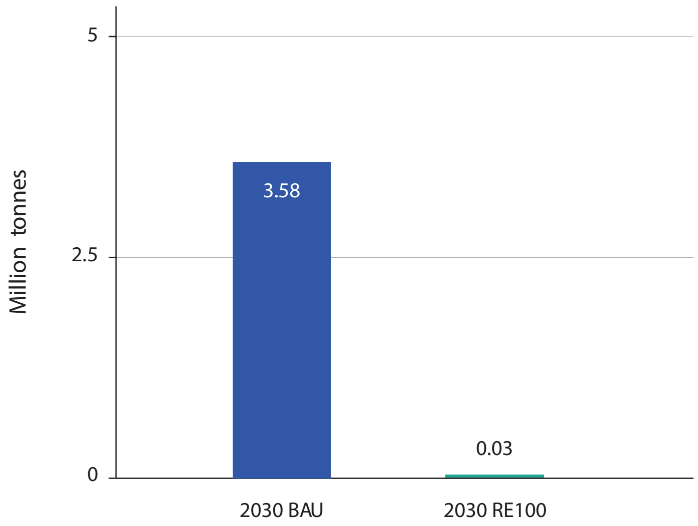


Figure 37.
The projected CO_2 emissions for UMC in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

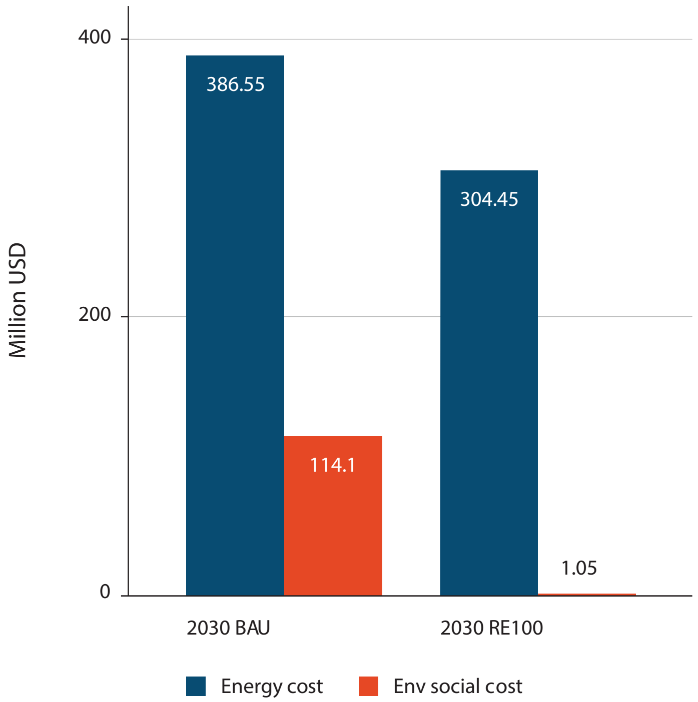


Figure 38.
The projected energy cost and environmental and social cost for UMC in 2030 under business as usual (BAU) and 100% renewable energy (RE) scenarios.

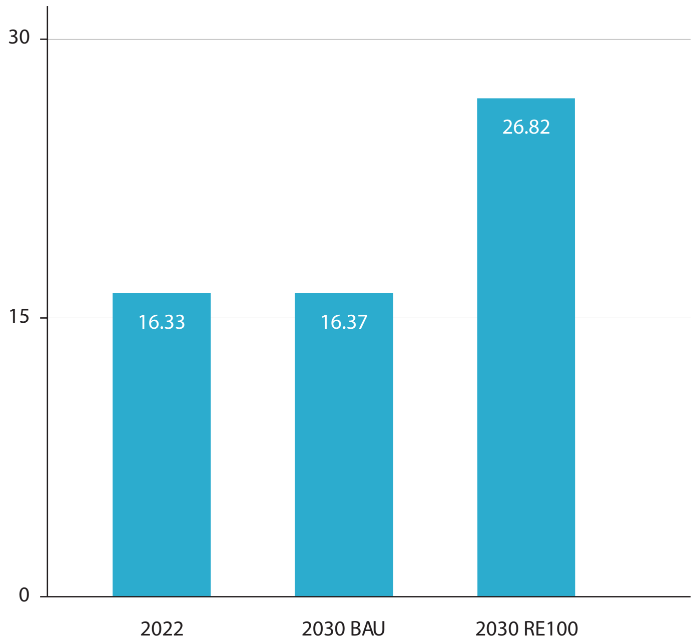


Figure 39.
The supply chain environmental competitiveness (SCEC) values for UMC in 2022 and projections for 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Innolux

Innolux has not yet issued a 100% renewable energy target.

If Innolux were to achieve its current target – 20% renewable energy by 2030 – it could emit 4 million tonnes of CO_2 in 2030. By comparison, if the company were to achieve 100% renewable energy by 2030, 3.94 million tonnes of CO_2 emissions could be avoided.

By transitioning to 100% renewable energy, Innolux could save 294.93 million USD in 2030. The savings would result mainly from the avoidance of carbon tax and an increase in the price of fossil fuels.

The SCEC value could increase to 15.19 in 2030, which is 1.5 times its 2022 SCEC value.

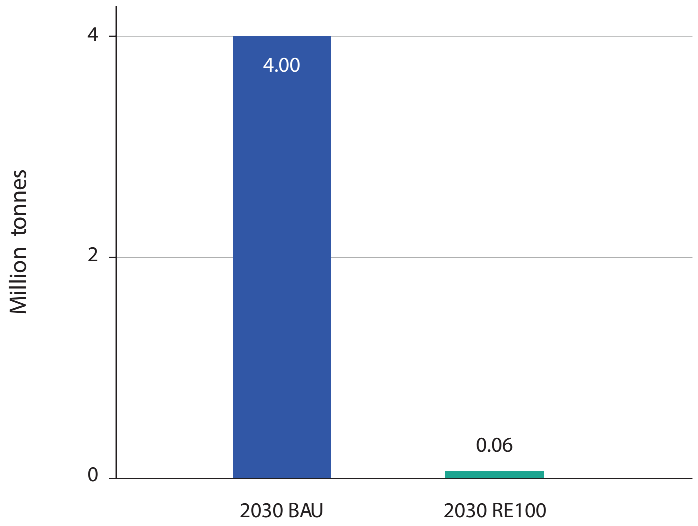


Figure 40.
The projected CO_2 emissions for Innolux in 2030 under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

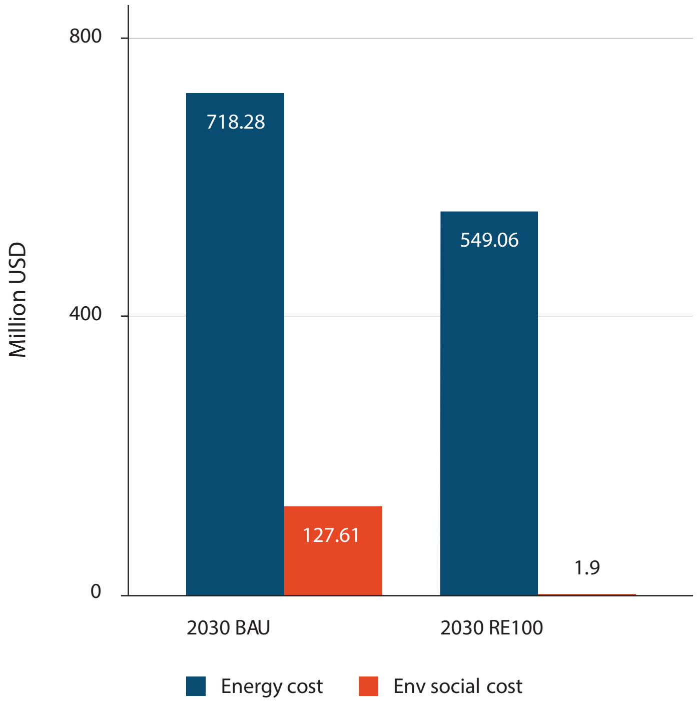


Figure 41.
The projected energy cost and environmental and social cost for Innolux in 2030 under business as usual (BAU) 100% renewable energy (RE100) scenarios.

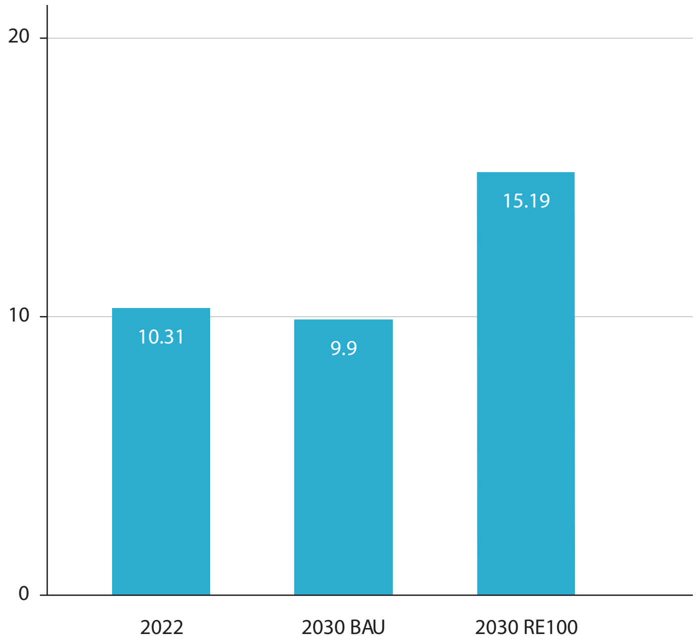
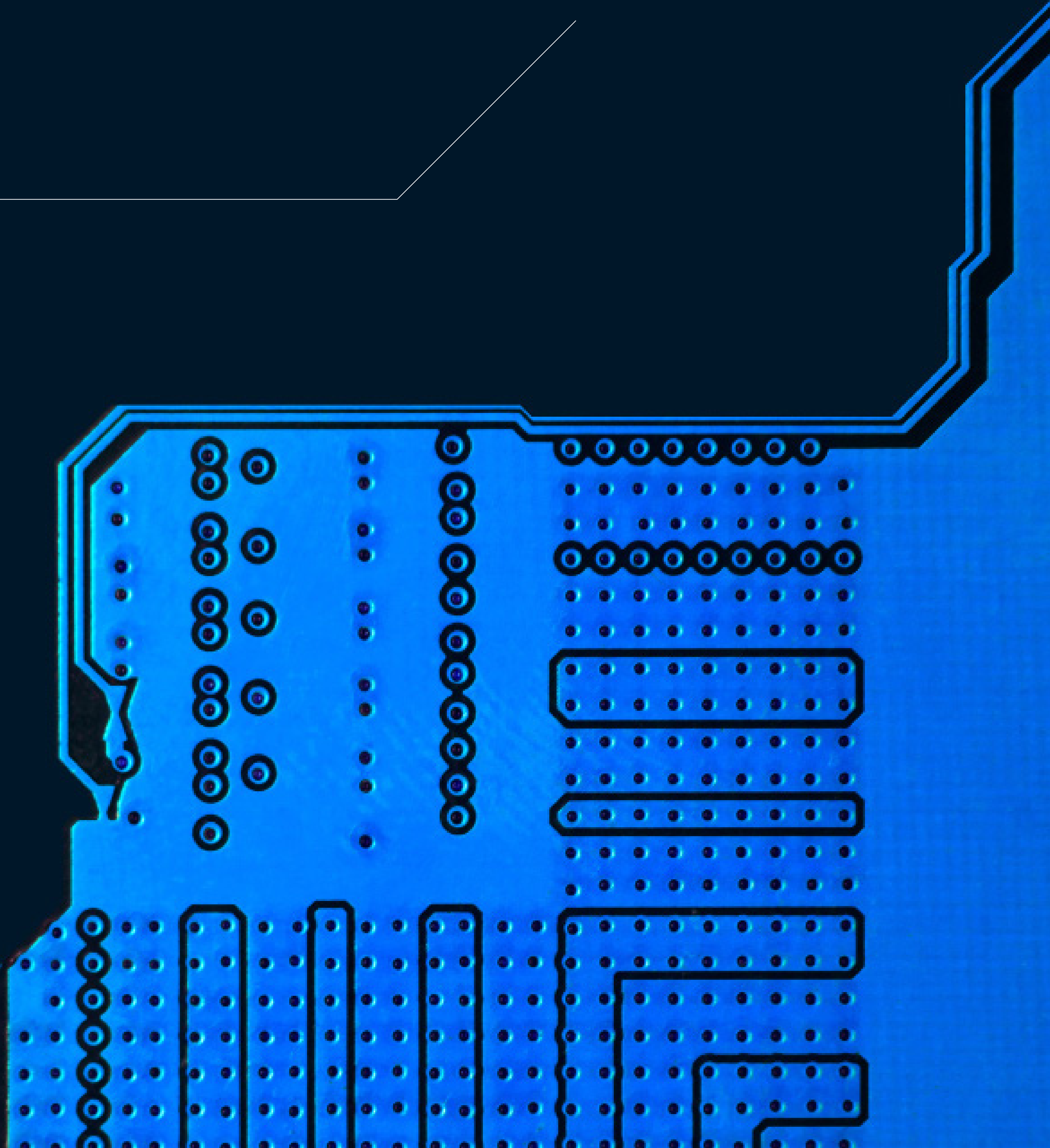


Figure 42.
The supply chain environmental competitiveness (SCEC) values for Innolux in 2022 and projected 2030 values under business as usual (BAU) and 100% renewable energy (RE100) scenarios.

Appendix



Prices and emission factors relating to power generation

This Appendix presents a summary of the fossil fuel electricity prices and renewable energy (RE) electricity prices in various global regions through to 2050 that were used in the preparation of this report (Figures S-1 to S-4). Throughout the report, we used the levelized cost of energy (LCOE) trend of fossil fuel and RE electricity (photovoltaic solar panels (PV) and wind) as references, and the current industrial and commercial electricity and green electricity market prices as a benchmark to project the fossil fuel-based and RE electricity price by region from 2022 to 2050.

We also summarized the life cycle carbon emission intensity for fossil fuels and RE electricity (Figure S-3).

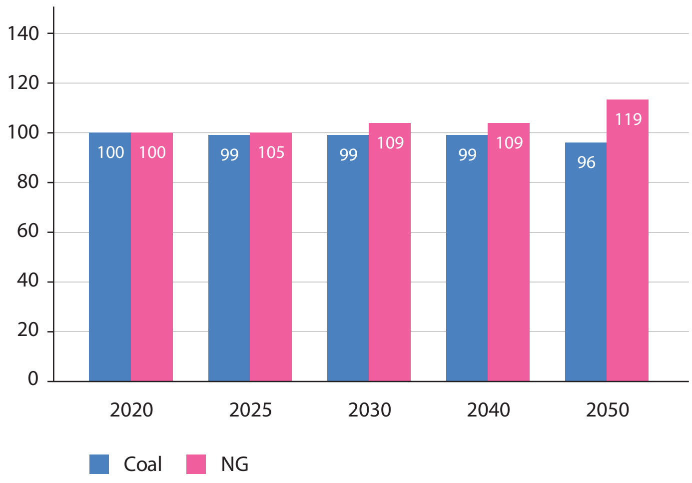


Figure S-1.
The levelized cost of energy trend of fossil fuel-based electricity, 2020 to 2050.

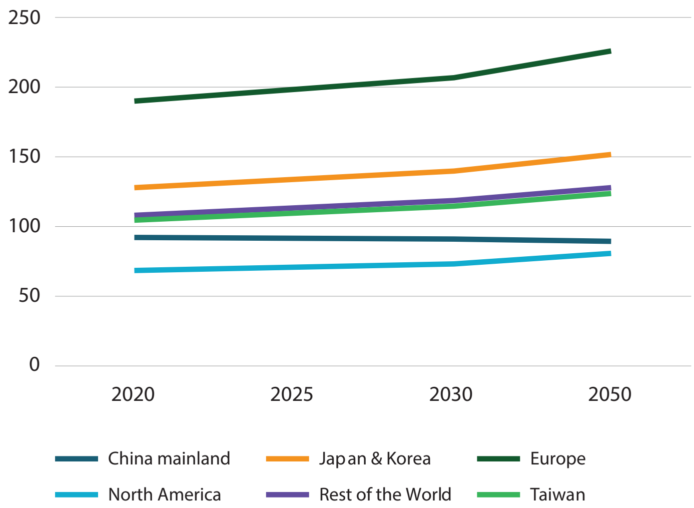


Figure S-2.
Fossil fuel electricity price projections by 2050

Source:
The true price was used as a reference. If no value was available for 2022, we used the 2023 value and estimated future prices based on the levelized cost of energy trend by 2050.

- Taiwan – refers to: https://udn.com/news/story/122907/7848125
- EU – the average value is based on: https://www.statista.com/statistics/1046605/non-household-electricity-prices-european-union-country/
- The price ratio between China mainland and the European Union, South Korea and The Organization for Economic Co-operation and Development (OECD), the United States and the rest of world refers to: http://www.sasac.gov.cn/n16582853/n16582883/c17715327/content.html

20 Energy Innovation (2018). Renewable Electricity Levelized Cost Of Energy Already Cheaper Than Fossil Fuels, And Prices Keep Plunging. Retrieved May 20, 2024, from https://energyinnovation.org/2018/01/22/renewable-energy-levelized-cost-of-energy-already-cheaper-than-fossil-fuels-and-prices-keep-plunging/

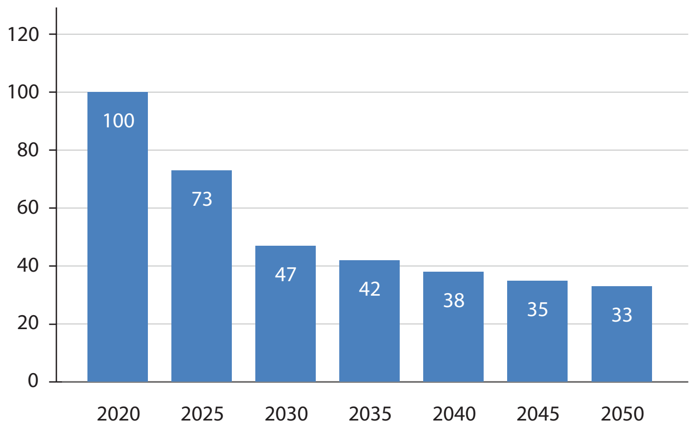


Figure S-3.
The levelized cost of energy trend of renewable electricity from 2020 to 2050.

Source:
REI, 2020
https://www.renewable-ei.org/pdfdownload/activities/REI_JP-RenewablePathwaysDecarboStrategy.pdf

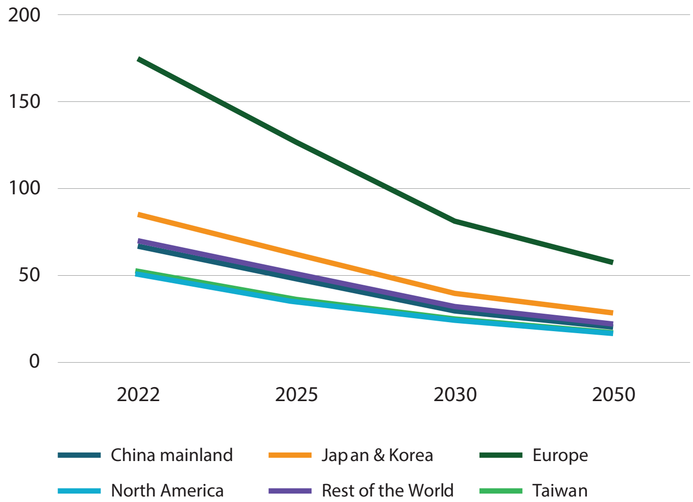


Figure S-4.
Renewable electricity (RE) price projections by 2050.

Source:
We used 2022 the true price for reference, and estimated the future prices based on the RE trend by 2050.

- Taiwan – the green certificate price refers to: https://udn.com/news/story/7238/7558187
- The European Union and United States refers to: https://energyinnovation.org/2018/01/22/renewable-energy-levelized-cost-of-energy-already-cheaper-than-fossil-fuels-and-prices-keep-plunging/
- China mainland – we used the green certificate price in the representative market of Jiangsu: https://mguangfu.bjx.com.cn/mnews/20211224/1195601.shtml
- We treat Korea and Japan as one subregion with consideration to their renewable energy electricity data availability, similarity on socioeconomic factors, energy structure and renewable energy policies: https://www.statista.com/statistics/1240816/japan-lcoe-pv-systems/

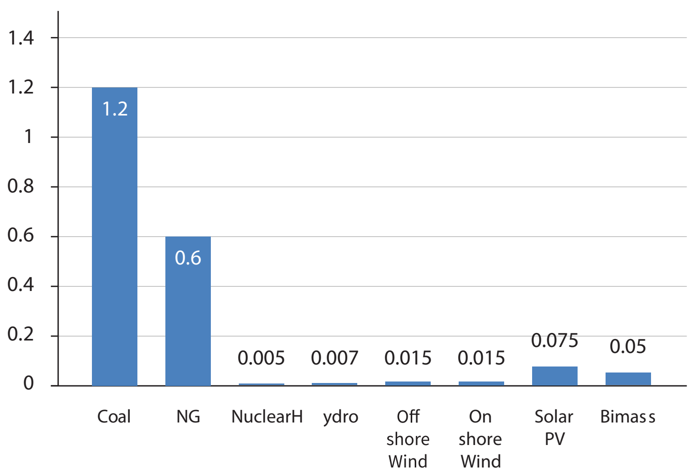


Figure S-5.
The life cycle carbon emission intensity of electricity by source.

Source: IEA

Carbon price

Carbon prices across multiple emissions trading systems (ETS) worldwide are expected to rise during the period from 2026 to 2030, in comparison to the period from 2022 to 2026. The average European Union ETS carbon price is expected to be 84.4 euros per metric ton of CO_2 during the period from 2022 to 2025, and is projected to rise to almost 100 euros per metric ton of CO_2 during the period from 2026 to 2030, according to a survey of International Emissions Trading Association members. EU ETS carbon pricing broke the 90 euros per metric ton of CO_2 barrier in February 2022, and in February 2023 it surpassed 100 euros per metric ton of CO_2. At the time of writing, April 2024, it was 66 euros.

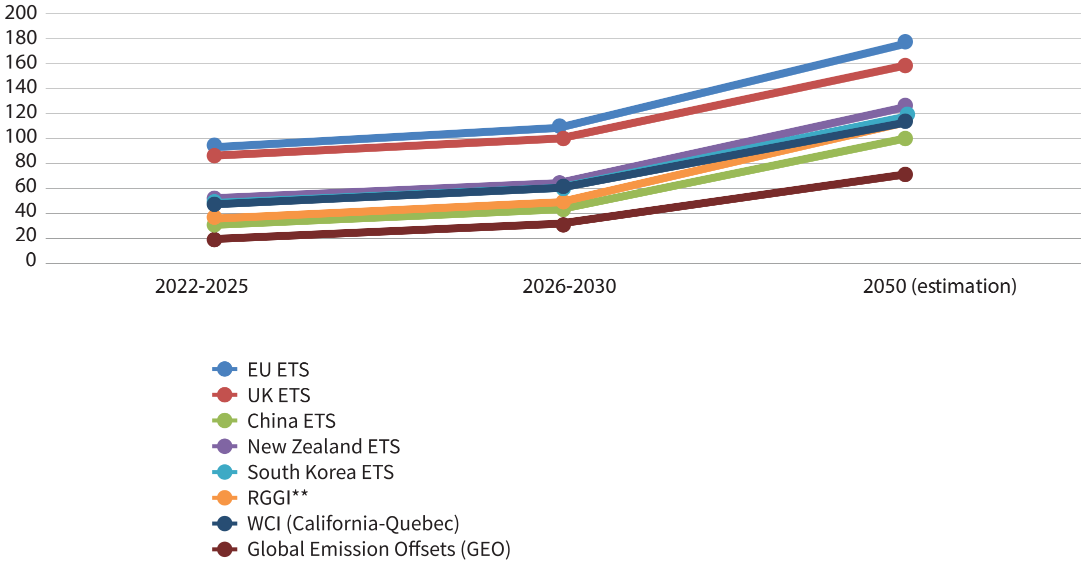


Figure S-6.
Carbon price projections by 2050.

Source:
IETA; PwC UK, 2023, accessed on the Statista database: https://www.statista.com/statistics/1334906/average-carbon-price-projections-worldwide-by-region/.

1. Market growth forecast

Table S-1:
Consumer electronics market forecasts (in trillion USD)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Statista	0.98	1.02	1.04	1.11	1.06	1.10	1.10	1.13	1.17	1.20
Deloitte	0.81			0.88						
Gartner	0.71	0.71	0.70	0.81	0.77	0.79				
GfK		0.88	1.04	1.04						

Source:
Statista Market Insights: https://www.statista.com/outlook/cmo/consumer-electronics/worldwide

Calculation equations

Indicator	Unit	Source and calculation
Revenue (a)	Billion USD	Firm's sustainability report
Energy consumption (b)	GWh	Firm's sustainability report
Renewable energy used (c)	%	=RE consumption/ total electricity consumption
Fossil fuel Electricity price (d)	USD/MWh	Statistics or literature
Fossil fuel cost (e)	MUSD	=b*(1-RE%)*d
RE electricity cost (f)	USD/MWh	Statistics or literature
RE cost (g)	MUSD	=b*(RE%)*f
Total energy cost (h)	MUSD	=e+g
CO_2 emission (i)	t	=b*(1-RE%)* (emission/non RE energy consume)+ b*(RE%)*(emission per RE (ton/kWh))
CO_2 price (j)	USD/t	ETS market price (ETS market prices)
CO_2 cost (k)	MUSD	= i*j/1000000
Env-socio cost (m)	MUSD	=k
Revenue (a)	billion USD	=a
Total cost (TC)	billion USD	=(h+m)/1000
SCEC index	-	=a/TC