Advancing ESG reporting through life cycle assessment in semiconductor manufacturing: tools, frameworks, and opportunities

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Advancing Environmental, Social Governmental (ESG) Reporting through Life Cycle Assessment in Semiconductor Manufacturing

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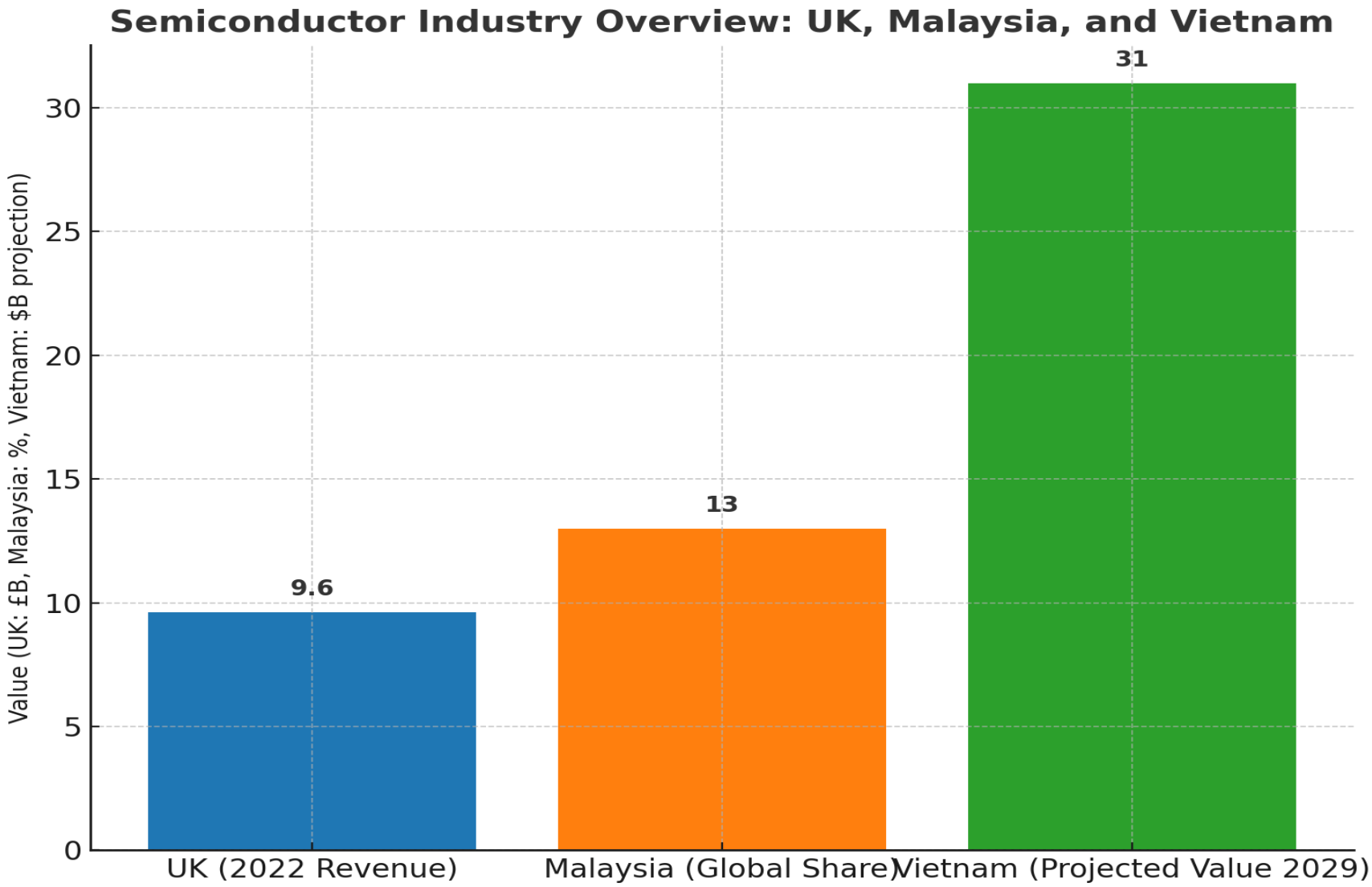
Global & Regional Semiconductor Highlights



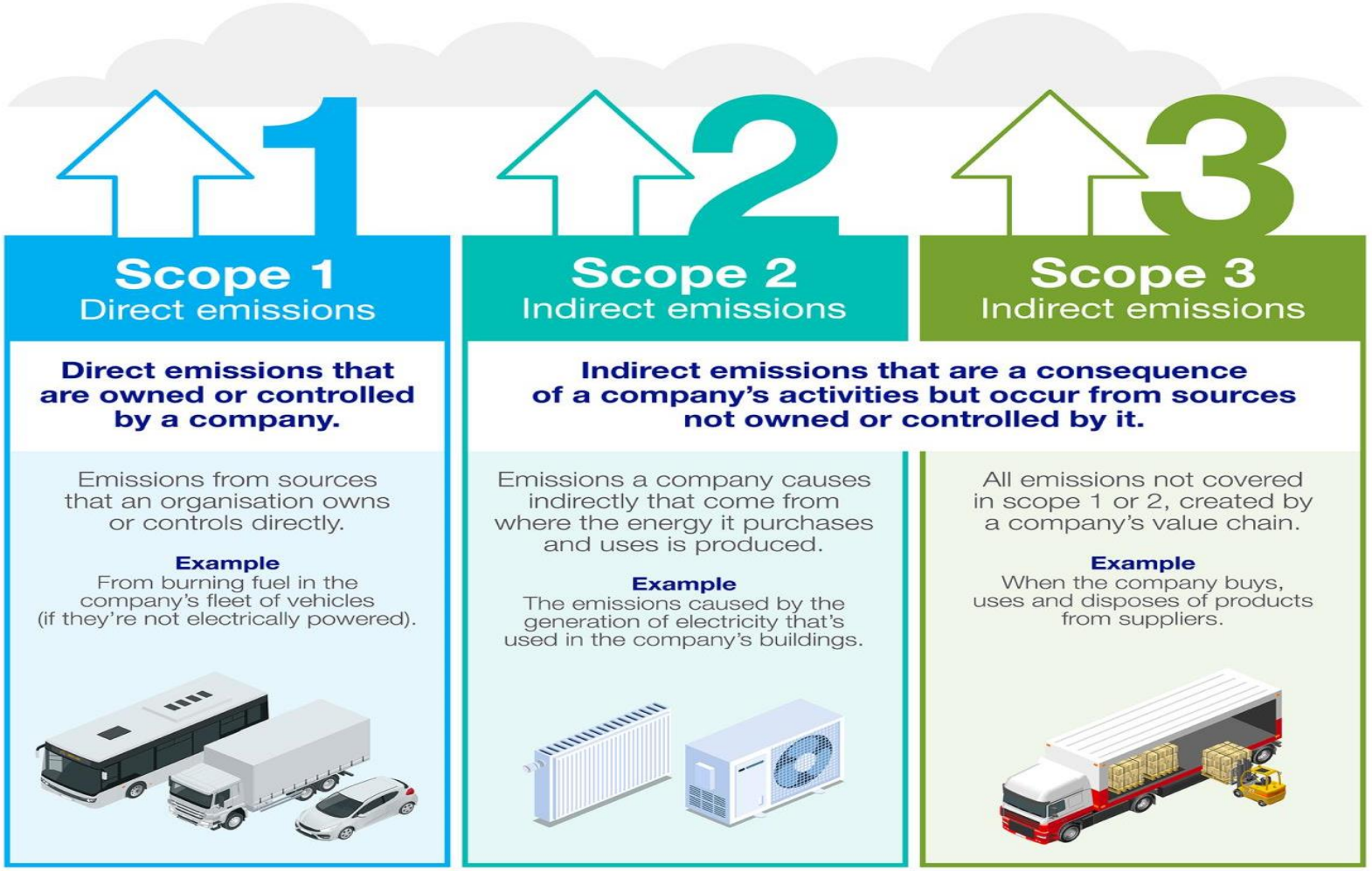
ESG Reporting Standards in Semiconductor Industry

Standard / Regulation	Scope	Applicability	Ref.
Global Reporting Initiative (GRI)	Broad sustainability disclosure (environmental, social, governance)	Encourages transparency in energy, emissions, and supply chain impacts	[1]
Sustainability Accounting Standards Board (SASB)	Industry-specific ESG metrics	Provides tailored metrics for hardware and semiconductor companies	[2]
Task Force on Climate-related Financial Disclosures (TCFD)	Climate-related financial risk and governance disclosure	Helps assess and report carbon risks in operations and value chain	[3]
Corporate Sustainability Reporting Directive (CSRD) (EU)	Mandatory ESG reporting for large companies operating in the EU	Requires EU-based fabs and suppliers to report in a standardised format	[4]

ESG Reporting Standards in Semiconductor Industry

Standard / Regulation	Scope	Applicability	Ref.
Carbon Disclosure Project (CDP)	Voluntary disclosure of carbon, water, and forest risks	Semiconductor firms report emissions and energy sourcing transparency	[5]
Greenhouse Gas Protocol (GHG Protocol)	Emissions accounting across Scope 1, 2, and 3	Enables tracking of fab emissions, purchased electricity, and suppliers	[6]
ISO 14001: Environmental Management Systems	Certification for environmental management practices	Promotes systematic control of environmental impacts in manufacturing	[7]
Responsible Business Alliance (RBA) Code of Conduct	Standards for labour, ethics, environment, and health/safety	Widely adopted in the electronics supply chain	[8]
Product Environmental Footprint (PEF) (EU)	Method for measuring the environmental performance of products	Supports LCA-based evaluation of semiconductor components	[9]

GHG Protocol – Emission Scopes



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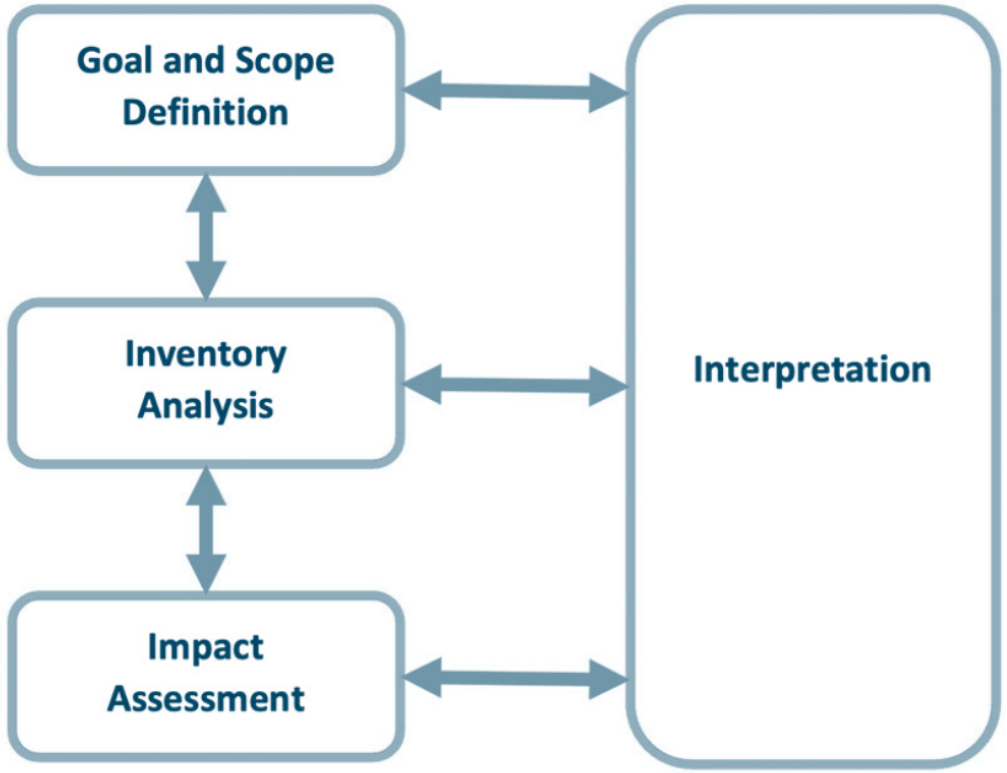
Major elements of ESG reporting (GRI)

Fig. 1. Major elements of ESG report according to GRI standards [1].

Life Cycle Assessment for the Semiconductor Industry

Role of LCA

- Identifies carbon hotspots and optimizes resource use.
- Addresses Scope 1–3 emissions with better accuracy.
- Enhances compliance with regulations like the EU Green Claims Directive.
- Supports eco-design and sustainable manufacturing strategies.
- The ISO 14040 standard introduces LCA and contains applicable definitions and background information.
- The ISO 14044 describes the process of conducting an LCA.



source: https://www.cem-wave.eu/blog/life-cycle-analysis-great-tool-greener-future

Comparative Analysis of Semiconductor Companies' ESG Strategies

Company	Key ESG Initiatives & Highlights
Intel	- RISE 2030 strategy embedding ESG into business operations - Aggressive net-zero target by 2040 - Investments in renewable energy and advanced water reuse initiatives [10]
TSMC	- Rigorous supplier ESG audits - ISO-certified environmental and safety systems - Dedicated human rights reporting - Internal ESG innovation programs [11]
Samsung Semiconductor	- ESG disclosures aligned with GRI and TCFD - Focus on energy efficiency and responsible materials sourcing - Strong emissions monitoring practices [12]
GlobalFoundries	- Emphasis on environmental health & safety, diversity, and equity - Recognized ESG ratings - Roadmap to achieve net-zero emissions by 2050 [13]
Micron	- Major strides in emissions reduction - Target of 100% renewable energy in key regions by 2025 - Active in circular economy initiatives (e.g., Semiconductor Climate Consortium) [14]

Past LCA Studies for Semiconductor Industry

Study (Author, Year)	Focus / Methodology	Key Findings
Deng et al. [17]	Hybrid economic-input-output LCA for laptops	Identified energy-intensive processes in IC packaging; highlighted uncertainties in data and boundary definitions
Asadi et al. [18]	Comprehensive LCA framework for semiconductor value chain	Considered upstream material extraction, fabrication, and end-of-life stages
Huang et al. [19]	Parametric carbon footprint model for wafer fabrication	Technology nodes, mask layers, and metal layers identified as key predictors of emissions
Belkhir & Elmeligi [20]	Broad LCA of ICT industry	Estimated global carbon footprint of ICT sector
Kang et al. [21]	Life cycle analysis of smartphones in China using site-specific data	Found component manufacturing (esp. semiconductor devices) dominated environmental impacts
Sivaraman et al. [22]	Modular carbon footprint modeling tool for semiconductor facilities (regression-based)	Enabled real-time emissions tracking, sensitivity analysis, and gate-to-gate scenario evaluation for process optimisation and ESG reporting

Past LCA Studies for Semiconductor Industry

Study (Author, Year)	Focus / Methodology	Key Findings
Liu et al. [23]	Environmental implications of nanomaterials in electronics	Showed nanomaterials both improve performance and reduce energy/material footprints; critical for sustainable next-gen semiconductor manufacturing
Microsoft LCA v2.1 [24]	AI-driven, digitalized LCA methodology integrating supplier data, IMEC inventory, and full material declarations	Allowed precise, part-level cradle-to-grave impact assessments; improved hotspot identification and low-carbon design strategies
Schischke et al. [25] & Proske et al. [26]	Development of Product Category Rule (PCR) for electronics	Critiqued ISO 14040/44 and EN 50693; supported harmonized data collection and reporting across manufacturers and suppliers
Liu et al. [27]	Empirical validation of lifecycle emissions for smartphones and data servers	Confirmed dominant impact of semiconductor fabrication; stressed importance of Scope 3 data integration

Conclusions

LCA in the Semiconductor Industry: Challenges, Opportunities & Future

Challenges
- Inconsistent data
- Complex supply chains
- Scope 3 quantification

Opportunities
- Semiconductor-specific PCRs
- Standardized data platforms
- Supplier engagement

Enablers
- Digitalization & AI
- Real-time LCA tracking
- Credible ESG reporting

Future Outlook
- Harmonized standards
- Better Scope 3 data
- Supply chain collaboration

→ Positioning the semiconductor industry as a leader in green manufacturing

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Thank you!

If you have any question, please contact Project Lead

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