Creating a Sustainable Semiconductor Industry for the AI Era

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Solutions, Architectures, and Community

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Agenda

1. Relevance of Sustainability
2. Environmental Impact of Semiconductors
3. AI, Semiconductors, and Energy
4. Methods for Reduction
5. Challenges and Constraints

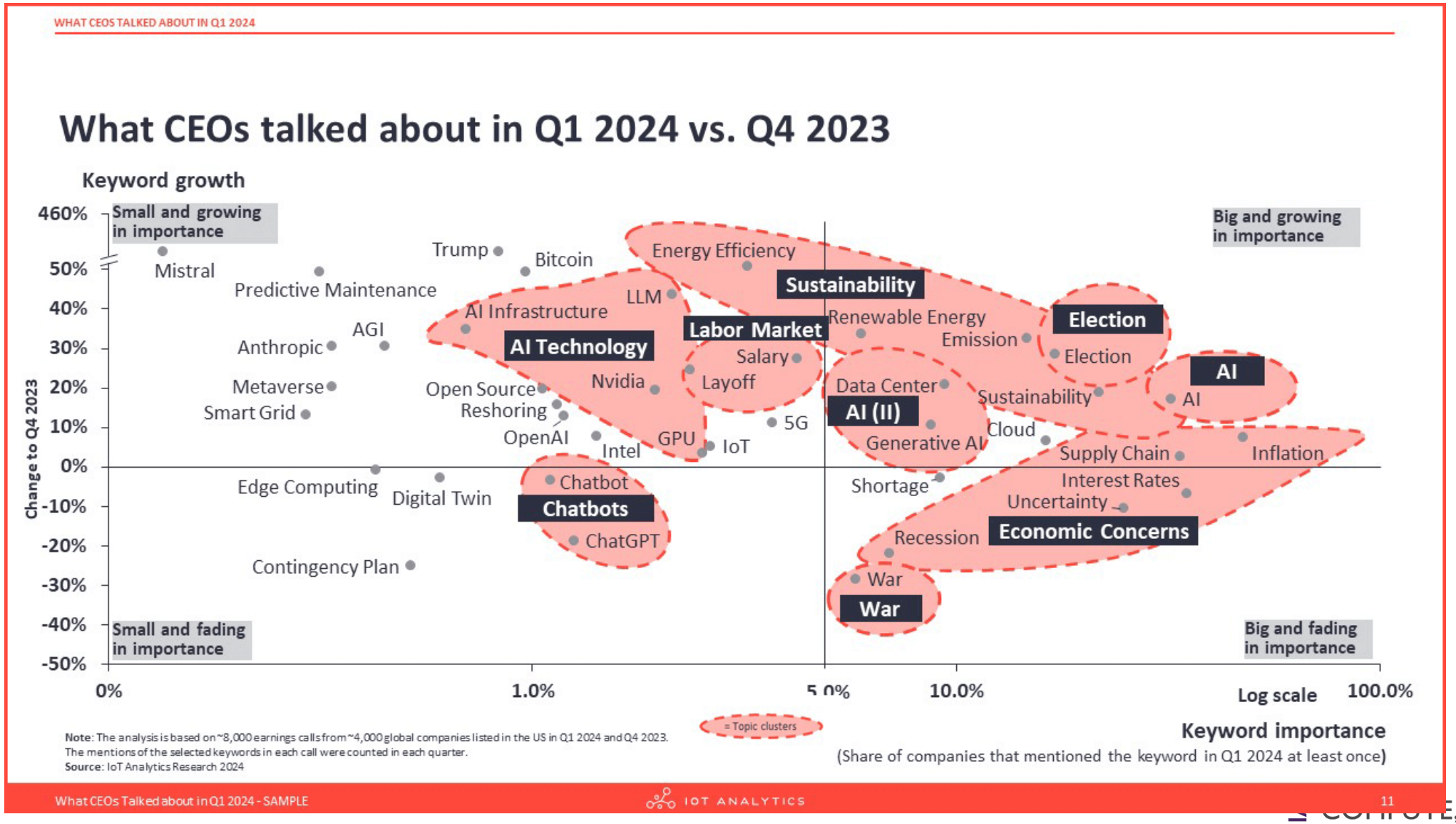
Sustainability

Sustainability

United Nations Brundtland Commission 1987 definition:

“meeting the needs of the present without compromising the ability of future generations to meet their own needs”

Sustainability



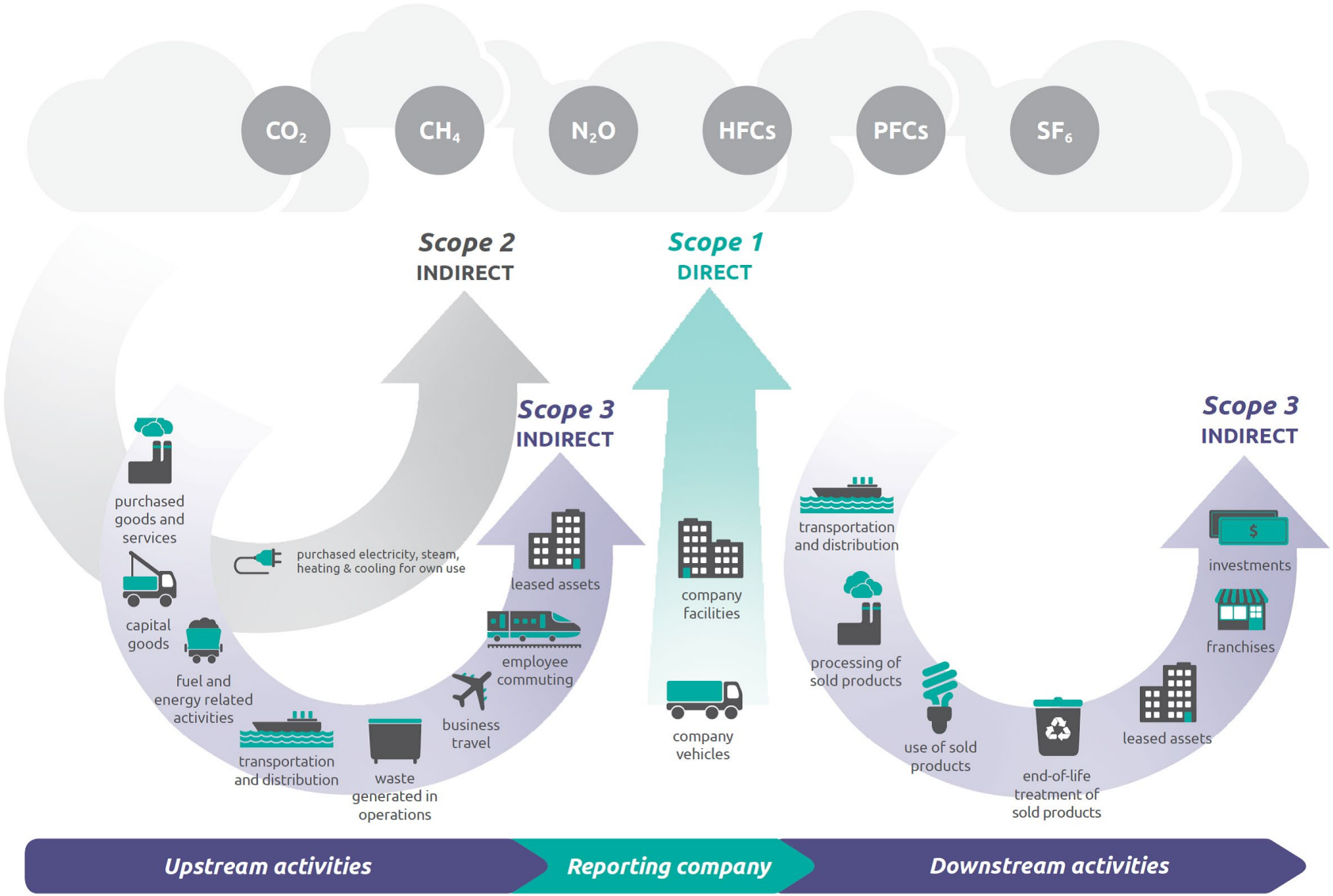
Sustainability – Global Legislation

- Europe
  - Corporate Sustainability Reporting Directive (CSRD)
- United States
  - California: SB 261, SB 253, AB 1305
  - Inflation Reduction Act
  - SEC Climate-related Disclosures
- Canada
  - Canadian Sustainability Standards Board (CSSB)
- Global
  - International Sustainability Standards Board (ISSB)

Sustainability

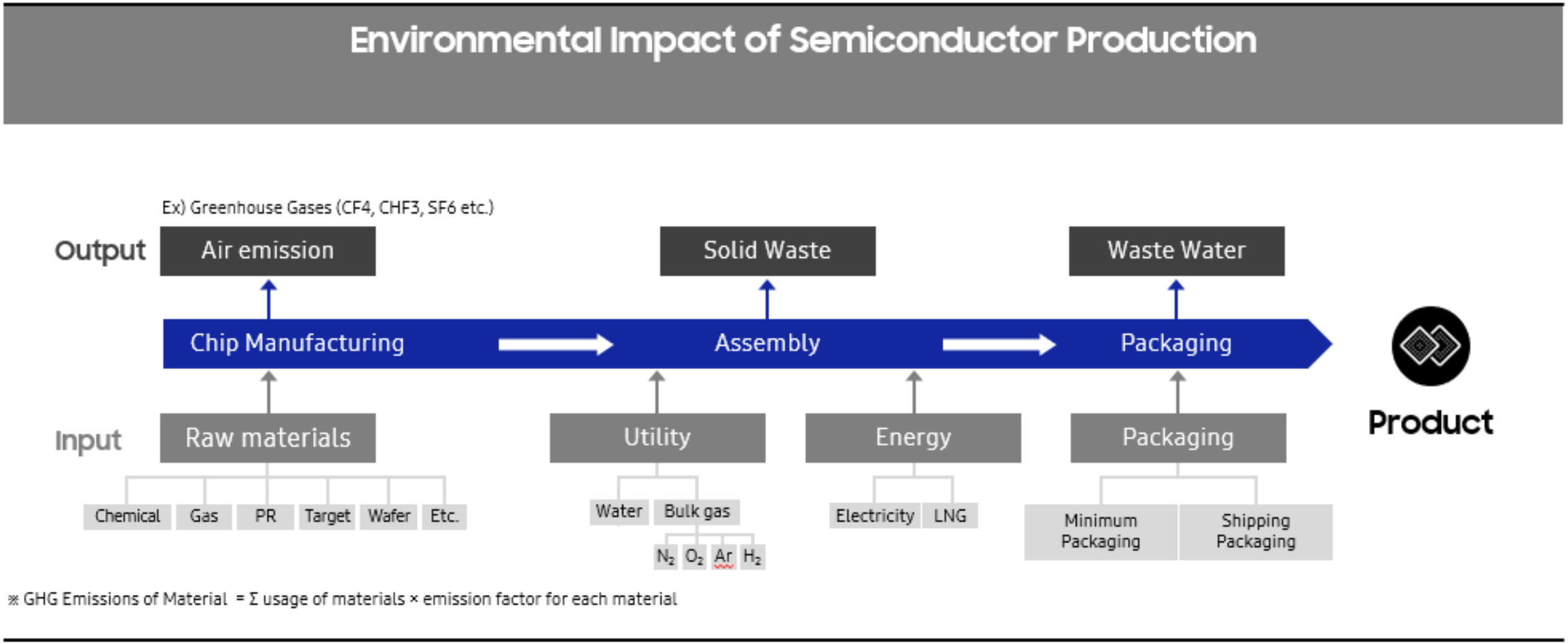
Company	Goals	Goal Year
Apple	Carbon Neutral for supply chain and all products	**2030**
Amazon	Net Zero carbon emissions	**2040**
Dell	Net Zero greenhouse gas across Scope 1, 2, 3	**2050**
Google	Net Zero emissions across all operations and value chain	**2030**
HPE	Net Zero GHG emissions across the value chain	**2040**
HPI	Net Zero GHG emissions across HP value chain by 2040; Supplies business achieving carbon neutrality by 2030	**2030, 2040**
Intel	Net Zero greenhouse gas emissions across Scope 1 and 2	**2040**
Meta	Net Zero emissions across value chain	**2030**
Microsoft	Carbon Negative	**2030**
Samsung	Net Zero carbon emissions for Scope 1 and 2	**2050**

Sustainability



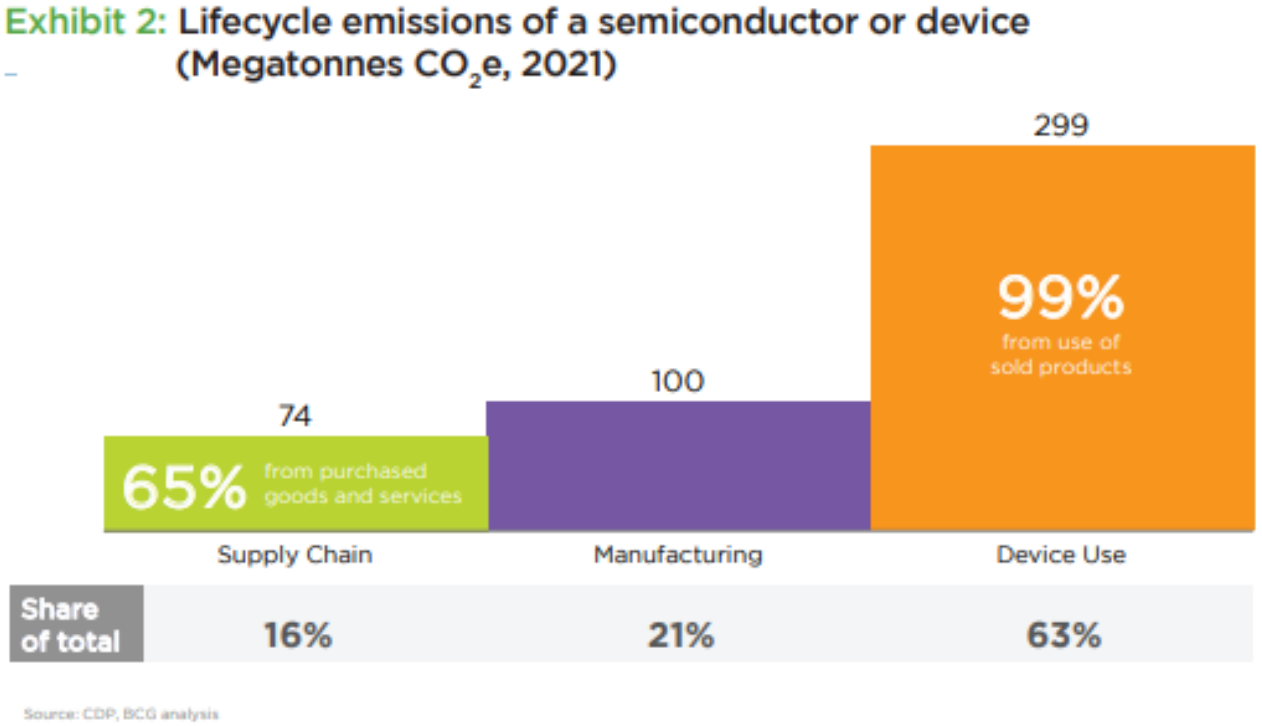
Semiconductors

Semiconductor Environmental Impact



Semiconductor Environmental Impact

- SEMI Semiconductor Climate Consortium
  - "Semiconductor devices produced in 2021 have a lifetime CO2e footprint of **500 megatonne (MT)** – 16% from supply chain, 21% from manufacturing, and 63% from device use."



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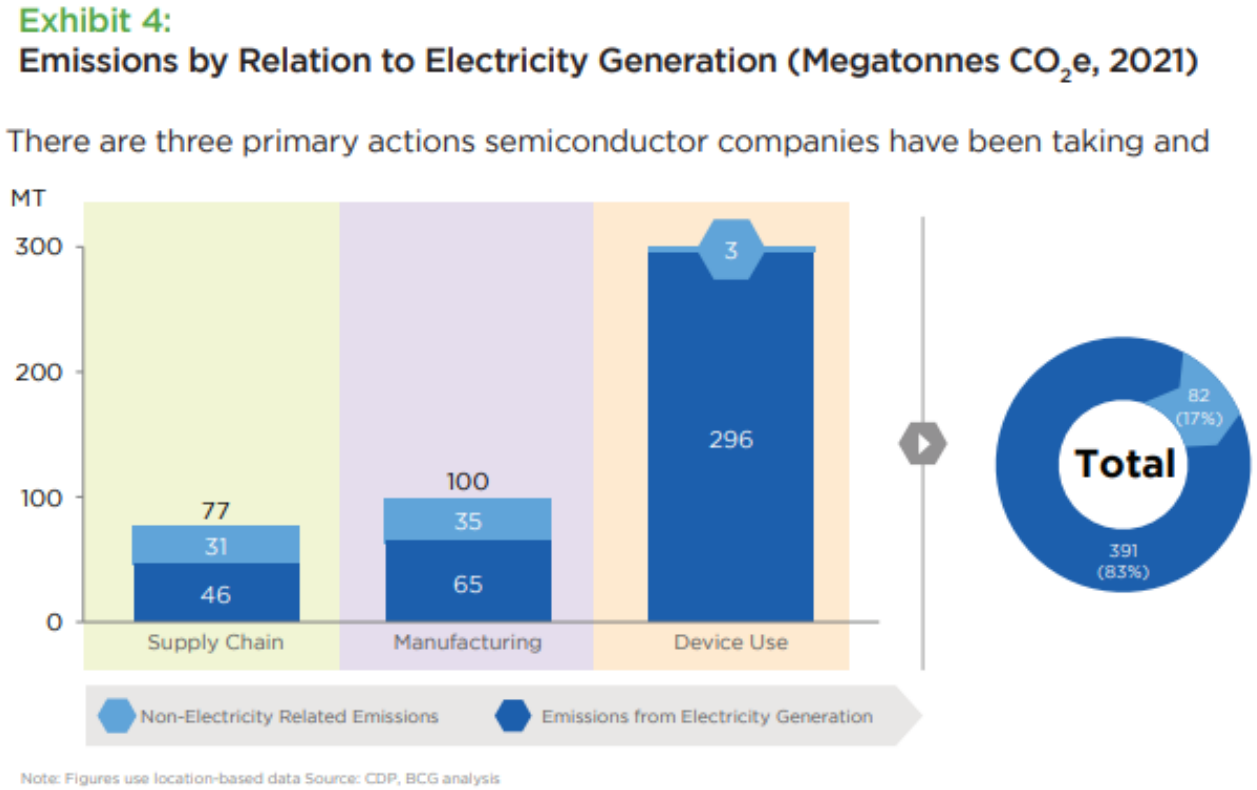
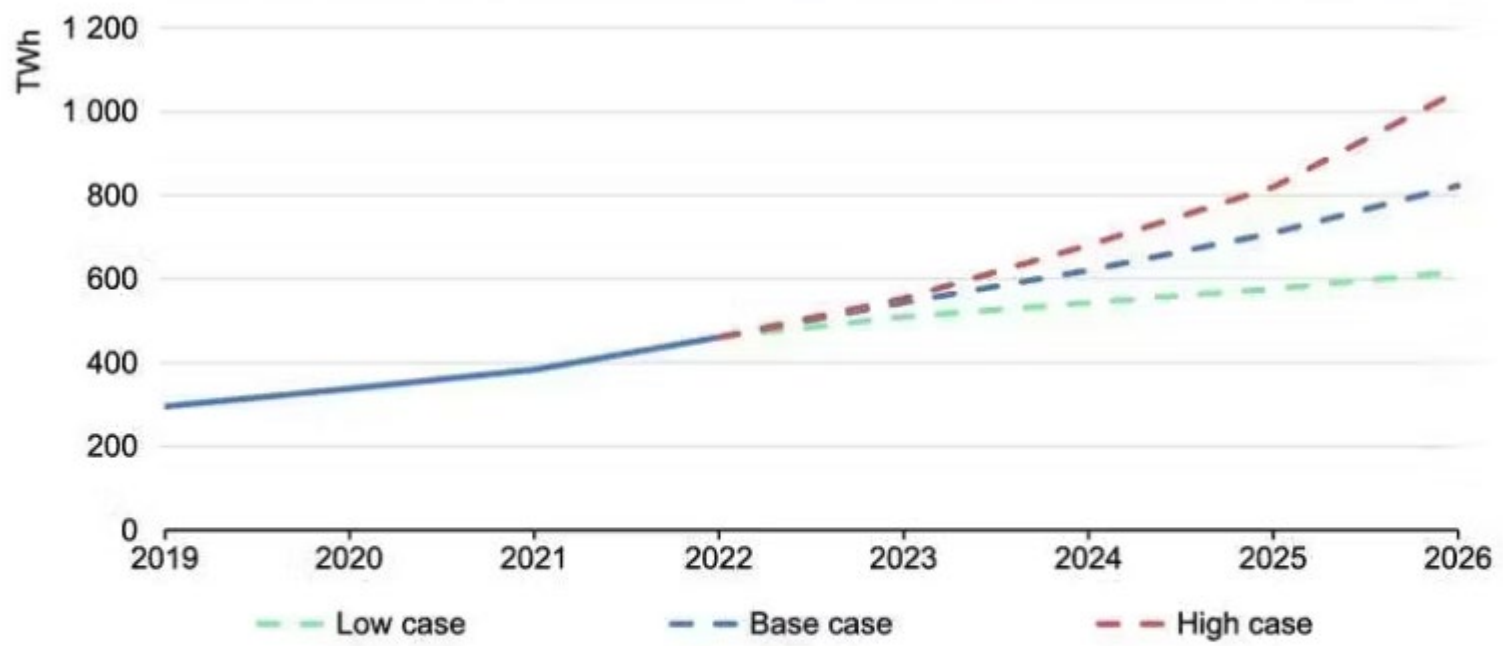


AI

AI

Global electricity demand from data centres, AI, and cryptocurrencies, 2019-2026



IEA. CC BY 4.0.

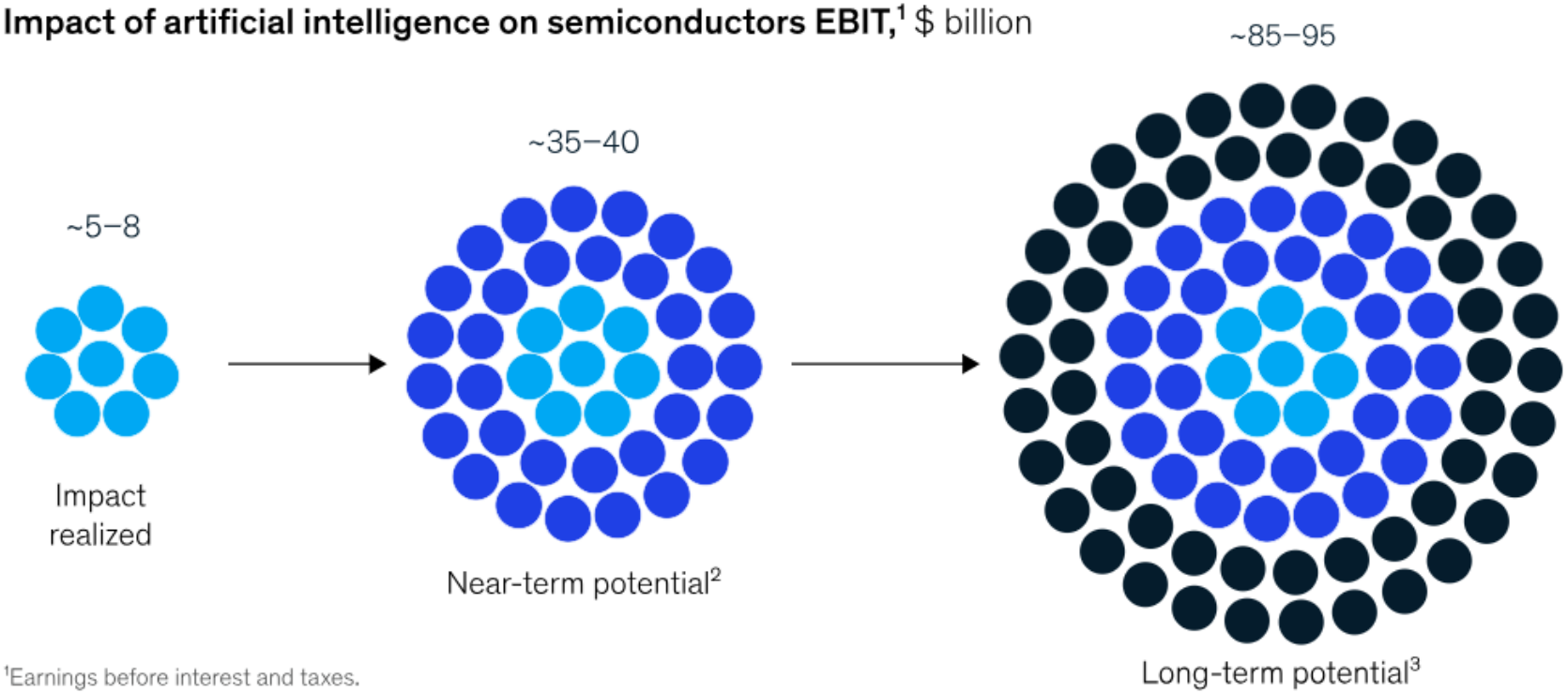
Notes: Includes traditional data centres, dedicated AI data centres, and cryptocurrency consumption; excludes demand from data transmission networks. The base case scenario has been used in the overall forecast in this report. Low and high case scenarios reflect the uncertainties in the pace of deployment and efficiency gains amid future technological developments.

Sources: Joule (2023), de Vries, The growing energy footprint of AI; CCRI Indices (carbon-ratings.com); The Guardian, Use of AI to reduce data centre energy use; Motors in data centres; The Royal Society, The future of computing beyond Moore's Law; Ireland Central Statistics Office, Data Centres electricity consumption 2022; and Danish Energy Agency, Denmark's energy and climate outlook 2018.

AI

Artificial intelligence could generate $85 billion to $95 billion for semiconductor companies over the long term.

Impact of artificial intelligence on semiconductors EBIT,[1] $ billion



[1]Earnings before interest and taxes.
[2]Near-term potential refers to gains within the next 2–3 years.
[3]Long-term potential refers to gains achieved 4 years or more in the future.

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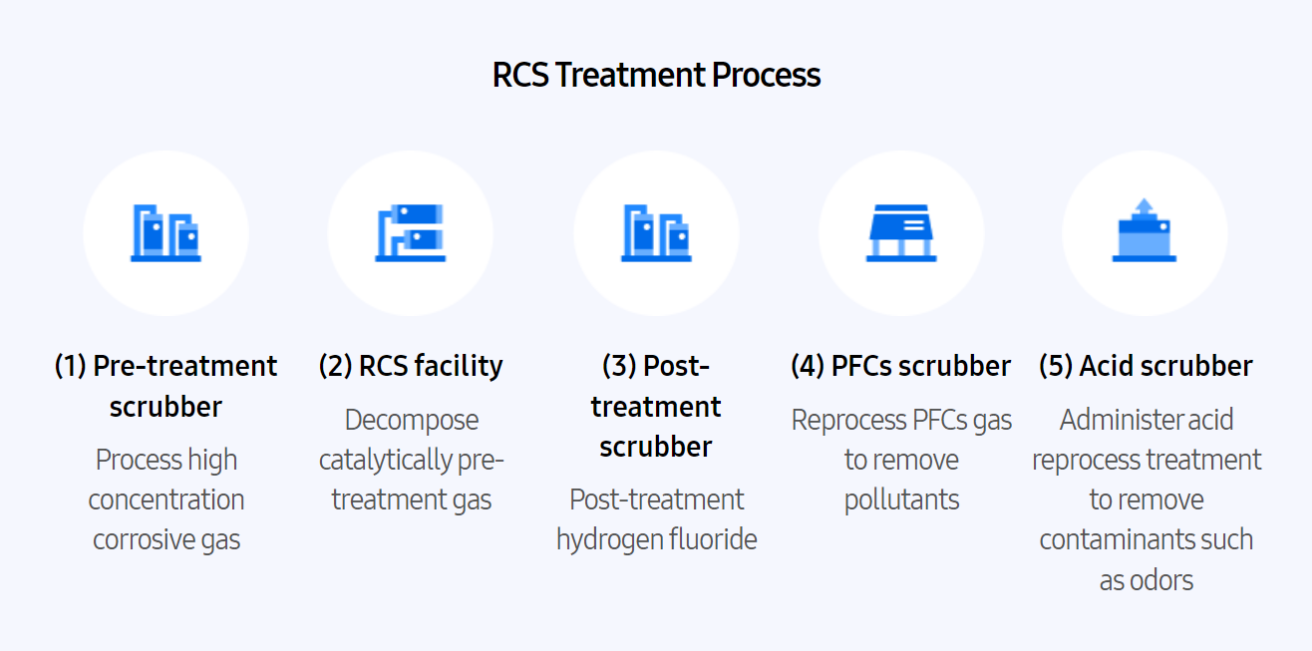
Methods for Reduction

Methods for Reduction

- Process gases
  - Semiconductor manufacturing uses gases with high Global Warming Potential (GWP)
  - “In the majority of established manufacturing processes up to 80% of fluorinated gases are released into the atmosphere at the end of the process” (Deloitte)
  - Some of these gases can be replaced: such as perfluorocarbons (PFCs) with nitrogen trifluoride (NF3), which has a lower GWP (Deloitte)

Methods for Reduction

- Abatement technologies
  - Regenerative Catalytic System (RCS)
  - Carbon Capture Utilization and Storage (CCUS)



Methods for Reduction

- Recycling: water, gases, materials

Scarcity Drives Fabs to Wastewater Recycling ›

Boosting water recycling at fabs by up to 98 percent keeps chip production on target

BY DEXTER JOHNSON | 25 JAN 2022 | 3 MIN READ |

Korean chipmakers

Samsung to use recycled neon gas in chip manufacturing

The Korean memory chip giant will be the industry's first to use recovered neon gas in the photolithography process

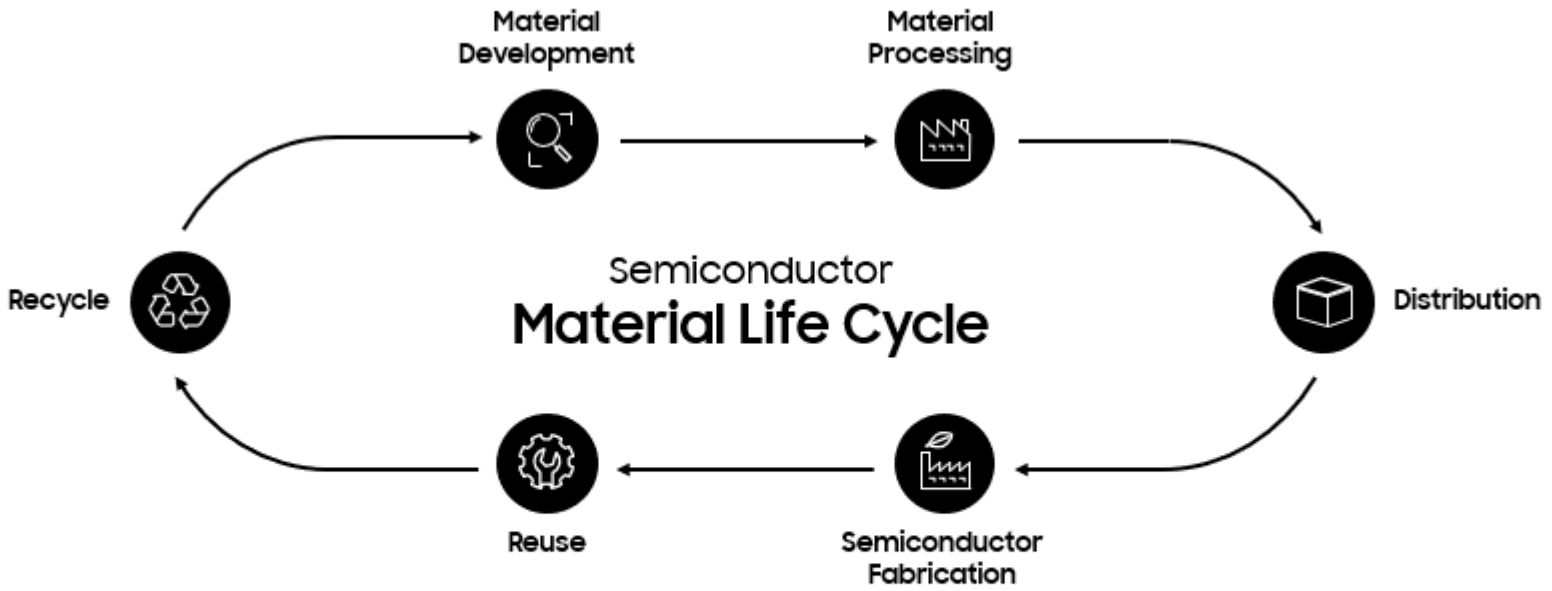
By Jeong-Soo Hwang Mar 07, 2024 (Gmt+09:00) | 2 Min read

Methods for Reduction

- Digital twins & efficiency
  - Creating a digital twin can help with “sensing, automating, and modeling to monitor and reduce raw materials use” (Deloitte)
  - “For manufacturing process stages that are hard to access or monitor in real time, process modeling and use of digital twins can be used” (Deloitte)

Methods for Reduction

- Circular economy



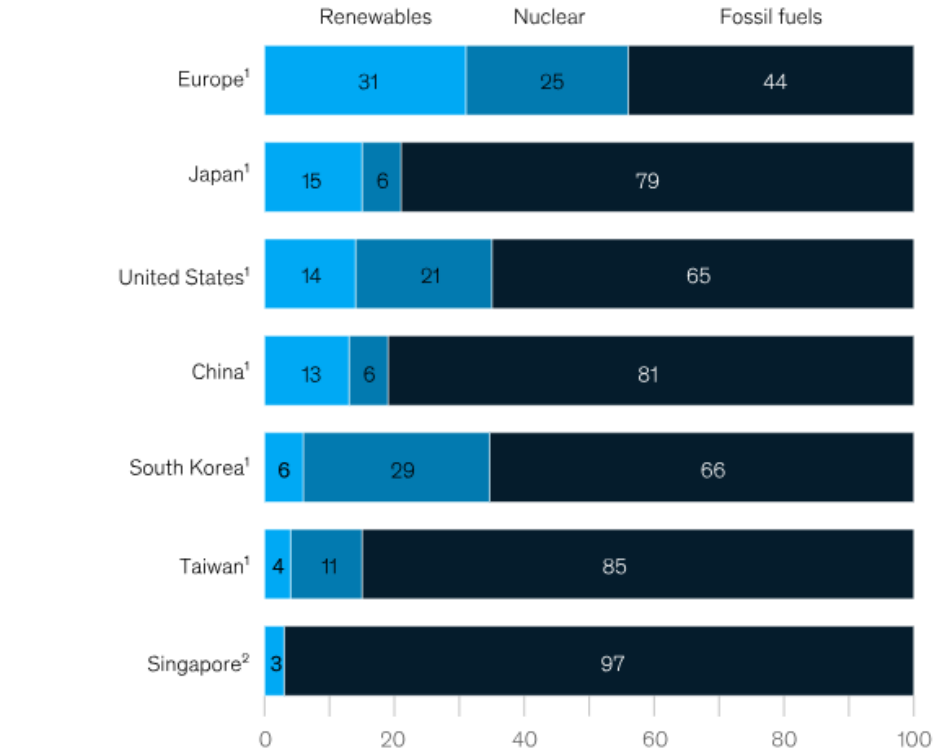
Actions	Material Development	Material Processing	Distribution	Semiconductor Fabrication	Reuse	Recycle
	Alternative Material Development and Sourcing	Eco-friendly Processing	Reusable Container	Highly-efficient Fabrication Process	Reusing Cycle Optimization	Waste Recycle Upcycle

Challenges/Constraints

Renewable Energy Availability

Access to renewable energy may be a major factor as semiconductor companies decide where they should build new fabs.

Share of electricity generation type, by region, %



Note: Figures may not sum to 100%, because of rounding.
[1]2020 data.
[2]2019 data.
Source: Enerdata; US Department of Energy

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Summary

- Sustainability is a critical concern for the semiconductor industry.
- There are many methods to abate emissions within the manufacturing process, as well as improving efficiency of use.
- AI poses a new challenge for sustainability, as well as a new opportunity for semiconductors.
- Sustainability is an interdisciplinary field that requires the participation of all stakeholders. In short: YOU are a part of this journey!

