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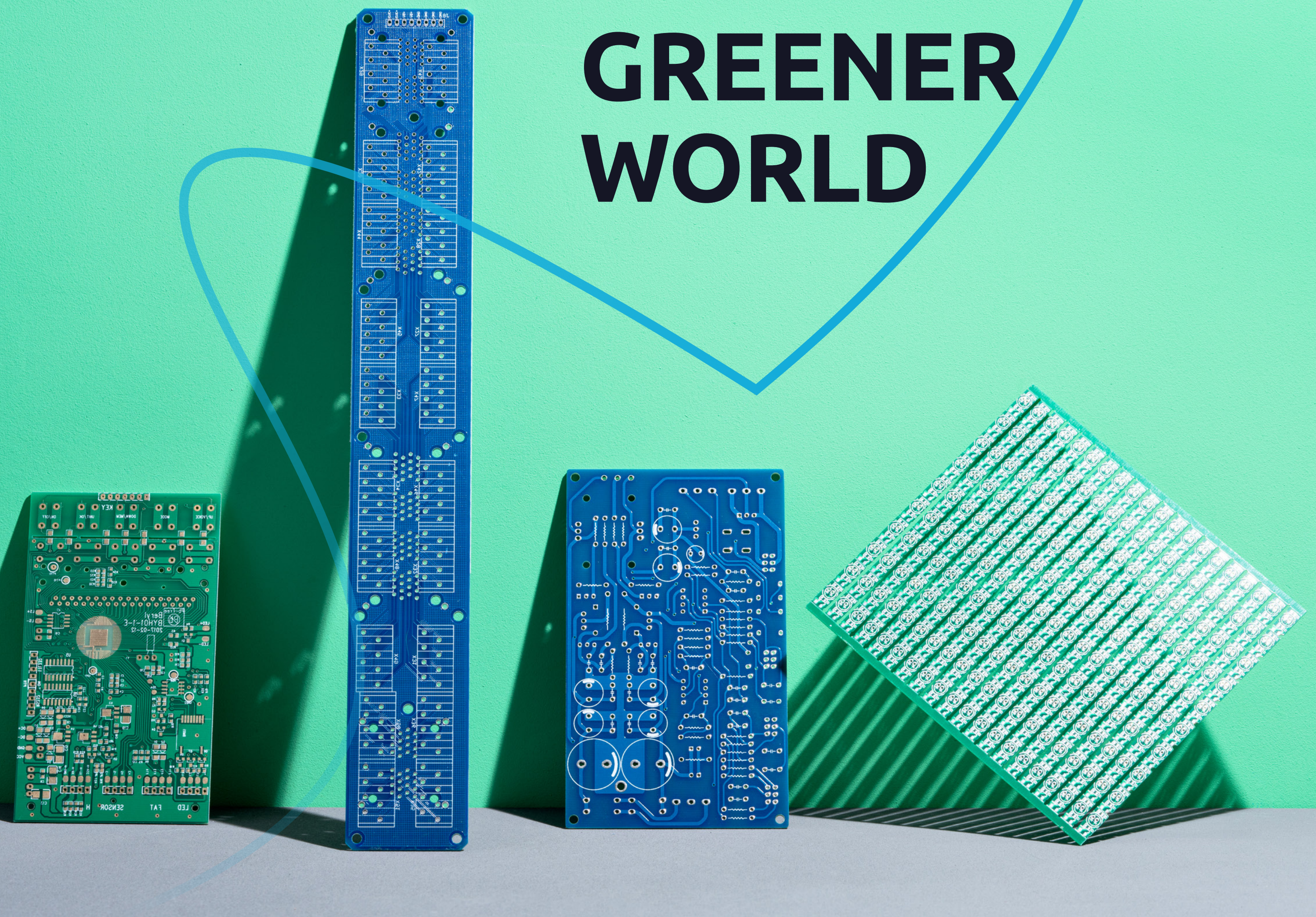
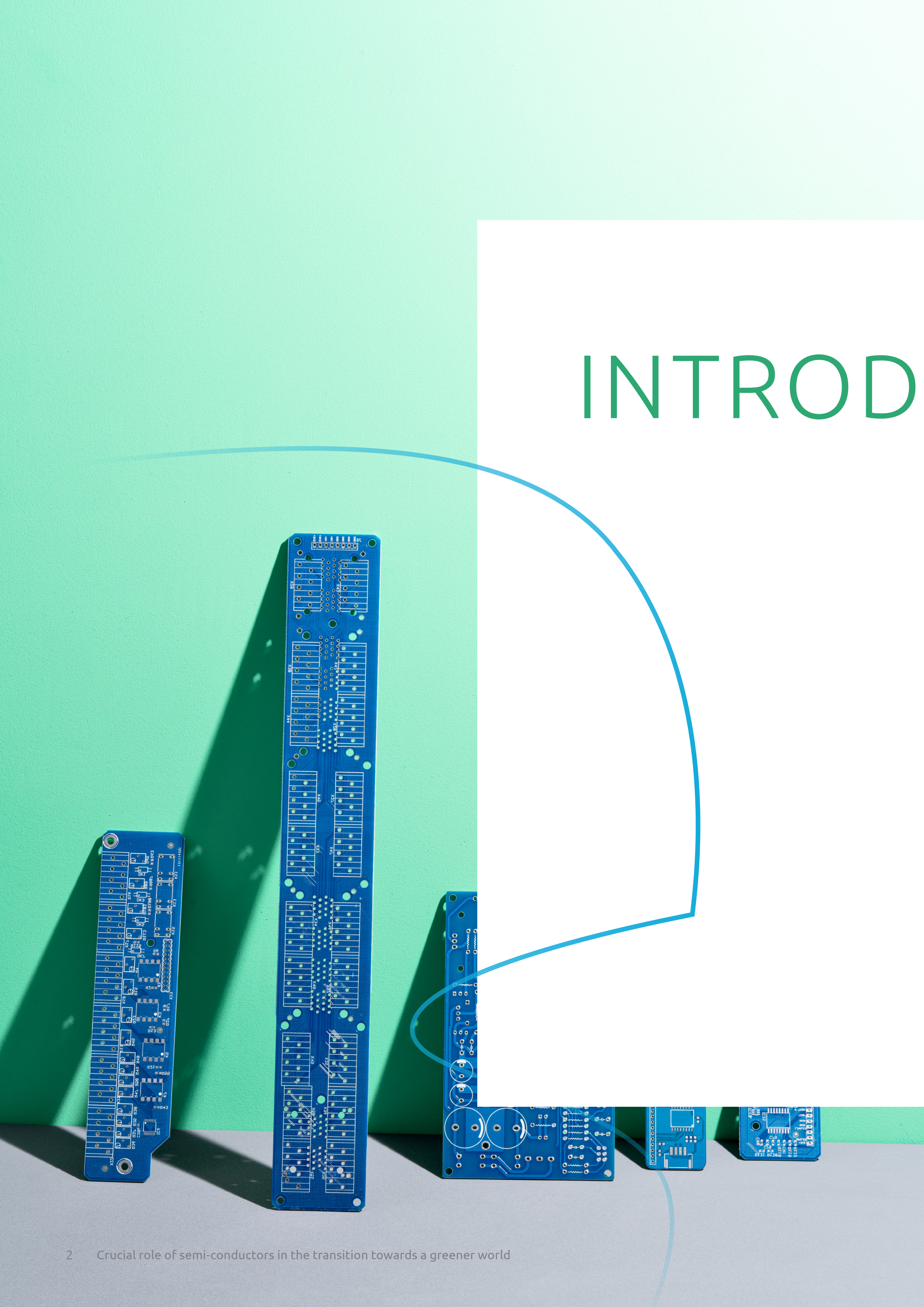
# THE CRUCIAL ROLE OF SEMICONDUCTORS
## IN THE TRANSITION TOWARDS
# A GREENER WORLD





# INTROD

# UCTION

With the boom in human and machine-generated data, IT capabilities, AI and connectivity, the global semiconductor market is likely to double by 2030, increasing from from 550 billion euros to over 1 trillion euros.[1.]

However, this rapid growth is creating environmental issues: ever more intensive use of raw materials and chemical products, significant emissions of process gases, etc.

As sustainable strategies play a central role in meeting consumer, investor and regulator expectations, it is essential for semiconductor players to address these issues by integrating environmental considerations right from the design phase of semiconductor components.

1. "Semiconductor Market Size, Share, Trends | Industry Forecast [2021-2028]" Fortune Business Insights, 2021

# ELECTRICITY CONSUMPTION:

## The key energy issue for manufacturers

**The vast majority (nearly 80%) of greenhouse gas emissions associated with the semiconductor sector is due to the direct use of energy (scopes 1 & 2) [2].**

Electricity is the main source of energy used to operate the fittings and hundreds of tools involved in the chip manufacturing process. According to data from the International Energy Agency, the semiconductor industry will consume around 2.5% of the world's electricity production in 2020. And to meet the sector's growth prospects, up to 3.5 times more electricity is expected to be consumed by 2030.

**Electricity consumption is therefore a critical issue for manufacturers, thus highlighting the need to implement strategies for energy optimization and sourcing from renewable sources as a short-term priority.**

Optimizing the energy consumption of companies in the sector starts with the energy used by tools, firstly by improving them (advanced etching techniques, increased lithography speed, etc.) or replacing them with energy-saving alternatives.

At the same time, manufacturers can use data, IoT and AI power to implement intelligent control systems for coupling and regulating installations and tools.

For example, analyzing production data using AI and machine learning could reduce machine downtime by half and improve manufacturing efficiency by 5-20%.

This optimization could also help to save energy and reduce the carbon footprint of the manufacturing industry [3].

With the aim of reducing the energy consumption associated with fittings in the semiconductor sector, there are ways of transitioning towards energy-efficient buildings, not only by reducing energy losses and recovering the heat produced, but also by optimizing the energy consumption of cleanrooms (reducing air pressure, increasing humidity, eliminating leaks) and making better use of ventilation and lighting (using LEDs, for example).

The other aspect of manufacturers' electricity strategy is related to their supply.

For their network supply, manufacturers can encourage the purchase of energy from renewable sources from public utilities,

private suppliers, or even through power purchase agreements (PPAs). At the same time, the use of autonomous energy sources to power their operations (photovoltaic, fuel cells

battery energy storage systems) will speed up the transition to a cleaner energy supply.

2. "Sustainability challenges in the semiconductor industry", TechXplore, 2020
3. "How AI and Machine Learning Are Revolutionizing The Manufacturing Industry", Forbes

# WATER, GASES AND SEMICONDUCTOR MATERIALS:

## Sustainability issue

In addition to electricity, water, often used in ultrapure form, is the second key raw material in the chip manufacturing process.

Eliminating all the impurities that can affect chip performance (such as metal ions, suspended particles or various bacteria) is a very energy-intensive process, not only because of the quantities of raw water required but also because of numerous hardware utilized (pumps, filters, etc.)

To keep pace with industry growth forecasts, the associated need for water could increase by 2.3 times by 2030[4].

**The development of water recycling initiatives, combined with the use of more environmentally-friendly chemicals, will reduce the pressure on ultrapure water.**

Although essential for manufacturing integrated circuits, the use of process gases has highly harmful consequences on the environment, particularly in terms of greenhouse gas emissions and various forms of pollution.

Manufacturers can adjust various parameters of the production process (temperature, chamber pressure), integrate alternative gases or low-emission processes, define gas reduction systems or recycle them, by capturing unused process gases using membrane separation or cryogenic recovery.

Finally, the adoption of better traceability and a more sustainable supply of the metals used in semiconductors, including silicon and germanium, are key areas of development for manufacturers.

Key actions that can be implemented include more environmentally-friendly and human-rights-friendly mining, eliminating the use of conflict minerals, and the development of sustainable alternatives to rare metals such as cobalt and lithium.

4 "Water demand for Semiconductor Manufacturing", Semiconductor Industry Association (SIA), 2018 / "Semiconductor Supply Chain Seeks Sustainable Solutions", EBN Online, 2020

# THE NEED FOR BETTER COLLABORATION BETWEEN INDUSTRY PLAYERS, INCLUDING BOTH SUPPLIERS AND CUSTOMERS

In addition to the environmental and human impacts associated with energy use, semiconductor manufacturers can help reduce their scope 3 upstream (raw material suppliers, transport) and downstream (distribution, use and end-of-life of their products).

At the upstream level, companies must be able to identify the greenhouse gas emissions associated with their raw materials and their suppliers' activities.

This traceability challenge requires, first and foremost, greater transparency throughout the supply chain, by implementing traceability tools and assessing the sustainable performance of their suppliers.

Also, close collaboration between partners, by encouraging, supporting and even developing the transition to sustainable practices in terms of energy, waste management and transport, will help to considerably reduce greenhouse gas emissions as well as costs.

As far as the downstream part of the process is concerned, there is a major challenge in raising customer awareness, by encouraging sensible use of chip-enabled devices, as well as the reuse and recycling of their products at the end of their life. In particular, taking into account the energy performance of chips during the design phase is an important factor, which manufacturers can manage more effectively. Another central area of scope 3 downstream concerns electronic waste management and associated emissions, which require the implementation of circular economy programs.

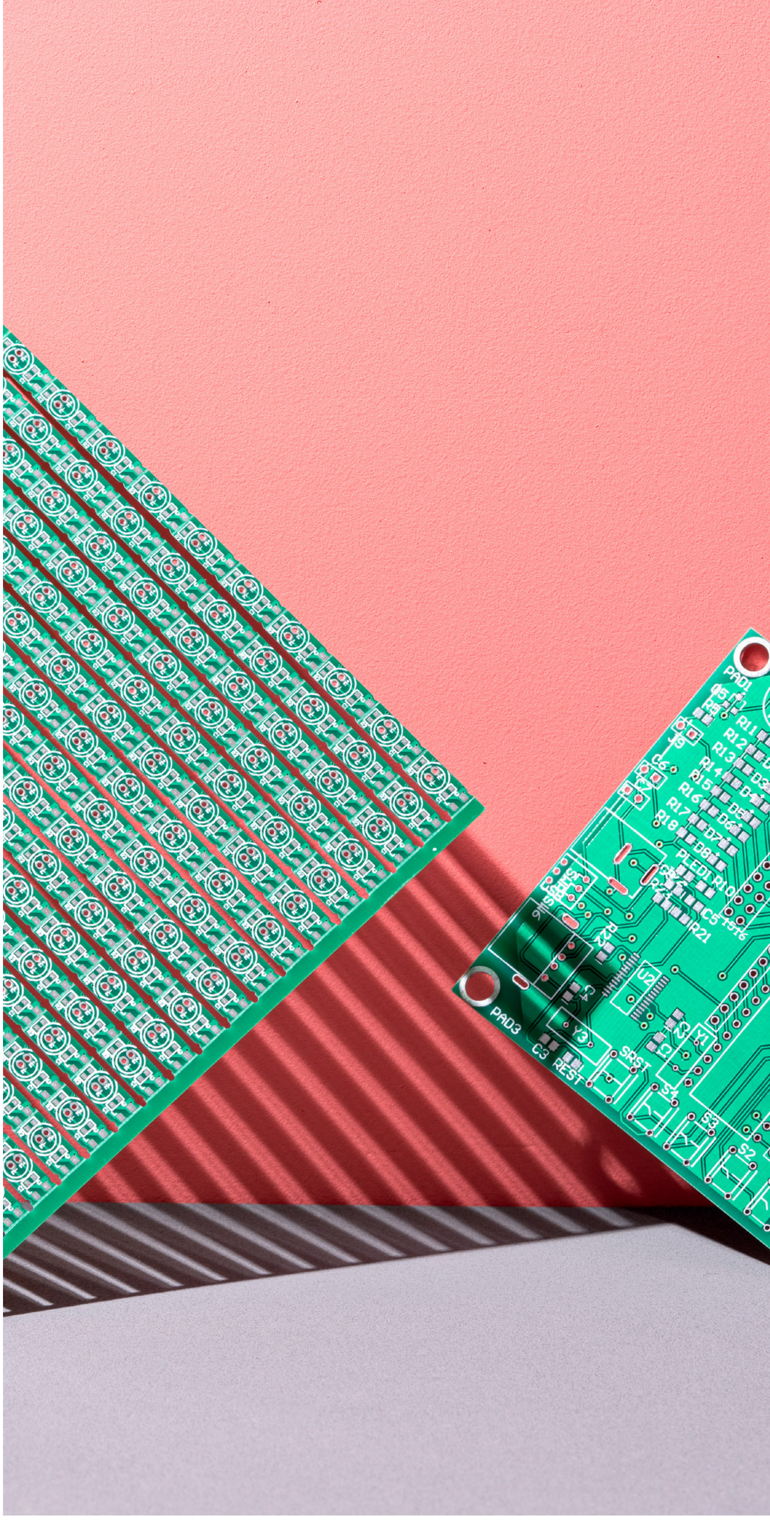
The reuse and recycling of materials, particularly silicon, waste reduction through more efficient production processes, as well as designing more sustainable products, based on recycled materials or ensuring better energy efficiency, are just some of the areas to be analyzed by semiconductor manufacturers.

**To achieve this, it is essential that all stakeholders in the value chain work together to increase manufacturers' effectiveness. To kick-start this dynamic, a lifecycle analysis of the products and services associated with semiconductors is key to developing an accurate vision of their impact and optimizing them.**

PLM-type tools can be particularly effective in providing the necessary visibility throughout the value chain.

On this basis, manufacturers can work towards defining measurement and transparency standards with regulators or build a low-carbon roadmap shared by all industry players.

# FIRST PROMISING INITIATIVES TOWARDS THE ECOLOGICAL TRANSITION OF THE SEMICONDUCTOR MARKET



## In recent years, the industry's commitment to sustainable practices has multiplied.

Qualcomm, for example, has announced a "Net Zero" objective for its operations by 2040, while STMicroelectronics is aiming for a 100% energy supply from renewable sources by 2027. As part of its commitments, NXP is aiming for 100% sustainable sourcing of minerals, excluding conflict zones.

Back in 2018, Intel and Nvidia collaborated to develop an energy-efficient AI server for data centers. The high performance of the DGX-1 server enables significant reductions not only in energy costs but also in terms of time-to-market, while increasing AI processing capacity.

Recently, initiatives have been launched to co-develop more sustainable alternatives, such as the collaboration between Soitec

and STMicroelectronics helped develop a technology for the manufacture of silicon carbide (SiC) substrates, which are the source of higher-performance, more energy-efficient power semiconductors.

**The energy transition of semiconductor manufacturers must now play a central role in their development strategy.**

**By pursuing their commitments and transforming their business model, semiconductor manufacturers will be able to solve the complex equation between continuing to grow, maintaining product performance and reducing their carbon footprint.**

# Our experts:

### *Nicolas Gaudillière*

Chief Technology Officer
Capgemini Invent

A CentraleSupelec engineer, Nicolas started his career in the 2000s. He initially worked as a cybersecurity consultant, before helping to set up Cloud service platforms for telecom operators and major integrators. In 2015, he joined Capgemini Invent as CTO to focus on the organizational and human transformations required for adopting numerous technological innovations such as IoT, cloud, AI, blockchain, 5G, and quantum. Today, Nicolas oversees the Telco, Media, and tech sector, supporting customers in optimizing their business strategy to seize new growth opportunities, streamlining their industrial models, and expanding their technological innovation policy, all while helping them achieve their sustainable development goals.

### *Olivier Marcillaud*

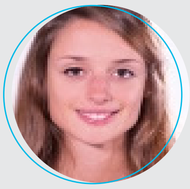
Senior Director Telecom
Media & Technology
Capgemini Invent

With more than 20 years of experience in the TMT sector, Olivier is experienced with work as both a consultant and in more operational roles in business development, operations, and IT. He is incredibly passionate about the Telecom sector, working on subjects related to infrastructures and operations, as well as on the challenges of sustainable transformation and its application.

### *Sanjiv Agarwal*

Vice President DSP
Global Semiconductor
Industry Leader

With about 30 years of experience in the TMT sector, Sanjiv is experienced with enabling digital transformation journey for customers using best-of-breed technology solutions and services. In his current role as global semiconductor industry leader, he is working closely with customers on their journey on producing sustainable technology, driving use of AI/ML, digital transformation, and global supply chain. He is incredible passionate about the role of technology and its impact on enterprise and human lives.



### *Pauline Lechopied-Bay*

Managing Consultant
Telecom, Media & Technology
Capgemini Invent

For the last 8 years, Pauline has supported the B2C and B2B transformations of many Telco, Media, and tech players. She is specialized in supporting transformations through the definition of new business models, the launch of new digital offers, and the transition to sustainable strategies.

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