European Semiconductor Industry Association

BACKGROUND NOTE

Europe's Unique Semiconductor Strengths in Edge AI

Brussels, 17 December 2025

Introduction

The European Union has identified artificial intelligence (AI) as a key priority for action and as a critical technology area vital for Europe's competitiveness. European Commission President Ursula von der Leyen has stated her ambitions for Europe to become a global leader in AI innovation in her Political Guidelines[1] as consumers and industries increasingly leverage AI solutions.

For industry, AI comes in manyfold forms, from machine learning for chip testing to predictive maintenance, and manufacturing cost optimisation to agentic systems based on large-language models (LLMs).

Already today, many devices used in citizens' daily lives are AI-enabled: smart phones, connected cars, smart watches, smart door locks, AI PCs – offering ever more innovative use cases, (energy) efficiency, and convenience.

In addition, the use of AI in industrial applications, such as production robots or process optimisation methods, is equally important. Europe's strengths in this area present clear opportunities. European companies account for more than half of the global market in industrial automation – a cornerstone of industrial AI. Yet, only about 10% of European manufacturing companies adopted AI last year. To translate this advantage into European solutions, a close collaboration between industry and governments is essential.

The purpose of this background document is to explain the complementarity of Cloud AI and Edge AI, with a focus on informing about the role of Edge AI with regards to Europe's future technology leadership.

[1] Ursula von der Leyen Candidate for President of the European Commission (18/07/2024). *EUROPE'S CHOICE. POLITICAL GUIDELINES FOR THE NEXT EUROPEAN COMMISSION 2024–2029*, Strasbourg, p. 10. URL: https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en

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EECA: European Electronic Component Manufacturers' Association
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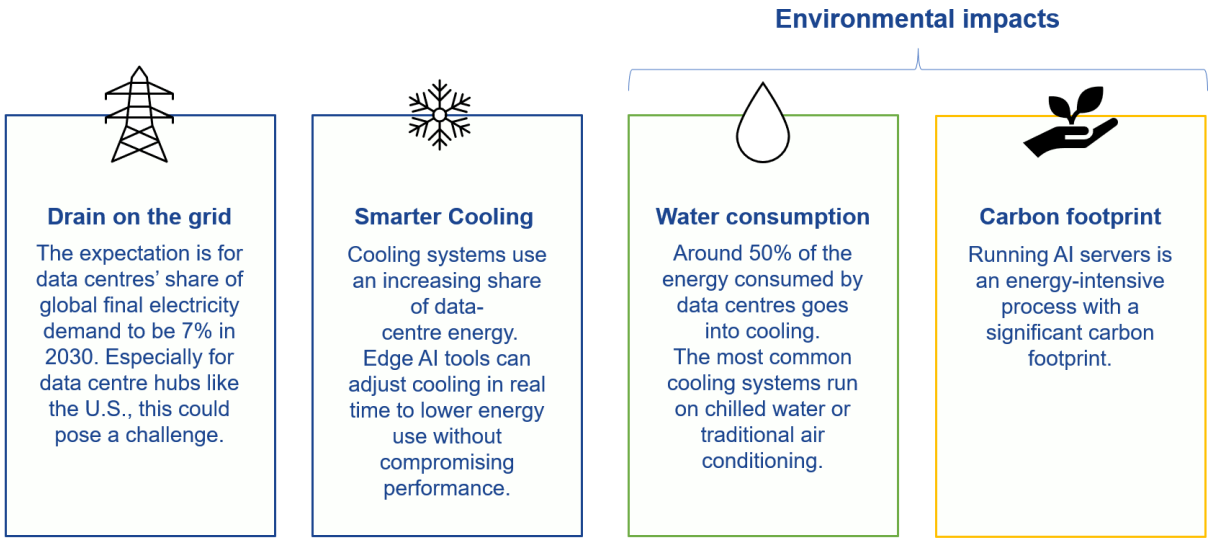
Cloud Processing – Cloud AI

Cloud computing enables the processing of vast amounts of data by leveraging powerful, centralised infrastructure. In the context of AI, such data centres are equipped with high-performance graphics processing units (GPUs) and central processing units (CPUs), which are essential to train the LLMs and run the model inferencing. In cloud-processing operations, data is first transferred from the individual device to the cloud, then processed by AI models, and then results are sent back to the device. 'Cloud AI' scales easily for users and is commonly used for applications where massive amounts of data need to be treated, for example smart chatbots, co-pilots, or data analytics, and is also used by the industry to process vast amounts of data from different sources such as digital twins in manufacturing or simulation-driven development.

To help address the significant energy demand of these compute-intensive cloud operations, the semiconductor industry in Europe is advancing its semiconductor solutions, which enable more efficient power conversion and supply delivery across the racks. These innovations help enable Europe's data centres and AI workloads to remain both high-performing and energy-saving, supporting the EU's goals for digital sovereignty and sustainability.

Semiconductor companies in Europe are global market leaders in power management integrated circuit (IC) solutions for data centres, and they have developed leading expertise in integrating hyper pure polysilicon, silicon (Si), silicon carbide (SiC), and gallium nitride (GaN) into their components. They also provide top-class high-speed backbone communication (intra-rack) within the data centres (e.g., 3+ Terabyte per second, or Tbps).



Source: Earth.org; Study: Making AI less "Thirsty": Uncovering and Addressing the Secret Water Footprint of AI Models; Infineon

Figure 1: Challenges that can be addressed by focusing on powering AI data centres more efficiently.

Edge Processing – Edge AI

Edge AI is increasingly essential across a wide range of applications, with consumer – such as Internet of Things (IoT) devices, automotive, or PCs – and enterprise use cases being key

examples. Edge AI enables robust on-device intelligence and real-time data processing where cloud-based approaches are limited by energy, cost, security, or latency constraints.

Many IoT devices only generate moderate amounts of data. AI models used to enhance these devices need to be very robust and accurate and implementations both on the model and the hardware need to be highly energy and cost efficient, often also requiring high security. Examples include home devices, such as smart door locks. In such use cases, energy intensive data transfer to the Cloud is not required. Instead, it is sufficient to run the trained AI algorithm directly on the device, on the 'edge'. The device is able to take decisions in real-time, since no data transfer to the cloud is necessary. At the same time, the process is energy efficient, ranging from ultra-low power battery (e.g. µWatts for voice-based human-machine interfaces) to few Watts only for very advanced algorithms.

Also, for more data-intensive applications such as cars, Edge AI enables low-power, real-time, and safety-critical use cases. Such solutions enable substantial energy and cost reductions in real-world applications, e.g. through local system-level models that enable precise battery status and charge in multi-cell battery management, and thus longer lifetime, better capacity utilisation, and less weight. Edge AI capabilities are increasingly used by enterprises to improve efficiency through data analysis. Enterprises often require real-time processing, low latency, and work in locations with poor connectivity, exposing them to delays during transmission to and from the cloud. To address this, Edge AI processes data at the source – on the plant floor, in hospitals, or at storefronts. Algorithms run locally, lowering power consumption and latency while improving performance.

At the core of Edge AI solutions are microprocessors, microcontrollers, and smart sensors in node sizes between 5-40 nm. The deployment of Edge AI requires innovative hardware components such as low-power AI accelerators, secure processing elements, integrated sensor-processor solutions, real-time processing capabilities, and power-efficient memory architectures. Semiconductor companies in Europe are well-positioned to leverage their existing expertise and market strengths to service these hardware demands and gain a global leadership position in this field.

Data privacy and security: keeping data locally – at the edge – helps to reduce security and privacy risks. As an encapsulated system, Edge-AI-enabled devices provide a high level of data security, since they do not require data transfers to the cloud for processing. For instance, smart door locks are rendered more secure by avoiding that hackers track activity and gather information on the edge-to-cloud link, also improving access / leave times.

The following paragraphs examine a selection of key Edge AI use cases, highlighting their relevance for Europe's industrial, automotive, and IoT ecosystems.

Edge AI Key Use Cases

The connected car as successful Edge AI application

In the future, the connected car will be a great example of convergence of the most advanced technologies. These 'robots' will also demonstrate the interaction and complementarity of Cloud AI and Edge AI solutions.

Connected cars, first and foremost, will require safety and security. Customers must be able to trust their car. They must be sure that the car stops in front of an obstacle and that the risk of external (cyber) attacks is controlled. Building an intelligent system like a connected car will require AI with high processing power, but also safety and security features, and sensors. Chipmakers in Europe are leading in this field.

Like a human being, a connected car will need real-time functions and reflexes. In addition, critical tasks like engine management need to be ensured at any time. Furthermore, perception capabilities, for example for decision-making in complex environments, will be required.

A connected car will thus need semiconductor solutions covering a wide range of capabilities, including intuitive movements, real-time functions and reflexes, and sensing and control of vital functions. These semiconductor solutions include Edge-AI capabilities, e.g. real-time decision-making. Chips for such operations range between 16-40 nm. Semiconductor companies in Europe have unique, globally competitive strengths in precisely those areas.

A connected car will also need to make decisions that require context awareness and the analysis of large amounts of data. This will either be enabled by Cloud AI, as a complimentary building block, or via higher-end Edge-AI processors in 5-nm or even more aggressively scaled nodes.

For the performance of the above functions, a connected car will rely on AI systems of reduced complexity and size, such as a microcontroller (MCU) and a microprocessor (MPU) combined or not on one piece of silicon ('crossover MCU'). As an encapsulated system, this can run on a small form factor providing significant energy, safety, and security gains.

Enterprise Edge AI solutions

By integrating artificial intelligence with industrial automation, applications of Edge AI are numerous and keep growing: the adoption of AI solutions has positive implications for the competitiveness of EU industries.

In manufacturing, for instance, Edge AI enables automated anomaly detection, asset tracking, product inspection, worker safety, vision-guided robots, as well as operational diagnostics to enhance production quality and efficiency. In smart factories, it makes operations more efficient and the factory floor safer and more agile. Predictive analytics on the edge provides insights for maintenance, reducing downtime, and improving overall system performance.

Edge AI use cases on the factory floor are expanding beyond computer vision, such as defect detection, to more advanced multi-model applications involving Generative AI (GenAI),

natural-language tools (text-to-speech, chatbots), and robotics. In practice, this means deeper integration into factory operations, allowing processes to adjust automatically based on incoming data – for example, moving from simply identifying a weld defect to actively correcting the welding tool as soon as issues appear.

These emerging Edge-AI use cases are expected to revolutionise industries. In manufacturing, GenAI-driven software – relying on local site data rather than Cloud AI – could facilitate an agile and dynamic supply chain.

AI PCs as the next evolution in computing

AI PCs are devices with specialised hardware – a CPU, a GPU, and integrated neural processing unit (NPU) – specifically designed to power AI applications and enable AI use cases at the edge.

AI PCs represent the next evolution of computing: while most PCs rely on the cloud to run AI apps, AI PCs feature dedicated hardware that support fast, efficient AI on the device. This allows taking advantage of advanced AI software locally, while helping keep data private and optimising productivity, performance, and battery life.

Benefits of Edge AI

Edge AI can help enterprises tackle any number of complex challenges by bringing AI capabilities to the edge. Reasons that an enterprise might choose to deploy Edge AI include:

- **Operational speed and efficiency**: Edge AI eliminates delays associated with cloud-based processing, minimising latency, and avoiding network bottlenecks.
- **Cost-effectiveness**: The growing volume of data from sensors and devices makes edge computing more cost-effective than sending data to the cloud and back.
- **Energy saving**: Edge AI devices are designed to facilitate low-power computing. Meanwhile, networking hardware like routers and switches consume less power, as traffic to and from the data centre is minimised.
- **Data privacy and security**: Keeping data local – at the edge – helps reducing security and privacy risks.

Opportunity for European Leadership

Both Cloud AI and Edge AI are critical for various sectors in Europe, but they serve different purposes and come with their own advantages and limitations. Cloud AI excels in processing large-scale and complex analytics on powerful servers in data centres, whereas Edge AI enables real-time decision making directly on the device with cost, energy-efficiency, and security benefits.

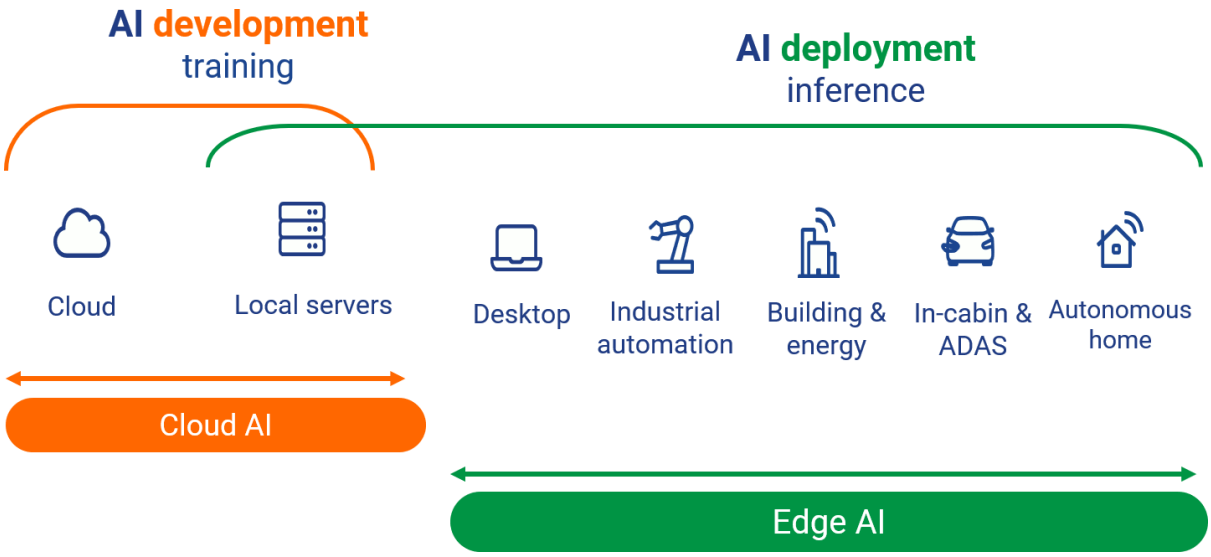
At any rate, EU industries will benefit from integrating AI solutions in manufacturing, healthcare, automotive, smart home, and smart energy management.

To summarise, Cloud AI and Edge AI are complementary AI semiconductor-enabled technologies that allow device manufacturers to embed AI in their products in a customised way.

The semiconductor industry in Europe has unique strengths in Edge AI solutions. Europe's lead markets – automotive, Industrial and Home IoT – require increasingly innovative solutions that enable the technological transformation towards intelligent systems ('smart robots' today and humanoid robots in the near future). Such systems involve embedded AI – i.e., Edge AI – delivering low power and high safety & security. Here lies the unique opportunity for Europe to become a global leader.

In addition, Europe is leading in hardware components increasing energy efficiency of data centres and AI systems including power semiconductors, power management ICs, and application-specific ICs (ASICs). 'Powering AI' is going to be another major opportunity for Europe to enable cloud-based AI data centre developments.

EU-level policymakers must recognise and leverage the complementary advantages of both Edge AI and Cloud AI and grasp the European capabilities. These European strengths must be reflected in future policy initiatives and be underpinned by dedicated strategies to enable industry in Europe to secure a leadership position in this next wave of AI innovation.



For further information:

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ABOUT ESIA

The European Semiconductor Industry Association (ESIA) is the voice of the semiconductor industry in Europe. Its mission is to represent and promote the common interests of the Europe-based semiconductor industry towards the European institutions and stakeholders in order to ensure a sustainable business environment and foster its global competitiveness. As a provider of key enabling technologies, the industry creates innovative solutions for industrial development, contributing to economic growth and responding to major societal challenges. Being ranked as one of the most R&D-intensive sectors by the European Commission, the European semiconductor ecosystem supports approx. 200.000 jobs directly and up to 1.000.000 jobs indirectly in systems, applications and services in Europe. Overall, micro- and nano-electronics enable the generation of at least 10% of GDP in Europe and the world.