EUROPEAN CHIPS SKILLS ACADEMY

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ETUDES & CONSEIL

SKILLS STRATEGY 2025

UPDATE ON THE TALENT GAP IN THE EU SEMICONDUCTOR ECOSYSTEM

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EXECUTIVE SUMMARY

THE EU TALENT GAP: A STRUCTURAL CHALLENGE

The European Skills Strategy 2024 report, published in October 2024 under the European Chips Skills Academy (ECSA) project and prepared by DECISION Études & Conseil, presented the projected talent gap in the semiconductor sector across the EU27 for the 2024–2030 period, based primarily on forecasted investment plans within the EU. According to the report, the aging of the European workforce, combined with industry growth, was expected to drive strong demand for talent: 271,000 job openings and a 5% annual increase in talent demand by 2030. Meanwhile, the supply of graduates was expected to follow past trends, with only a 1% annual increase in semiconductor-related fields such as electronic, mechanical, software, and chemical engineering. This imbalance between supply and demand was projected to result in a talent gap of 75,400 skilled workers by 2030, corresponding to an average annual shortfall of 12,600 workers.

These projections, made in mid-2024, have since been revised following two major developments:

- **The postponement or cancellation of four key investment projects in the EU**: (1) Intel's factory in Magdeburg, Germany; (2) Intel's back-end facility in Poland; (3) GlobalFoundries' investment in Crolles, France; and (4) the Wolfspeed/ZF factory in Saarland, Germany.
- **The 8% downturn in the European semiconductor market in 2024**, which led several companies to freeze or slow recruitment plans.

Taking these factors into account, the talent gap, initially estimated at 75,400 by 2030, now stands at around 65,000 as of October 2025. This corresponds to an average annual shortfall of about 10,800 skilled workers across the European Union over the six-year period from 2024 to 2030.

By 2030, the European semiconductor industry is expected to face an average annual shortfall of around 10,800 skilled workers across the value chain, mainly due to an ageing workforce and the limited growth of graduates in semiconductor-related fields of study.

Although the talent gap has narrowed and its onset delayed, it remains a structural challenge for Europe, particularly as it is expected to widen beyond 2030. Given the long lead time required to expand the skilled workforce, urgent action is needed – especially in the regions where demand is most concentrated: Saxony,

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Brainport Eindhoven, Ireland, Belgium, Crolles, Catania, Northern Italy, Bavaria, Baden-Württemberg, Czech Republic.

Main Talent Gap Locations in 2025

Segment	Key Regions / Actors
Design & Test	Most IDMs and fabless companies in Europe
Front-end	Germany, Ireland, Italy, Austria (ESMC, Intel, ST, Infineon, AMS…)
Back-end	Italy, Malta, Portugal (Silicon Box, ST, Amkor…); possibly France in 2026
Pilot Lines	Belgium, France, Italy, Germany, Spain
Equipment & Tools	The Netherlands, Germany (ASML and ecosystem…)
Materials	Mainly Italy and Finland (wafers), and Germany (gases and advanced chemicals)

KEY FINDINGS FROM THE 2025 INDUSTRY SURVEY

The 2025 ECSA survey on the skills needs from the European Semiconductor Industry gathered **102 responses across 75 organizations**, with a balanced representation of SMEs, large companies, universities and RTOs.

In 2025, the EU microelectronics industry expects to hire at similar levels to 2024, with skills shortages persisting across most occupational categories.

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36% of companies plan to increase their workforce, citing three main drivers:

- The EU Chips Act 1.0.
- Geopolitical considerations related to European economic security.
- Specific needs in design, AI and data analysis.

On the other hand, 49% expect to maintain their current workforce while 14% anticipate reducing hiring, due to:

- Weak demand from user industries.
- An insufficiently attractive investment framework in Europe - particularly due to high energy costs.
- Automation and AI which are reducing hiring needs while increasing upskilling requirements.

The persistence of the skills shortage is mainly attributed to:

1. **An ageing workforce**, with 30% of employees expected to retire between 2024 and 2030 (~114,000 people).
2. **Insufficient training provision for certain roles:** insufficient training pipelines in electrical engineering in specific countries (such as France and Italy), and EU-wide shortages in training pipelines for specific profiles: system designers, analog designers, and cybersecurity experts.
3. **The limited attractiveness of the semiconductor industry** amid growing competition for talent from the energy and environment sectors.

The persistent structural gap between an ageing workforce and the limited inflow of new graduates threatens the European ecosystem's ability to sustain its global competitiveness.

Education and training systems are adapting slowly, and long-term investment and EU-wide coordination is required despite modest early progress from recent initiatives (EU Chips Act, EU-funded projects, etc.).

The most sought-after and hardest-to-fill job profiles in 2025 remain:

- **Software engineers.**

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- **Design engineers,** with shortages particularly acute for system and analog specialists, driven by system-level integration, Europe's strengths in sensors and power electronics, and AI-related design needs.
- **Cybersecurity experts**, who have overtaken data specialists as the third most in-demand profile, reflecting growing vulnerabilities linked to digitalization.

Other roles, including process engineers, technicians, and robotic engineers, remain in demand but are somewhat easier to fill, though shortages persist for experienced positions.

The most sought-after and hardest-to-fill skills in 2025 remain:

- **System architecture.** Overtaking AI, reflecting its central role in integrating hardware and software for safety-critical applications and complex SoC systems. The shortage is driven by long training times, the need for cross-disciplinary expertise, and Europe's limited specialized programs, with many roles requiring master's or doctoral-level qualifications.
- **Artificial Intelligence.** Artificial Intelligence remains a key factor, influencing nearly all job profiles. Designers, test, verification, and software engineers are among the most affected, but manufacturing-related roles – such as process and automation engineers and technicians, and quality and reliability engineers – are also being transformed by the use of new AI-powered automation tools. Finally, operator roles are increasingly at risk due to automation and AI, highlighting the need to upskill operators to technician-level positions.

Finally, **Security (1) and Edge IoT/Edge AI (2) are the two top technology trends reshaping skills needs in 2025.** Security has become a universal requirement, embedded across the value chain and spanning many roles well beyond cybersecurity specialists. Edge IoT and Edge AI further reinforce demand for expertise that bridges hardware and software, particularly in system design, embedded development, and application engineering.

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1. Short term

A) Fund upskilling & reskilling programmes

First, funding upskilling and reskilling programmes are urgently required to address the evolving skill needs of the semiconductor and related industries.

Upskill the existing workforce:

- Notably enabling engineers to transition from digital design towards analog or system design
- And supporting manufacturing profiles to operate new AI- and robotics-based tools as well as to manage the associated data.

In parallel, reskilling initiatives should target workers from other industrial sectors, such as the automotive industry, in order to expand the talent pool available to the semiconductor ecosystem.

B) Attract talent from countries with labor surplus

Second, stakeholders call for stronger efforts to attract talent from countries with a labor surplus, both within and beyond the EU.

At the intra-EU level, countries such as Spain, Croatia, Romania, Bulgaria and Greece are identified as potential sources of skilled professionals.

At the extra-EU level, cooperation should be reinforced with India, Africa and Asia.

To support this objective, the panel recommends:

- Launching dedicated mobility programmes for students and workers
- Simplifying the administrative procedures governing mobility
- Fostering international cooperation with the most relevant partner countries

2. Long term

A) Increase training capacities in targeted fields

In 2025, as has been the case consistently since 2020, respondents have identified as a top priority the need to **increase training capacities in targeted fields**. Two specific actions are recommended in this regard:

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- **System designers, analog designers, and cybersecurity experts.** The EU faces shortages of 3,300 system designers, 2,100 analog designers, and 2,600 cybersecurity experts by 2030. These roles require highly specific training and experience, while the number of professionals to be trained remains relatively limited. The creation of specialised training hubs across the EU is essential to bridge this gap.
- **Electrical and electronic engineers in specific locations.** By 2030, the industry will require 53,400 professionals with electrical engineering backgrounds to support manufacturing, design, and testing. At the EU level, the main challenge is to attract existing STEM students to electrical engineering studies. However, in certain countries or regions (e.g. in France and Italy), training capacities in electrical engineering appear insufficient and/or are declining. There is an urgent need to expand these capacities in such areas. Short-term relief could also come from intra-EU mobility, leveraging countries with surplus graduates (Spain, Romania, Greece, Bulgaria, Croatia), and from extra-EU migration from regions such as India.

The panel insists on **the urgent need to strengthen the overall education and training ecosystem** for microelectronics across Europe.

- **Increase public education investment in microelectronics.** As education funding is being reduced in several Member States – directly affecting electrical engineering training capacities – stakeholders observe a parallel rise in "quick" or low-quality certificates aimed at short-term attractiveness. Such practices undermine the EU's ability to compete in an increasingly complex global environment. Coordination with national Ministries of Education is essential to ensure sustained public funding for electrical engineering and microelectronics programmes in targeted geographical areas.

  This increased funding would also enable the development of modern digital and remote learning infrastructures – such as virtual classrooms, simulation environments, and collaborative online labs – that are indispensable for providing high-quality training across the EU.
- **Set up innovative training initiatives to support upskilling and reskilling.** Initiatives such as summer schools or accessible online training platforms, including recognized certification schemes, would enable professionals at different career stages to upskill or reskill efficiently.

In summary, the European semiconductor skills gap remains structural and long-term. Although the recent market slowdown has temporarily eased pressure, Europe's ability to meet future industrial targets will depend on **sustained policy coordination, expanded training capacity, and effective mobility and attraction measures.**

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B) Attract students and graduates to the semiconductor industry

The second major recommendation stresses the need to **raise awareness and strengthen guidance on education pathways** leading to careers in microelectronics. Beyond increasing training capacity, Europe must inspire young people – starting early – to discover opportunities in the semiconductor and electronics industries.

- **Promote early engagement in STEM and microelectronics.** Efforts should start well before university, at primary and secondary school levels, by introducing pupils to science and technology through hands-on activities such as robotics and electronics labs, hackathons, and after-school clubs. Member States should integrate introductory microelectronics modules – covering electronics, programming, materials science, and emerging technologies – into school curricula to make technology more tangible and appealing. Coordination with national education ministries from Member States is crucial in this regard.
- **Train and support teachers.** Teachers are central to sparking students' interest but often lack the tools to do so. "Train-the-trainer" programmes and updated teaching materials are needed to familiarize educators with new technologies and help them deliver engaging STEM and microelectronics lessons.
- **Create structured orientation and outreach programmes.** Establish accessible career-orientation platforms and public awareness campaigns highlighting the diversity of careers in microelectronics – from engineering and design to sustainability and digital innovation – and their role in Europe's technological sovereignty. Industry experts sharing their experiences via social media and outreach events can further inspire students and demystify technical professions.

C) Ensure the participation of the semiconductor industry

The third major recommendation calls for the **active involvement of the semiconductor industry in education and training.** Companies should move beyond identifying skills needs to co-develop and deliver training, ensuring learners gain both technical expertise and practical experience.

- **Co-develop training and curricula with academia.** Closer collaboration between industry and education providers is essential to align learning outcomes with industrial needs. Companies should help design and deliver courses – such as summer schools and workshops – while universities regularly update curricula to reflect technology and market advances.

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- **Support internships and apprenticeships.** Stakeholders call for structured, co-funded internship and apprenticeship programmes, particularly in SMEs and start-ups, where hands-on experience is most valuable. Dual-track systems combining academic study and industrial placement would improve employability and strengthen long-term links between students and the industry.
- **Establish joint training centres and innovation hubs.** Stakeholders recommend setting up joint training and competence centres co-developed by academia, industry, and public authorities. These hubs would serve as focal points for advanced training and technology transfer, offering practical courses and collaborative projects while strengthening regional ecosystems and aligning programmes with evolving industrial needs.

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INTRODUCTION – THE ECSA WP3

ECS ACADEMY

The European Chips Skills Academy (ECSA) is an Erasmus+ program aiming at bridging the gap between education, training, and industry to tackle Europe's skills and talent shortages in the semiconductor industry. ECS-Academy 1) implements and operationalizes the Pact for Skills 2) establishes the first-of-a-kind decentralized academy for microelectronics, linking industry, research, HE and VET currently operating in isolation 3) develops innovative training and curriculum to provide reactive and proactive response to the skills needs of the sector.

ECS-Academy is an Alliance of 18 partners, with 30+ organizations endorsing the project, covering the whole of the EU Educational Area and the entire value chain of microelectronics.

WORK PACKAGE 3 (WP3)

The objective of WP3 "European Chips Skills Academy: Skills Anticipation, Skills Strategy and Educational Programme" is to seamlessly connect the world of education and the world of work in microelectronics by bringing education, training, research, innovation, and industry together under the same roof. This is the first-of-a-kind decentralized academy for the microelectronics and chips sector, establishing territorial focal points (HEI, VET, industry) that are interconnected and operate in sync following guidelines and objectives co-created by the Pact for Skills and the Board established in WP2.

DECISION Etudes & Conseil is the leading partner of the consortium for the Deliverable D3.1 and D3.2 under the supervision of TU Graz.

OBJECTIVE AND SCOPE OF SKILLS MONITORING IN THE ECSA

OBJECTIVES

In 2024, DECISION Etudes & Conseil developed and applied a methodology to quantitatively assess and forecast the semiconductor talent gap across 3 objectives:

- Assess current situation: tools, data, research models and assumptions to evaluate the state-of-the-art in semiconductor skills monitoring.
- Anticipate future needs: scenario-building to gauge and anticipate skills and competences.

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- Monitor qualitatively and quantitatively the talent gap in the EU using a core methodology of Input/Process/Output between the world of education and the world of work.

This led to the European Skills Strategy 2024 report, published in October 2024.

From 2025 onwards, and in subsequent editions, the skills analysis focuses exclusively on qualitative aspects, based on the results of the ECSA Survey. These updates complement the quantitative baseline established in the 2024 report.

SCOPE

The sectoral scope of the ECS Academy is the semiconductor value-chain, as defined in the diagram below. As a consequence, the Skills Strategy focuses on the different sub-segment of this value-chain:

- Research & Developments (made by Research and Technologies Organizations)
- Design
- EDA & IP
- Equipment & tools
- Materials
- Manufacturing (Front-end, back-end)

Additionally, the Skills Strategy focuses on semiconductor-related activities carried out by players other than those traditionally involved in the semiconductor value chain. These players are occasionally involved in semiconductor manufacturing or, more commonly, in semiconductor design:

- Original Equipment Manufacturers (OEMs).
- Electronic Manufacturing Services (EMS).
- Printed Circuit Board (PCB).
- End users in the automotive, industrial equipment and aerospace/defence/security sectors.

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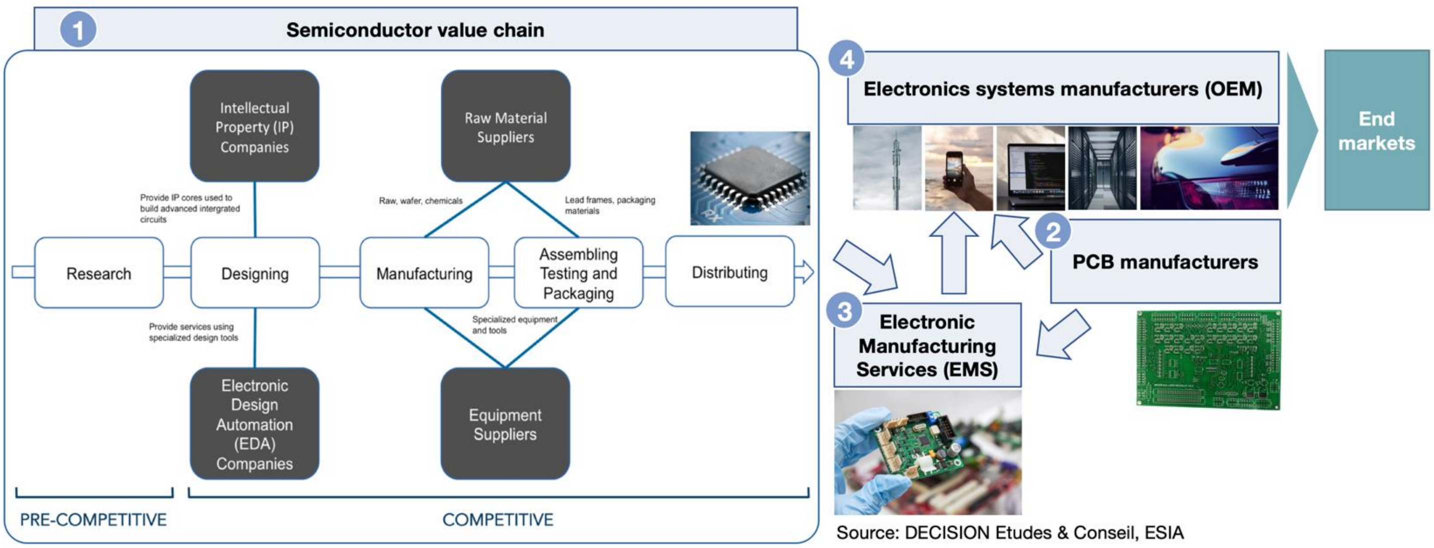
Figure 1: The semiconductor value-chain



Source: DECISION Etudes & Conseil

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QUANTITATIVE ANALYSIS – EU TALENT GAP UPDATE

INTRODUCTION: MAPPING THE EU SEMICONDUCTOR VALUE CHAIN

The European Union (EU) is home to several leading companies in the global semiconductor industry. Notably, it hosts four major European integrated device manufacturers (IDMs): STMicroelectronics, Infineon, NXP and Bosch. In addition to these European IDMs, the EU also benefits from the presence of major foreign IDMs operating within its territory, including Intel, ON Semiconductor, Analog Devices, Renesas, and Samsung. The contribution of pure-play foundries to the European ecosystem remains limited, despite the presence of X-Fab (Europe) and GlobalFoundries (United States). The EU is also home to some of the largest and most prominent fabless companies, such as Melexis (Europe) and Qualcomm and NVIDIA (United States). Furthermore, ASML, the global leader in photolithography, has a strong presence within the EU. The Union benefits from a comprehensive ecosystem surrounding ASML, including organizations such as TNO, TRUMPF, and Carl Zeiss. In addition, leading US equipment manufacturers Applied Materials and KLA Corporation are strongly established in Europe. The EU also enjoys a strong ecosystem in materials and tools, with players such as Atlas Copco, Linde, and Siltronic. Finally, the EU hosts three leading research and technology organizations (RTOs): Imec, CEA-Leti, and Fraunhofer.

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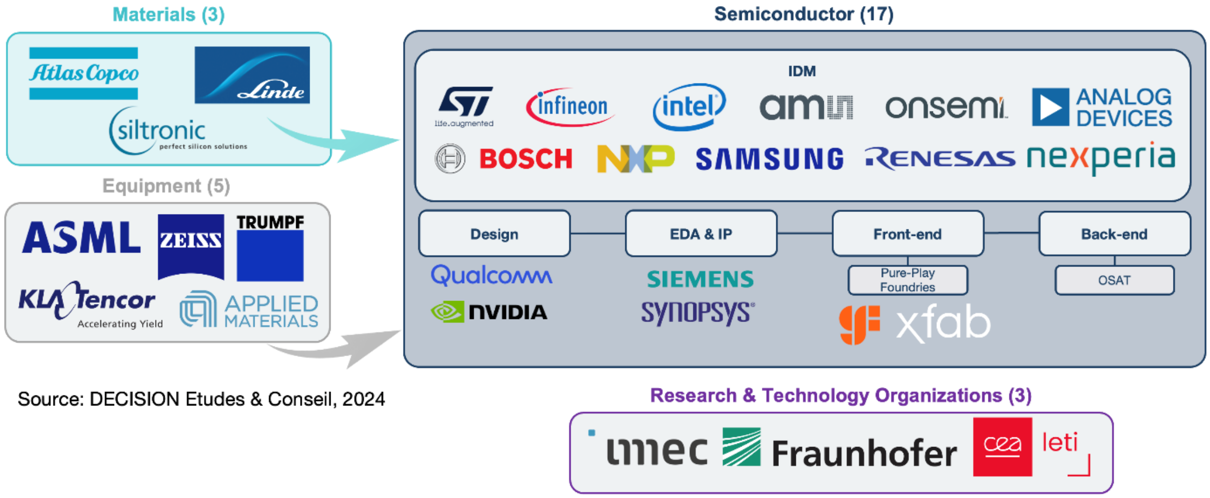
Figure 2: The TOP 28 employers on EU soil across the semiconductor value chain

The 28 organizations that each employ 2,000 or more people on EU soil along the semiconductor value chain.



Source: DECISION Etudes & Conseil, 2024

[1]

In terms of end-markets, European suppliers are leading providers of embedded systems. This market covers a number of sectors, including automotive, industrial and robotics, energy, health and care, aerospace, defence and security, and telecommunications infrastructures.

THE EU TALENT GAP REMAINS A STRUCTURAL ISSUE AMID THE MARKET DOWNTURN

The European Skills Strategy 2024 report, published in October 2024 under the European Chips Skills Academy (ECSA) project and prepared by DECISION Études & Conseil, presented the projected talent gap in the semiconductor sector across the EU27 for the 2024–2030 period, based primarily on forecasted investment plans within the EU.

According to the report, the aging of the European workforce, combined with industry growth, was expected to drive strong demand for talent: 271,000 job openings and a 5% annual increase in talent demand by 2030. Meanwhile, the supply of graduates was expected to follow past trends, with only a 1% annual increase in semiconductor-related fields such as electronic, mechanical, software, and chemical engineering.

This imbalance between supply and demand was projected to result in a talent gap of 75,400 skilled workers by 2030, corresponding to an average annual shortfall of 12,600 workers.

These projections, made in mid-2024, have since been revised following two major developments:

- **The postponement or cancellation of four key investment projects in the EU**: (1) Intel's factory in Magdeburg, Germany; (2) Intel's back-end facility in Poland; (3) GlobalFoundries' investment in Crolles, France; and (4) the Wolfspeed/ZF factory in Saarland, Germany.
- **The 8% downturn in the European semiconductor market in 2024**, which led several companies to freeze or slow recruitment plans.

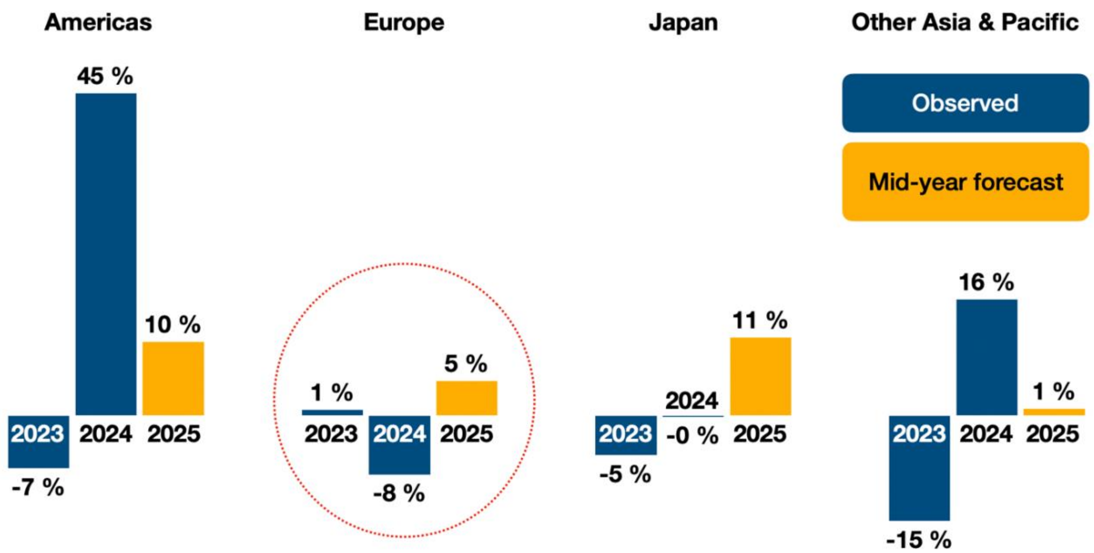


Figure 3: Estimated Semiconductor Sales Growth for 2023–2025

Source: DECISION Etudes & Conseil, data from WSTS Spring 2025

The cancellation of the four aforementioned projects is estimated to reduce the European talent gap by approximately 7,000 people:

- Intel's investments in Magdeburg and Poland represented a potential of 5,000 direct employees by 2030.
- GlobalFoundries' investment in Crolles was expected to generate around 1,000 jobs.
- The Wolfspeed/ZF factory in Saarland was projected to create at least 600 jobs.

As for the semiconductor market downturn, its main effect is expected to be a **delay** in the talent shortage timeline -postponing the onset of the most critical gap by at least one year.

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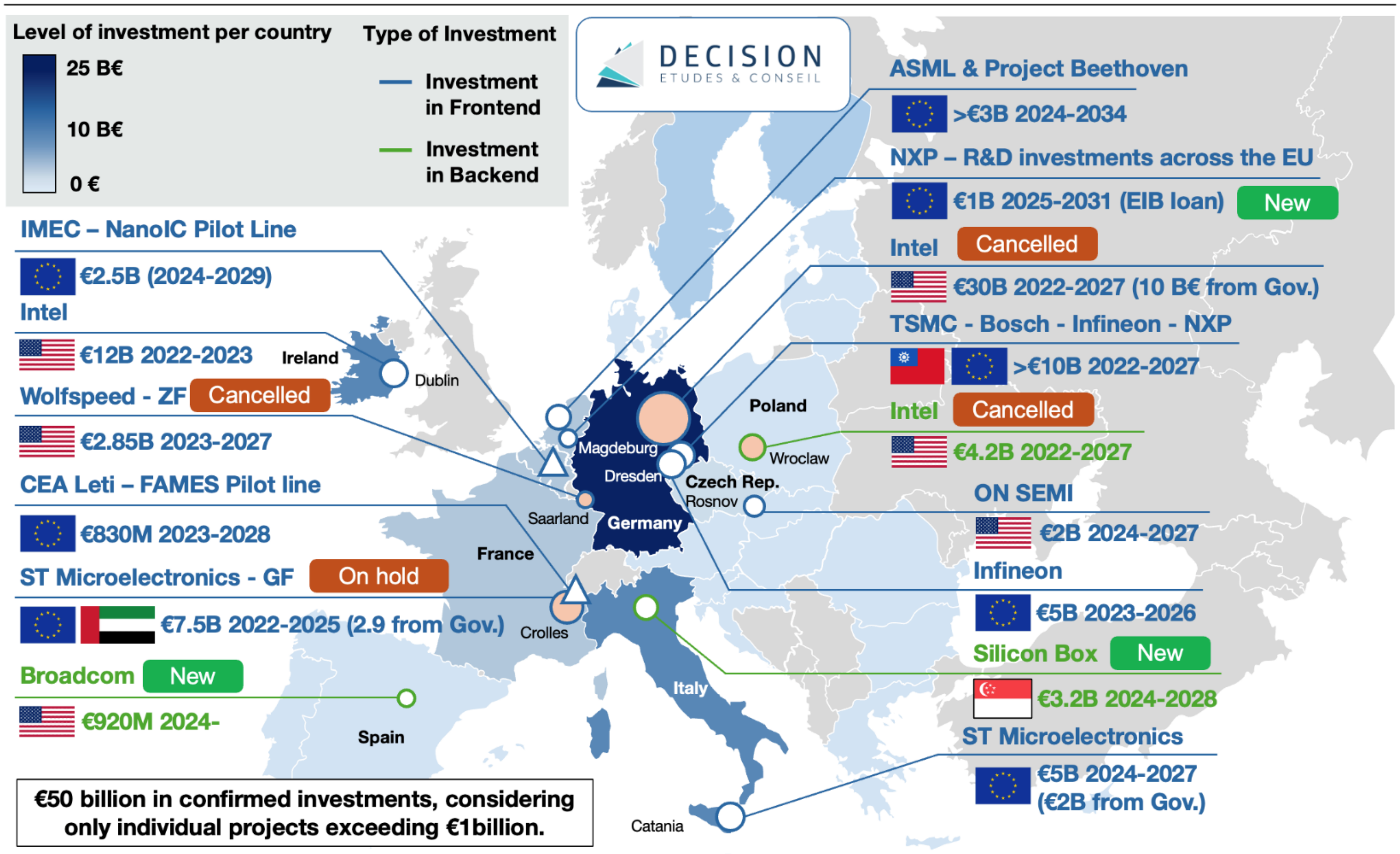
In parallel many investments initiated in the last years are still ongoing, raising the demand for talent, as illustrated in the map below from the report [Monitoring semiconductor value chains: Implications for International Cooperation (ICOS)](#).

Figure 4: Evolution of Semiconductor Investment Plans in the EU (Over € 1B), January 2024 – May 2025



Source: DECISION Etudes & Conseil, ICOS, June 2025

Taking these factors into account, the talent gap initially estimated at 75,400 by 2030 now stands at around **65,000** as of September 2025, equivalent to **an average annual shortfall of 10,800 skilled workers** across the European Union.

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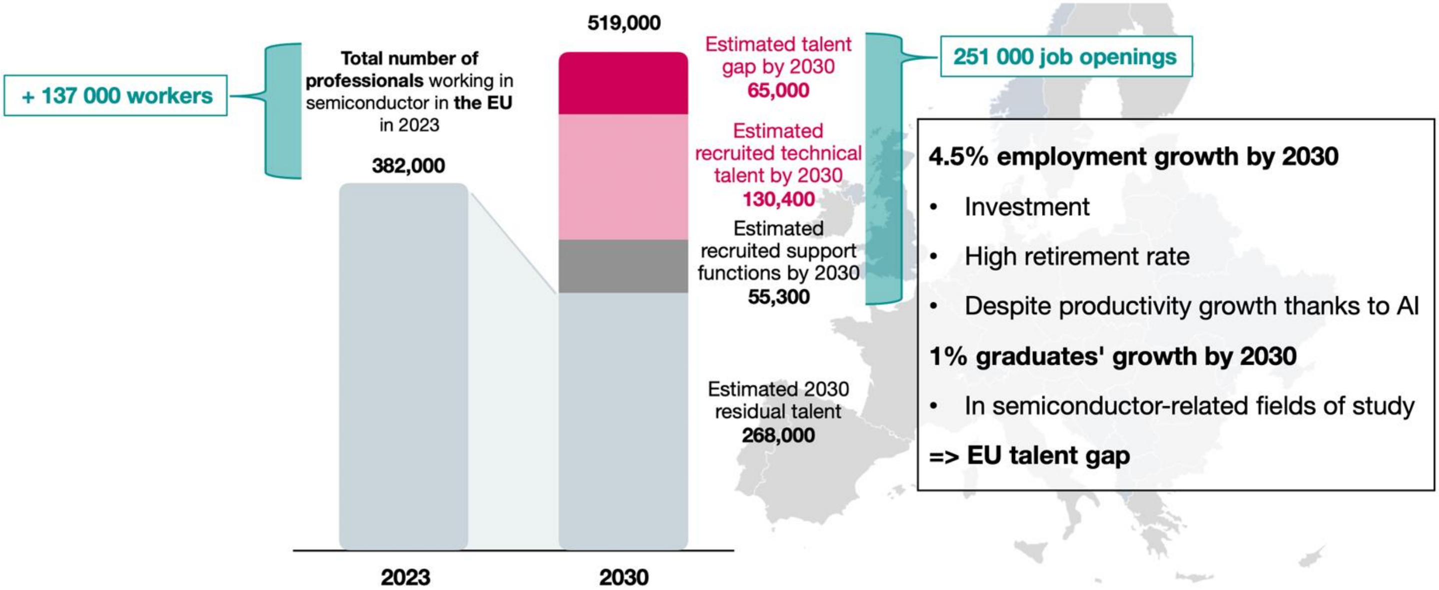
By 2030, an average annual shortfall of 10,800 skilled workers is expected across the EU to meet the needs of the European semiconductor industry along the value chain, mainly due to an aging workforce.

Although the talent gap has narrowed and its onset delayed, it remains a structural challenge for Europe, particularly as it is expected to widen beyond 2030. Given the long lead time required to expand the skilled workforce, urgent action is needed.

Figure 5: EU Semiconductor Value Chain: Talent Gap Forecast (2024–2030)



Source: DECISION Etudes & Conseil, European Skills Strategy, ECSA, October 2025

Finally, the talent gap is unevenly distributed across the EU, concentrated in regions with the highest demand: Saxony, Brainport Eindhoven, Ireland, Belgium, Crolles, Catania, Northern Italy, Bavaria, Baden-Württemberg, and the Czech Republic.

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On the contrary, within the EU27, Spain, Romania, Greece, Bulgaria, and Croatia have the largest surplus of electrical engineering graduates relative to the current size of their national semiconductor ecosystems, as illustrated in the map below.

Figure 6: EU regions facing a talent gap versus talent surplus in semiconductor industry

Source: DECISION Etudes & Conseil, October 2025

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QUALITATIVE ANALYSIS – RESULTS FROM THE 2025 SURVEY

This qualitative analysis serves to enhance our understanding of specific professions at risk of shortages, which fall within the major categories identified in the quantitative analysis in the 2024 Skills Strategy report. Furthermore, it allows for a more nuanced exploration of the reasons behind the current tension in these professions.

This qualitative analysis was initiated in the METIS project and has been out since 2020 based on a questionnaire answered by key stakeholders of the EU ecosystem (large companies, SMEs, Research and Technology organizations, Universities, VET providers, industry associations, etc.). This year's survey follows the structure of past years surveys that have been carried out in the first edition of the Skills Strategy report as well as in the METIS project. This allows for a continuous monitoring of the answers from the involved stakeholders to follow the trends on skills in the EU semiconductor industry. Annex 1 provides a comprehensive overview of the methodology employed in the online survey.

In 2025, 102 experts from 75 organizations across Europe participated in this work.

KEY EVOLUTIONS IN 2025

1) WHAT NEW JOB PROFILES AND SKILLS ARE EMERGING IN THE EU SEMICONDUCTOR INDUSTRY IN 2025?

As was the case every year since 2020, respondents were asked to identify and describe the new job profiles and/or skills they have identified during the year. The results are summarized in the tables and bar charts below. In fact, no category (profile or skills) is totally new in 2025 in the EU ecosystem as the job profiles and skills listed here were already identified by our consortium during previous years. However, these results provide a clear perspective on how EU stakeholders are encountering these profiles and skills emerging in their work environments in 2025. Professionals looking to remain competitive in the semiconductor industry should consider developing expertise in these areas.

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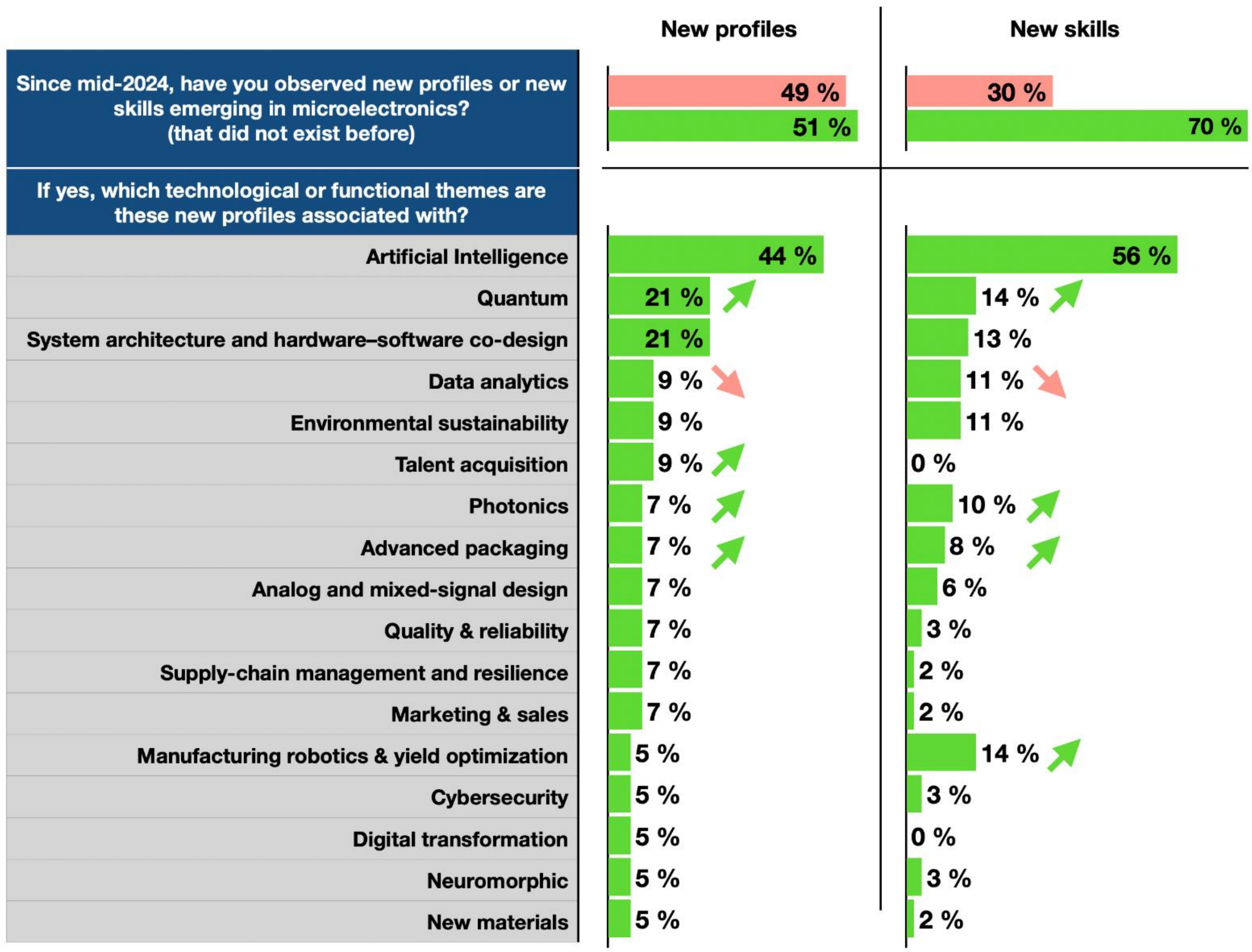
Figure 7: New profiles and skills noticed by the stakeholders in 2025



Panel: 84 answers (left) and 90 answers (right)

Source: 2025 ECSA Survey, DECISION Études & Conseil

Artificial Intelligence (AI)

As is the case since 2022, AI-related profiles come in first position as an emerging job profiles:

- <u>Machine learning engineers</u> – Software engineers designing, training, and optimizing machine learning models, with a solid understanding of hardware constraints such as memory, latency, and energy

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efficiency. They ensure that AI algorithms can be efficiently deployed on target devices (CPU, GPU, NPU, or ASIC) and collaborate with hardware engineers to co-optimise models and architectures. Also referred to as *AI algorithm engineers*.

- AI hardware engineers – Specialists developing and implementing hardware solutions optimized for AI workloads. They design architectures and circuits enabling efficient acceleration of machine learning models, focusing on compute performance, data movement, and power efficiency. Also known as AI hardware specialists.
- AI applications engineers – Professionals integrating AI-based functionalities into semiconductor products to better address the requirements of specific end-user industries while balancing market and technical constraints.
- Automatic Design Generation engineers – Engineers transforming traditional chip-design workflows by leveraging AI tools to accelerate and enhance design efficiency (e.g. training neural networks for electrical implementation or sizing).
- AI system designers / architects – Senior professionals managing multidisciplinary teams responsible for the design, manufacturing, and material sourcing of complex chip systems (SoC, chiplet, ASIC) embedding AI capabilities.
- New profiles are also emerging to address the legal aspect of AI (legal experts in the ethics of emerging technologies), and the sustainability of AI chips.

Similarly, AI-related skills come in first position as emerging skills. They are increasingly required across nearly all engineering and technical domains, as AI drives automation, simulation, and data-driven decision-making throughout the semiconductor value chain. Emerging AI skills include:

- AI Model Engineering and Deployment - Skills to design, train, and optimise machine learning and neural network models, including *AI-at-the-edge* deployment and *AI-SoC* integration. Engineers need to understand model architectures, inference efficiency, and hardware–software co-optimization.

  Generative and agentic AI tools are increasingly used here to accelerate model creation, testing, and refinement.
- AI-Assisted Design and Verification - Use of AI to automate and enhance hardware design workflows — from IP generation and RTL coding to analog/mixed-signal (AMS) design and verification. Engineers must master AI-based EDA tools, scripting, and data-driven exploration of design space.

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Generative AI supports automatic code and testbench generation, while agentic systems are emerging for iterative optimization and self-correcting verification cycles.

- AI for Process and Manufacturing Optimization - Application of AI and machine learning to improve process stability, yield, and equipment performance. Includes predictive maintenance, fault detection, and the use of AI-powered simulation in process development.

  Generative models are used for synthetic data creation and simulation while agentic systems enable autonomous control and adaptation of production parameters.

- Data and AI Analytics - Mastery of large-scale data analysis, combining big data pipelines with machine learning models for quality, reliability, and performance optimization. This includes developing dashboards, anomaly detection, and predictive models for production and R&D.
- AI Literacy and Strategic Understanding - The transversal capacity to understand where AI provides efficiency or innovation gains -and where it introduces risks. This includes identifying relevant use cases, evaluating AI limitations (e.g. bias, energy cost, explainability), and integrating AI ethically into workflows.

In short, the ability to effectively use, adapt, and co-design AI tools and processes is rapidly becoming a baseline competence across both technical and non-technical roles in the semiconductor industry.

Annex 2 presents a detailed analysis of how AI affects the talent gap in the semiconductor industry, considering both the factors that widen and those that narrow the gap.

Quantum

In 2025, 21% of respondents report the apparition of quantum-related job positions in their working environments, as opposed to 9% in 2024 and 1% in 2023.

The demand for quantum-related skills in Europe is growing, notably with the rollout of quantum chip pilot projects under the *Chips for Europe* initiative (Pillar 1 of the EU Chips Act). In 2025, the Chips Joint Undertaking selected six consortia under its quantum calls, supporting a range of quantum technologies (superconducting, trapped-ion, neutral-atom, photonic, spin-based, and diamond-based platforms) and building a European value chain from design to fabrication and testing.

This marks a significant shift towards skills in quantum device fabrication, testing, instrumentation, and software control, as well as toward integration of quantum and classical semiconductor technologies.

Emerging quantum-related profiles include:

- Quantum Computing Engineers / Quantum Semiconductor Engineers – Specialists developing quantum components and circuits, often with expertise in superconducting electronics, cryogenics, and quantum-classical interface control.
- Quantum Materials and Device Engineers – Experts working on diamond-based, spin-based, and photonic quantum devices, focusing on material synthesis, defect control, and system reliability.
- Quantum Algorithm and Software Engineers – Professionals designing quantum algorithms, quantum programming models, and hybrid quantum–classical software stacks for simulation and control.
- Post-Quantum Security Architects – Engineers defining quantum-resistant cryptographic schemes and ensuring secure hardware and communication infrastructures in the post-quantum era.
- Quantum Sensing and Metrology Engineers – Specialists developing quantum sensors, leveraging atom-based, spin-based, or diamond technologies for ultra-precise measurements.

The main emerging quantum-related skills include:

- Quantum physics and mechanics fundamentals – Understanding of quantum phenomena underpinning device operation, including superposition, entanglement, and tunnelling effects.
- Quantum algorithms and programming – Mastery of quantum algorithm design, quantum machine learning (QML), and hybrid quantum-classical architectures for computing and simulation.
- Quantum materials and device physics – Expertise in the physics and characterization of new materials and post-Moore devices (e.g. diamond, topological, or spintronic systems).
- Quantum hardware and circuit design – Skills in the design, modelling, and testing of superconducting, photonic, or semiconductor-based quantum circuits, with practical knowledge of cryogenic systems and low-noise electronics.
- Hybrid quantum–classical systems integration – Ability to co-design and integrate quantum and classical components within the same architecture, ensuring interoperability, data flow, and control between quantum processors and conventional semiconductor systems.
- Post-quantum security and cryptography – Expertise in designing and implementing cryptographic and hardware security solutions resilient to quantum attacks, including quantum-resistant encryption algorithms and secure communication protocols.

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In summary, quantum-related skills in Europe are moving from academic research to industrial application. The most critical competencies now lie in translating quantum theory into manufacturable devices, integrating them into the broader semiconductor ecosystem, and preparing for post-quantum transitions in computing and security.

System Architecture and Hardware-Software co-design

In 2025, 21% of respondents globally reported an emerging need for system designers (also referred to as systems architects, SoC architects, 3D systems architects) in their working environments. These professionals, typically holding a master's degree or PhD (EQF 7-8), are at the forefront of designing increasingly complex systems that integrate a range of microelectronic components.

Systems designers are especially required in the EU to design the next generation of Cloud-to-edge IoT platforms, often (but not only) working at low-power and harsh environments: smart sensors for automotive ADAS, systems for zonal car units, industry 4.0, health & care, aerospace-defence, etc.

Emerging system-related profiles include:

- System Designers / System Architects – Experts responsible for defining overall system specifications and ensuring interoperability between hardware and software layers. Increasingly involved in AI-enabled architectures, chiplet-based systems, and system-in-package (SiP) integration.
- Edge Computing Architects / Engineers – Specialists developing low-latency, energy-efficient architectures for local data processing, bridging IoT nodes and cloud infrastructures.
- System-Level Verification and Validation Engineers – Professionals ensuring functionality and performance across complex SoCs, often using multi-domain simulation, hardware emulation, and AI-assisted verification tools.

The main emerging system-related skills in Europe include:

- System and IC Co-Design – Ability to co-optimise hardware and software architectures to balance power, performance, and functionality.
- Advanced Integration Technologies (Chiplet, 2.5D, 3D) – Technical expertise in the physical integration of multiple dies within a single system, addressing interconnect design, thermal management, and packaging constraints.
- System Software and Middleware Integration – Understanding of system-level software layers, driver development, and middleware integration for heterogeneous computing platforms.

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- Low-Power and Edge Computing Design – Competences in designing and optimizing architectures for low-energy operation, real-time processing, and secure IoT connectivity.
- System-Level Verification and Emulation – Upskilling in verification techniques for large-scale SoCs, including FPGA prototyping, layout validation, and hardware/software co-simulation.
- System Robustness and Compliance by Design – Integration of reliability, fault tolerance, and safety-by-design principles at system level to ensure compliance with domain-specific standards (e.g. automotive, medical, aerospace).

In summary, system design is rapidly evolving toward multi-domain integration, where hardware, software, and network intelligence converge. Engineers with the ability to co-design across abstraction layers -from transistor-level logic to distributed edge systems- are becoming critical to Europe's semiconductor and digital-system competitiveness.

Data Analytics

In 2025, only 9% of respondents report the emergence of data analytics–related job positions in their working environments, compared with 24% in 2024.

Despite the strong and growing demand from the semiconductor industry, the European education and training ecosystem appears to be supplying data specialists in sufficient numbers, thereby easing the talent shortage in this field. As a result, the need for new data analytics positions is perceived less strongly in 2025.

Data specialists typically include:

- Data Analysts – Professionals interpreting and visualizing data to support decision-making and performance monitoring.
- Data Engineers – Experts building and maintaining data pipelines, ensuring accessibility, quality, and security of large datasets.
- Data Scientists – Specialists developing and deploying advanced analytics, machine learning, and predictive models for semiconductor R&D and manufacturing.
- Data Quality and Integration Managers – Professionals ensuring data consistency and interoperability across design, production, and business systems.

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Sustainability / Environmental-related job profiles

In 2025, 9% of respondents globally report an emerging need for new environmental-related job profiles, and 11% report an emerging need for sustainability-related skills in their working environments. As environmental regulations tighten and energy costs rise, the semiconductor industry increasingly integrates sustainability objectives into manufacturing, design, and materials management.

Emerging profiles include:

- Sustainability Specialists / ESG Experts (EQF 6-7) – Professionals ensuring that environmental objectives are integrated throughout semiconductor production and product design.
- Lifecycle Analysts (EQF 7) – Experts evaluating the environmental impact of components across their lifecycle.
- Electronic Waste Recycling Engineers (EQF 7-8) – Specialists developing sustainable recovery and recycling methods for microelectronic components.
- PFAS and Materials Compliance Experts – Engineers monitoring the elimination or reporting of restricted substances in manufacturing.
- Renewable Energy Managers – Responsible for reducing carbon emissions and integrating renewable energy sources in production sites.

Emerging skills include:

- Knowledge of sustainable manufacturing and energy efficiency practices (ISO 50001).
- Competence in eco-design, green materials, and circular economy principles.
- Ability to assess lifecycle impacts and implement waste minimization strategies.
- Understanding of ESG frameworks, social responsibility, and diversity and inclusion aspects linked to sustainability.

In summary, sustainability is no longer peripheral but a design and production requirement across the European semiconductor value chain.

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Talent Acquisition

9% of respondents globally report an emerging need for new profiles associated with talent acquisition. Since 2021 and as competition for semiconductor talent intensifies, companies increasingly invest in global recruitment and in-house skills development. In 2025, firms emphasize long-term workforce strategies combining international hiring, continuous training, and education outreach.

Emerging profiles include:

- Global Talent Acquisition Managers – Coordinating international recruitment beyond the EU to attract specialised talent.
- Skills Development Managers – Designing internal training programmes and partnerships with universities.
- Semiconductor Education Outreach Coordinators – Promoting the field among younger students (ages 12–17) to build future talent pipelines.
- Hybrid Work and Training Facilitators – Managing remote engineering collaboration and hybrid workforce integration.

The HR function in semiconductors is evolving from administrative support to a strategic pillar of competitiveness and innovation.

Photonics

7% of respondents globally report an emerging need for new photonics-related job profiles, and 10% report an emerging need for photonics-related skills in their working environments.

Emerging profiles include:

- Photonic Integrated Circuit (PIC) Engineers – Designing, simulating, and testing integrated photonic circuits and components across a variety of applications, from optical interconnects to sensing and quantum systems.
- Process and Integration Engineers – Managing fabrication flows combining photonic and electronic components.
- Test and Characterization Engineers – Performing optical testing, reliability analysis, and yield optimization for photonic devices.

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Emerging skills include:

- Understanding of optoelectronic principles and integrated photonics design.
- Expertise in chiplet-enabled photonic integration and hybrid optical–electrical packaging.
- Knowledge of simulation tools, optical alignment, and post-Moore device concepts.

Advanced Packaging

7% of respondents globally report an emerging need for new packaging-related job profiles, and 8% report an emerging need for packaging-related skills in their working environments. In Europe, these needs are mainly driven by investments in advanced packaging by Silicon Box in Novara and by STMicroelectronics in Catania and Malta.

Emerging profiles include advanced packaging technicians and engineers.

Emerging skills include:

- Mastery of 3D IC design, chip-package co-design, and thermal simulation.
- Understanding of heterogeneous process integration (SiC, GaN, photonics).
- Familiarity with new packaging materials and sustainability constraints.

Packaging has evolved from a back-end process into a strategic field of design innovation, with Europe now deploying significant industrial and pilot projects to secure strategic know-how in this domain.

Manufacturing Robotics and Yield Optimization

In 2025, a particularly high number of respondents (14%) reported experiencing the implementation of new automation and robotics tools requiring new associated skills. Traditional equipment engineers are evolving toward roles combining robotics, AI, and data-driven process control, marking a shift toward fully automated and intelligent manufacturing environments.

Emerging skills include:

- Understanding of AI tools for process optimization and predictive maintenance.
- Knowledge of advanced process control (APC), statistical process control (SPC), and Industry 4.0 systems.

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Cybersecurity

5% of respondents globally report an emerging need for cybersecurity specialists, and 3% report an emerging need for cyber-related skills in their working environments. Despite this surprisingly low percentage, cybersecurity has become a core design requirement, embedded throughout the semiconductor product lifecycle.

Emerging skills include:

- Understanding of hardware attack vectors and secure design principles.
- Knowledge of cryptographic algorithms and post-quantum security.
- Understanding of secure embedded software and edge-device protection principles.

Digital transformation expert

This year and for the first time, 5% of respondents report new roles emerging to drive the digitalization of semiconductor production and R&D processes, supporting automation, connectivity, and data integration.

Emerging profiles include:

- Digital Twin Engineers – Developing virtual replicas of production lines and equipment.
- IoT Integration Specialists – Deploying connected systems for monitoring and predictive control in fabs.

Digital transformation profiles bridge traditional process engineering and the data-driven paradigm of Industry 4.0. Their growing presence illustrates that even front-end fabs -long considered among the most automated in the world- continue to find new margins for optimization in Europe through enhanced digitalization and intelligent data integration.

Soft Skills

While technical expertise remains essential, many respondents this year highlight the critical importance of soft skills in the semiconductor industry. As projects grow in complexity and interdisciplinarity, success increasingly depends on collaboration, adaptability, and communication.

Thus, collaboration and communication stand out as the most sought-after skills. They encompass the ability to work effectively across teams and disciplines, share knowledge, and resolve conflicts constructively — as well as the capacity to explain complex technical topics to non-specialists by selecting and prioritizing the most relevant information and issues.

Other key soft skills include:

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- Adaptability and Agility – Comfort with iterative development, feedback-driven improvement, and changing technologies.
- Creative and Critical Thinking – Capacity to analyse complex challenges, propose innovative solutions, and make data-informed decisions.
- Leadership and Mentoring – Guiding teams, fostering learning, and maintaining motivation in high-pressure environments.

In short, the ideal semiconductor professional combines deep technical expertise with strong interpersonal and adaptive skills -a balance increasingly decisive for innovation and project success.

Supply Chain Management

Supply chain management has become a strategic concern across the semiconductor industry since the COVID-19 crisis and the subsequent chip shortage. In 2025, companies continue to strengthen their logistics and procurement capabilities to secure supply, manage export-control compliance, and improve resilience. Sustainability and circularity are now also integral parts of supply-chain operations, with growing attention to materials traceability, packaging waste reduction, and carbon footprint monitoring. The semiconductor supply chain is no longer a purely logistical function but a technology-driven and regulatory field, where specialists must combine expertise in digital tools, regulatory frameworks, and sustainable procurement.

Business and Strategic Development

A small but consistent number of respondents report the growing need for **business development and marketing engineers** able to navigate the increasingly complex market for advanced components. These profiles bridge technical and commercial domains: they translate product specifications into market value, support strategic partnerships, and anticipate regulatory and industrial shifts such as those induced by the EU Chips Act. The traditional boundaries between marketing, application engineering, and business strategy continue to blur as commercial roles become more technically proficient.

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2) IMPACT OF THE GLOBAL WAVE OF INVESTMENT AND OF THE EU CHIPS ACT ON HIRING PLANS IN EUROPE

As in every year since 2021, respondents were asked whether they experienced any concrete and significant impact on their hiring plans in Europe based on two key factors:

1. The global wave of semiconductor investment observed since 2021.
2. The EU Chips Act, launched in early 2022.

Figure 8: Share of stakeholders whose recruitment policies have been affected by: (1) the global wave of semiconductor investment observed since 2021, or (2) the EU Chips Act launched in early 2022.

In 2025, do you experience the impact of the following elements on your recruitment policies?		
Yes	The global wave of semiconductor investment observed since 2021	38 %
	The EU Chips Act launched in early 2022	32 %
	Both	40 %
No		28 %
Do not express an opinion		33 %

Panel: 101 answers

Source: 2025 ECSA Survey, DECISION Études & Conseil

Compared with 2024, the share of respondents indicating that their recruitment policies were affected by either the global investment wave or the EU Chips Act has decreased by 15% and 20% respectively.

In 2025, only 40% of respondents report experiencing the impact of at least one of these factors, while 28% report no impact and 33% prefer not to answer.

Investment vs. Chips Act: Diverging Effects

The global investment surge of 2021–2023 initially triggered a sharp rise in talent demand across Europe. However, by 2025, macroeconomic headwinds and slower market growth have tempered hiring dynamics.

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While major investments in fabs and pilot lines continue, several respondents highlight reductions in fab-related headcounts – particularly process engineers – due to weaker market prospects, potential overcapacity, and rising automation.

The EU Chips Act plays a more nuanced role. It is widely recognized for raising public and academic awareness of semiconductors and for re-attracting scientific and engineering talent to the sector. Yet many respondents consider its direct impact on hiring volumes limited. Pillar 1, while strengthening Europe's innovation capacity, has also intensified competition for highly skilled professionals in new domains – such as advanced processors, new materials, and advanced packaging – without necessarily expanding the overall talent pool across the ecosystem. Pillar 2 has so far not compensated for the broader market slowdown.

Rising Competition for Senior Talent, increasingly sourced outside of Europe

Across the EU, companies and research institutions alike report a tightening labour market. Competition for experienced engineers and senior researchers has intensified. Firms increasingly rely on global recruitment, sourcing candidates from Asia or North America to fill key positions. Meanwhile, early-career hiring remains comparatively easier, as the increased visibility of the semiconductor sector has attracted new graduates.

Several respondents also underline that workforce-supporting infrastructure – such as education programmes, training capacity, and mobility schemes – remains insufficient. As a result, investments in fabs are seen as requiring parallel investments in human capital. In response, industry-led training initiatives are gaining momentum, focusing on upskilling technicians and engineers in emerging domains such as advanced packaging, automation, and AI-driven manufacturing.

Awareness and Image Effects

Beyond direct employment effects, both the global investment wave and the EU Chips Act have strengthened the visibility and attractiveness of the semiconductor sector. Several respondents note that initiatives such as Green Chips EU and Chips Act-related career fairs have made semiconductors a more appealing field for young engineers. Equipment suppliers in particular report increased interest in semiconductor-related technologies and a higher level of understanding among potential recruits.

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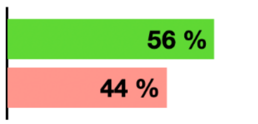
3) IMPACT OF GEOPOLITICAL TENSIONS ON RECRUITMENT POLICIES

Geopolitical instability is becoming an increasingly influential factor in semiconductor workforce planning. Since 2021, tensions such as the U.S.–China technology rivalry, export control regimes, and reshoring policies have reshaped hiring strategies across Europe. The 2025 ECSA Survey asked stakeholders whether these tensions have affected their recruitment policies, as shown below.

Figure 9: Share of stakeholders whose recruitment policies have been affected by geopolitical tensions

Have you noticed any impact of geopolitical tensions on your recruitment policy?	
Yes	56 %
No	44 %



Panel: 85 answers

Source: 2025 ECSA Survey, DECISION Études & Conseil

In 2025, 56% of respondents report that their recruitment policies have been affected by geopolitical factors. The most visible impacts concern localization of hiring, restricted international mobility, and heightened compliance requirements.

Geopolitical Uncertainty Driving Hiring Slowdowns

Persistent geopolitical instability and fluctuating trade policies are also feeding business uncertainty, leading several major companies to implement temporary hiring freezes or to scale down contracting activity, temporarily lowering the talent gap.

Export Controls Driving Restrictions on Talent Mobility

Export control regulations and technology-transfer restrictions have become a major constraint for cross-border recruitment. Companies and research institutions report stricter screening procedures for non-EU applicants, particularly from countries considered high-risk or subject to export bans. Respondents mention the need to avoid hiring from restricted countries such as Iran, Russia, Belarus, and, in some cases, China. Several also note the emergence of informal embargoes on certain nationalities for sensitive R&D activities (in particular China).

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Universities face growing administrative hurdles in securing export-control licenses for joint research and technology exchange, while tightening visa policies in some EU Member States – notably the Netherlands – have further complicated international student and researcher mobility.

Through these combined effects, geopolitical tensions are amplifying Europe's structural talent shortage by limiting access to qualified non-EU professionals and slowing academic cooperation with third countries.

Increased Hiring Security and Compliance Requirements

Companies are reinforcing IP protection protocols and compliance checks in recruitment, especially for positions related to advanced design, secure chips, and defence applications. In some cases, defence-related contracts and dual-use technologies require personnel screening and government clearance, adding delays and complexity to the hiring process.

These evolving requirements have created demand for specialists in export-control compliance, IP protection, and cyber-sovereignty, expanding the HR and legal dimensions of semiconductor recruitment.

Changing Composition of Applicants

Despite these constraints, the semiconductor sector continues to attract strong interest from non-EU candidates. Respondents report a noticeable increase in applications from India, Africa, Ukraine, and Russia, as well as from the United States, reflecting both global workforce mobility and Europe's perceived stability in the sector.

However, additional vetting and compliance requirements lengthen recruitment timelines, particularly for positions involving sensitive technologies.

Summary

Overall, geopolitical tensions have reshaped recruitment in the European semiconductor ecosystem, making it more regional, more security-conscious, and more compliance-driven.

While this shift aligns with sovereignty objectives under the EU Chips Act and broader industrial policies, it also exacerbates existing skill shortages by restricting access to global talent pools.

Companies increasingly respond through workforce localization, internal upskilling, and dedicated compliance expertise to ensure both competitiveness and regulatory alignment.

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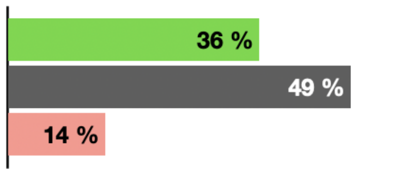
4) HIRING TRENDS

Overall, the outlook for hiring in 2025 remains broadly consistent with last year's survey results. A larger share of respondents indicated that they expect to maintain their current hiring levels, while the proportion planning to reduce recruitment has slightly declined (from 22% to 14%). The share of stakeholders anticipating an increase in hiring has remained stable compared with 2024.

Figure 10: Distribution of the hiring strategy of stakeholders in 2025 compared to 2024

In 2025, do you expect to hire more or less on EU soil compared to 2024?	
Hire more	36 %
Remain the same	49 %
Hire less	14 %



Panel: 96 answers

Source: 2025 ECSA Survey, DECISION Études & Conseil

Among the 36% of stakeholders expecting to expand their workforce, the main reasons cited include:

- **The EU Chips Act 1.0.** The materialization of factory and R&D projects in line with the EU Chips Act 1.0.
- **The European economic security.** The need to strengthen the European workforce to support economic security amid growing geopolitical tensions.
- **Strong needs in specific domains.** Rising demand for skills in specific domains such as AI, data analytics, and design.

Several academic and training institutions also reported an increase in student enrolments, the launch of new programs (e.g. MSc in chip design), and additional EU-funded opportunities, all driving the recruitment of teachers and trainers to meet growing demand.

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By contrast, 49% of respondents expect to maintain their current workforce, and 14% anticipate reducing hiring. The main reasons cited are:

- **Weak demand from user industries**
    - The uneven recovery of the semiconductor cycle since 2023, with persistent weakness in Europe's key downstream sectors such as automotive, industrial automation and IoT, health & care, and telecommunication infrastructure.
    - The European automotive industry's continuing loss of market share, exacerbated since 2023 by a surge in Chinese EV exports to Europe and slower export growth from European manufacturers.
- **An insufficiently attractive investment framework in Europe**
    - Several investments announced under the EU Chips Act 1.0 have yet to translate into tangible hiring opportunities.
    - Several European companies continue to prioritize investments in Asia, citing more favorable competitiveness factors. Among these, higher energy costs in Europe since 2022 are the most frequently mentioned as a key deterrent.
- **Automation and AI reducing hiring needs while increasing reskilling needs**
    - Greater fab automation is reducing the need for new technicians, especially operators.
    - The adoption of Artificial Intelligence is decreasing demand for new engineers – particularly in software, design, and test.

    In parallel, these trends are increasing the need to reskill existing staff to use these new tools effectively.

Academic institutions echoed this cautious sentiment, pointing to:

- Reduced public funding for teaching positions.
- A decline in the number of international students compared with previous years.
- Falling enrolment in STEM fields in certain regions.

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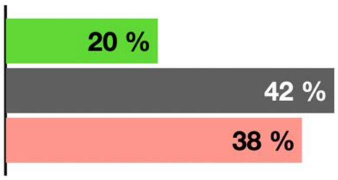
5) SKILLS SHORTAGE EVOLUTION

Overall, the 2025 results show a pattern similar to last year among those who perceive the skills shortage as worsening (38%), while the share of respondents reporting an improvement has increased (from 8% last year to 20% this year). This is mostly attributed to weak economic growth and postponed projects, which have temporarily eased competition for talent.

Figure 11: Distribution of the perception of stakeholders towards skill shortage in 2025 compared to 2024

In 2025, the skills shortage within your organization has	
Improved	20 %
Remained the same	42 %
Worsened	38 %



Panel: 96 answers

Source: 2025 ECSA Survey, DECISION Études & Conseil

38% of stakeholders indicated that the shortage has worsened. Respondents pointed to the persistent difficulty of recruiting -especially software engineers, system designers, analog designers, and cybersecurity specialists. From the industry's perspective, universities are too slow to adapt. Universities, for their part, underlined that companies often hire graduates very early, reducing the pool of potential teaching assistants and reflecting the strong competition to attract talent.

The main challenges identified are:

- Workforce ageing.
- A lack of attractiveness, reflected in brain-drain and the difficulties faced by foreign students to move to or remain in Europe.
- Intensifying competition for talent from the energy and environment sectors.

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By contrast, 42% of stakeholders indicated that the shortage has remained the same since 2024, and 20% even reported an improvement. The mean reason cited are:

- Weak economic growth and postponed projects, which have temporarily eased competition for talent.
- Rising unemployment across Europe, which has made more skilled professionals available for reskilling in the semiconductor industry (e.g. from the automotive sector).
- Increased investment in education and training -including EU-supported projects- which are beginning to show modest positive effects, such as the creation of new master's programmes and dissemination initiatives.

Several training providers and academic institutions also noted that students now enter with stronger basic knowledge.

MOST CRITICAL JOB PROFILES

DEMAND AND SHORTAGE ON THE JOB MARKET IN 2025

As in the previous ECSA skills strategy report, stakeholders have been asked to identify:

- The job profiles that are the most sought-after by the industry (high demand).
- The job profiles that are the most difficult to fill (high shortage).

PROFILES THE MOST SOUGHT-AFTER

Following past years' trend, software and design engineers remain the two profiles that are the most sought after in the EU with 57% and 52% of the answers respectively. Respondents emphasized that the high demand for software engineers is driven by the pervasive role of software across nearly all semiconductor products, with applications ranging from embedded systems and firmware to AI, safety, cybersecurity, and cloud solutions. Comments highlighted the rising complexity of software, the growing importance of software-defined systems (e.g., Software Defined Vehicles), and the need for integration with hardware, automation, and data management. At the same time, proprietary or legacy software requires continuous development and maintenance, which cannot be substituted by off-the-shelf solutions. A recurring concern is the mismatch between demand and supply, with shortages of qualified graduates and experienced engineers, leading to high

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costs and talent scarcity. Similarly, the need for design engineers remains strong, as they are considered the foundation of semiconductor development and innovation. The increasing complexity of IC and system co-design, new requirements from AI and analog design, and the need to adapt to regulatory frameworks such as the Cyber Resilience Act were all cited as key factors reinforcing demand. In addition, many respondents underlined the strategic dimension of design capabilities, stressing that Europe must invest in this field to reduce dependence on non-European players, fulfill the EU Chips Act roadmap, and foster innovation through hardware development made in EU.

Within the design position, system designers are the most sought-after specific profiles at 47%, followed by analog and digital design engineers both at 31% of the answers:

- The strong demand for system design engineers reflects the shift from chip-level to system-level solutions and the rise of SiP/SoC and chiplets integrating ML-based features. Respondents emphasized that customers now expect complete solutions rather than individual ICs, making system design capabilities crucial. System-level expertise is also considered mission-critical for enabling cost and performance optimization, managing trade-offs across architectures, and supporting projects funded under the EU Chips Act. IC–system co-design is a rising challenge.
- The EU continues to experience strong and rising demand for analog designers, driven by sensing and power applications, although the field is perceived by students as less attractive than digital design. The analog designer role represents the most difficult talent gap to address, as it requires a rare combination of design and programming skills, together with at least five years of field experience. In addition, this profile -like other design roles- is increasingly affected by the rise of AI-enabled analog generation tools (e.g., BAG), creating new upskilling needs.
- Finally, many companies are expanding their design workforce in Asia -particularly in India- rather than in Europe, due to the talent gap, putting at risk the objectives of the Digital Decade and the EU's economic security.

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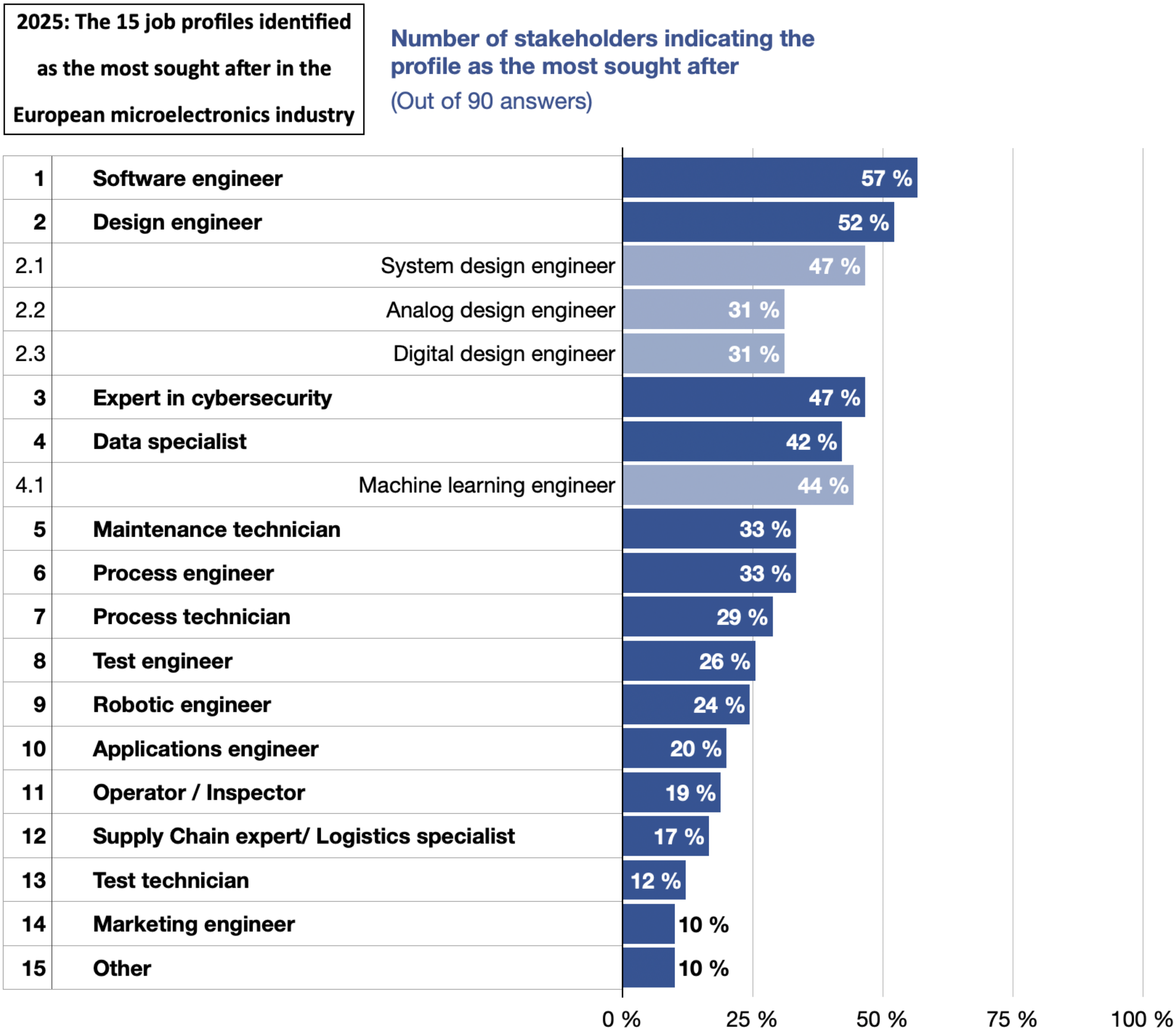
Figure 12: Ranking of the job profiles indicated as the most sought-after in 2025



For this question, all the stakeholders were not limited in their choice of answers and could choose between several job profiles. This is why the totals exceed 100%.

Source: 2025 ECSA Survey / DECISION Etudes & Conseil

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Compared with last year, data specialists moved to the fourth most in-demand profile (42% of responses), while cybersecurity experts overtook them, becoming the third most sought-after category, cited by 47% of respondents. Demand for cybersecurity experts has surged since 2023, placing them ahead of data specialists in this year's ranking. Respondents considered cybersecurity to be critical, with the need extending from system-level security down to chip and firmware architectures. The rapid digitalization and automation of industry, combined with rising connectivity, are described as increasing vulnerabilities and exposure to cyberattacks. Geopolitical tensions, espionage, and the growing sophistication of cybercrime further amplify these risks. Several respondents stressed that the shortage of qualified experts is acute, as the demand created by both civilian and military needs far exceeds the available workforce.

The demand for data specialists remains very high, driven by the explosion of data generated across the semiconductor value chain, from manufacturing processes to customer-facing services. Effectively collecting, analyzing, and exploiting data is now essential to leveraging automation, and improving productivity. Within data specialists, machine learning engineers were frequently mentioned as a priority profile, as AI and ML are becoming pervasive — both as standalone applications and as tools to enhance productivity and process optimization. Respondents stress that demand for ML specialists is growing faster than supply.

Maintenance technicians, process engineers and technicians, robotic engineers received between 24% and 33% of stakeholder votes, driven by investments in the expansion of manufacturing capacity in Europe, notably under the EU Chips Act Pillar 2. Respondents highlighted the increasing process complexity, driven for instance by new process blocks for wide bandgap materials and heterogeneous integration, which require highly specialized skills.

Test (and verification) engineers received 26% of stakeholder votes. Demand is driven by the need to validate highly integrated systems (e.g., SoC), against a rising number of parameters.

Applications engineers received 20% of stakeholder votes. One of the difficulty in filling this position lies in its customer-facing nature, which requires both technical expertise and client interaction skills.

At the lower end of the ranking, profiles such as operators/inspectors, supply chain and logistics experts, test technicians, and marketing engineers were cited by 10% to 19% of respondents. The demand for supply chain and logistics experts reflects the geopolitical changes reshaping global supply chains, which require new expertise to adapt sourcing strategies.

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PROFILES THE MOST DIFFICULT TO SOURCE

Software engineers are indicated as the most difficult profiles to fill in the European semiconductor industry in 2025 (27% respondents). Respondents pointed to the persistent shortage of skilled graduates in domain-specific expertise, with only a few having advanced knowledge in embedded software development, data optimization and hardware integration. Some companies also reported difficulties in retaining software engineers, as many candidates prefer remote work arrangements or are drawn by higher salaries in other industries or services.

Designers are also indicated as the most difficult profiles to fill in the European semiconductor industry in 2025 (27% respondents). The shortage is particularly concentrated in system and analog design roles. The lack of specific training programs in Europe is consistently highlighted, while stakeholders even report that retiring professors are often replaced by chairs focused on other fields. At the same time, new students tend to prefer software-oriented careers at the expense of design. Electronics and physics-based programs that underpin advanced IC design are also reported as areas where essential skills are often missing among new graduates. Finally, the shortage is exacerbated by global competition, as design engineers are highly sought after outside Europe.

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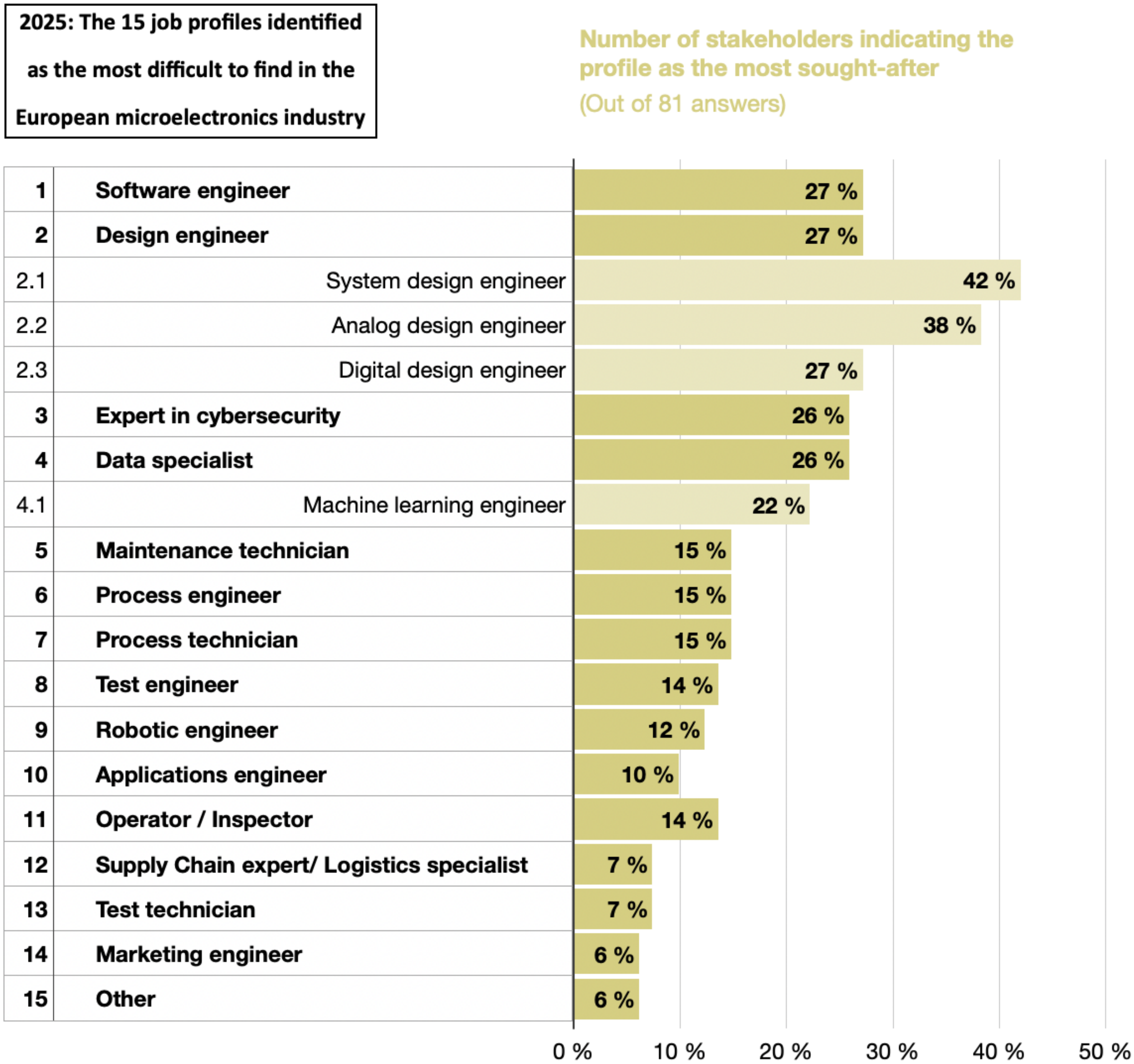
Figure 13: Ranking of the job profiles indicated as the most difficult to fill in 2025



For this question, all the stakeholders were not limited in their choice of answers and could choose between several job profiles. This is why the totals exceed 100%.

Source: 2025 ECSA Survey / DECISION Etudes & Conseil

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Analog design expertise is highly experienced based, requiring practical, hands-on learning that is difficult to acquire in purely academic settings. As a result, the supply of qualified analog engineers remains consistently below demand, even as Europe retains relative strengths in analog-intensive domains such as sensors and power electronics.

System design requires interdisciplinary expertise, spanning hardware, machine learning, and security, as well as the ability to manage complexity across highly integrated SoC systems. This makes it difficult to train new graduates, as the skills needed are acquired only through significant experience. Demand continues to rise, driven by new materials (e.g., GaN), increasing integration complexity, and customer requirements for system-level solutions.

Cybersecurity experts and data specialists are reported to be almost as difficult to recruit, each cited by 26% of respondents. The rapid growth in cybersecurity needs has outpaced the development of adequate training programs, while the semiconductor industry faces strong competition from other sectors for qualified graduates. Moreover, the industry requires specific expertise in hardware and connectivity security -skills that are difficult to find even among graduates with cybersecurity degrees.

The shortage of data specialists is driven by similar factors. Respondents highlighted that while demand for data skills is general and widespread, effective performance in semiconductor-related roles requires domain-specific knowledge, which remains rare. Competition for talent is intense, with many sectors outside semiconductors also seeking data expertise. Within this category, machine learning specialists were described as especially difficult to recruit. Respondents emphasized that Machine Learning (ML) roles not only require a broad understanding of data science but also a deep domain knowledge to identify relevant applications and deliver efficient solutions within semiconductor design and manufacturing processes.

Manufacturing-related profiles such as process engineers and technicians, maintenance technicians, operators/inspectors, and robotic engineers, are considered relatively less difficult to fill, cited by 10% to 15% of respondents. This illustrates the challenges in rolling out manufacturing investments under Pillar 2, with many projects being put on hold or cancelled. Difficulties still stem from limited vocational training, particularly for technicians and operational-level staff. For process and robotics engineers, the main challenge lies in aligning education and training with new equipment and advanced technologies.

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FROM 2020 TO 2025: EVOLUTION OF THE DEMAND OF JOB PROFILES ON THE EUROPEAN JOB MARKET

The figure below compares the responses collected each year since 2020 to the question "Indicate the job profiles that are the most sought-after on the EU job market."

Design engineers and software engineers have consistently been the top two most in-demand profiles over the past five years. In third position overall during the 2020–2025 period, the demand for process engineers was relatively stronger between 2020 and 2023 but has declined in the past two survey editions, revealing persistent implementation challenges for manufacturing investments under Pillar 2, many of which have been delayed or cancelled. By contrast, demand for machine learning engineers and cybersecurity experts has grown steadily, underscoring the rising integration of AI, big data, and advanced analytics in semiconductor manufacturing, as well as the need for secure systems and solutions in the face of increasing cyber threats, including those linked to AI.

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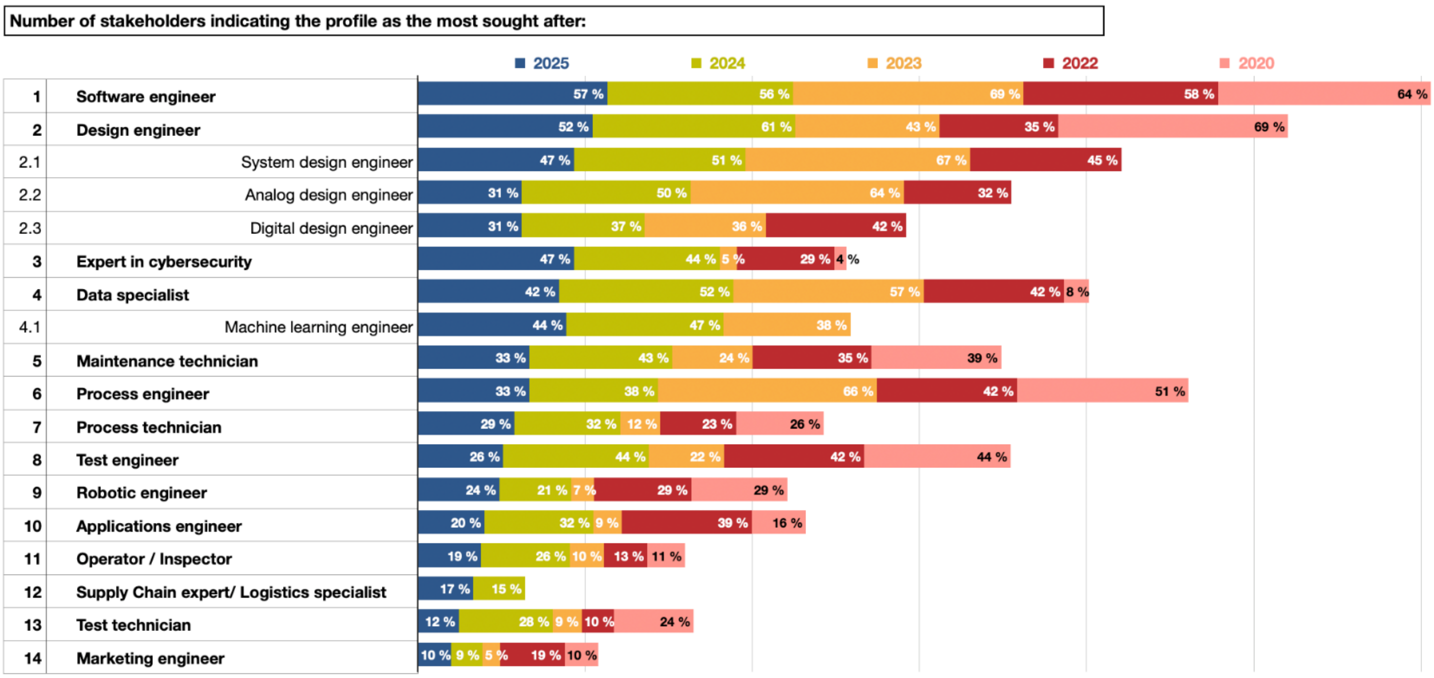
Figure 14: Share of the stakeholders over the past years indicating the profiles as one of the most sought after



For this question, all the stakeholders were not limited in their choice of answers and could choose between several job profiles. This is why the totals exceed 100%. Some categories have been added over the years, thus being unobserved data earlier. This is the case for System, Analog and Digital engineer in 2020, Machine learning engineer before 2023 and Supply / Logistics expert before 2024.

Source: 2024 & 2025 ECSA Survey / METIS Yearly Monitoring Reports 2020-2023 / DECISION Etudes & Conseil

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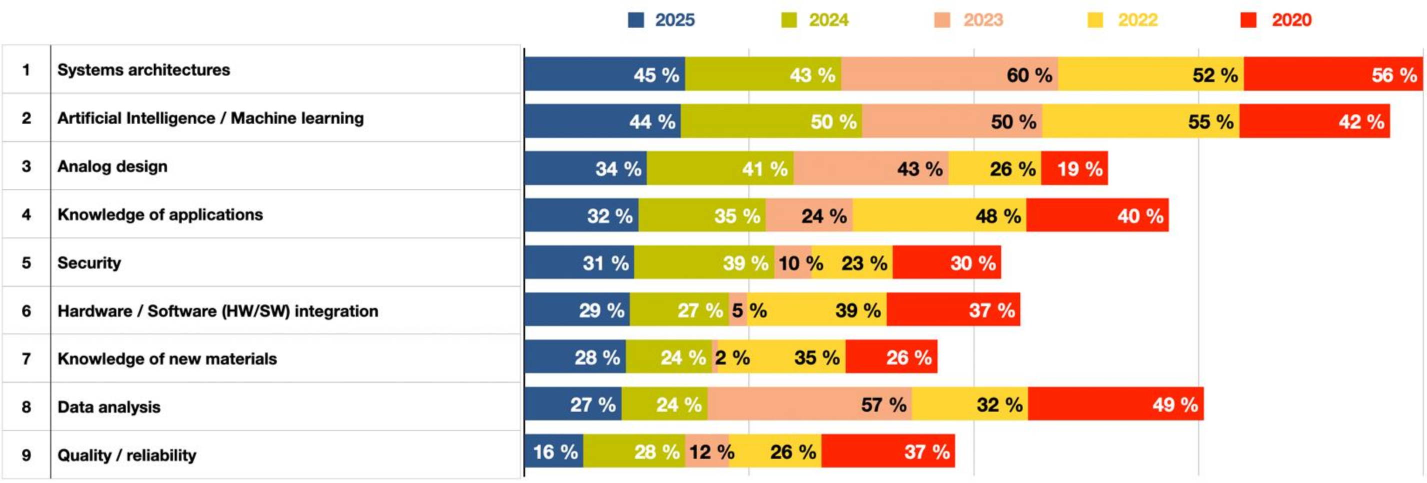
MOST CRITICAL SKILLS

TECHNICAL SKILLS

This chapter summarizes the skills identified as most critical for the European microelectronics industry between 2020 and 2025. Critical skills are defined as both the most sought-after and the most difficult to find in the job market.

Figure 15: From 2020 to 2025: Share of stakeholders indicating the profile as one of the most critical



For this question, all the stakeholders were not limited in their choice of answers and could choose between several job profiles. This is why the totals exceed 100%.

Source: 2024 & 2025 ECSA Survey / METIS Yearly Monitoring Reports 2020-2023 / DECISION Etudes & Conseil

System architecture and analog design rank first and third among the most critical skills. Both system architecture design and analog design require:

- Cross-disciplinary expertise
    - System architecture: Hardware-software co-design and integration, system-level modeling and simulation, signal processing and control theory, interaction with packaging, thermal management, and reliability engineering.

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- Analog design: Beyond digital design skills, expertise in noise, power management, and signal integrity; mixed-signal and sensor interface integration, and consideration of packaging and system-level constraints.

- A master's degree followed by 5 to 10 years of experience.

Since 2020, Europe is lacking specific training programs to develop such profiles. While the number of required talents is relatively limited (around 1,000 graduates per year across Europe), establishing dedicated training programs is essential to replace an aging workforce and preserve the EU's competitiveness in analog and system design.

Artificial Intelligence (AI) ranks second. Chapter 1.4 details how AI affects most job profiles in today's semiconductor industry.

Knowledge of applications ranks fourth, reflecting the difficulty of finding talent not only able to master technical fields related to design, manufacturing, or materials, but also capable of linking them to the needs of user industries.

Finally, data analysis has lost some momentum since 2020. At that time, demand from semiconductor companies for data analysts was just emerging, while such profiles were scarce across the EU, leading to intense competition among employers to attract them. The situation has since reversed: the EU market now counts many data analysis graduates, while the semiconductor industry shows limited demand and faces fewer recruitment challenges. Data analysis has also been integrated in training modules of most engineering and technicians profiles since 2020.

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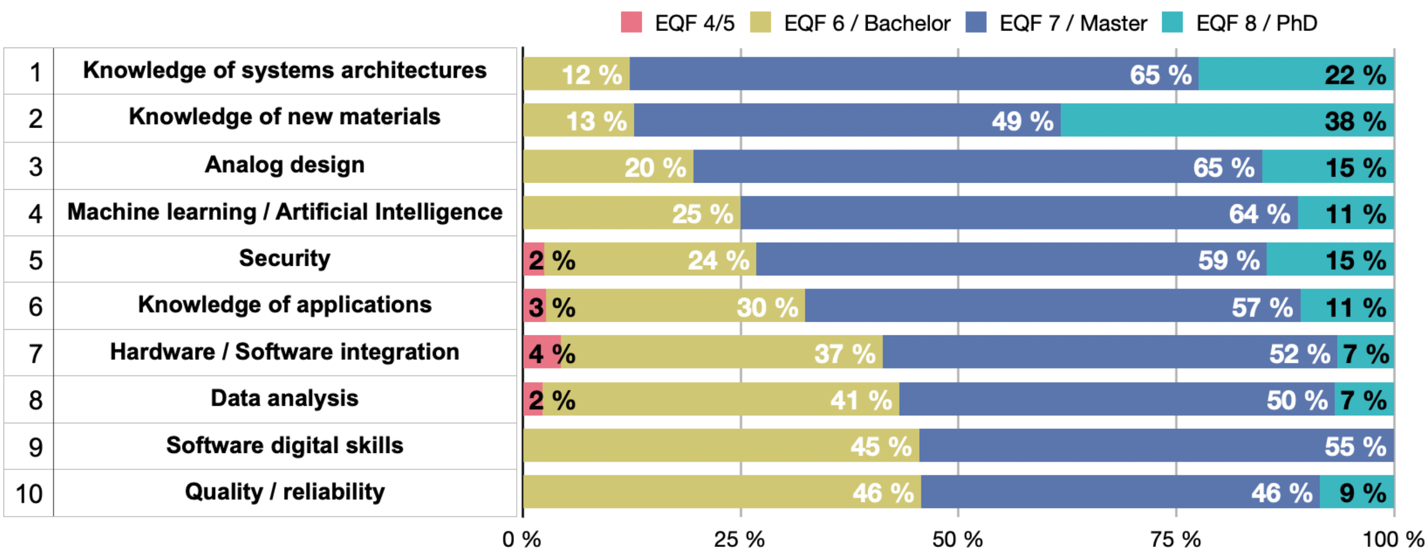
MINIMUM EDUCATIONAL LEVEL

The diagram below presents the share of stakeholders indicating the minimum educational level from which each skill is required.

Figure 16: Share of stakeholders indicating the minimum educational level from which the skill is required



From the answers 66 stakeholders in 2025.

Source: 2025 ECSA Survey / DECISION Etudes & Conseil

The need to establish new master's programs dedicated to **system architecture design** and **analog design**, followed by PhD pathways, clearly emerges.

The need to strengthen **knowledge of new materials** -although less pressing at the EU level- requires dedicated research-oriented master's programs followed by PhDs. On the topic of new materials, dual curricula (Bachelor and Master) combining electrical engineering with biology and chemistry are consistently requested, although only a limited number of such profiles will be needed at the EU level by 2030 (~200 graduates per year across Europe).

Master's programs should adapt to ensure they cover **AI skills**, **advanced security skills**, and modules related to **application knowledge**.

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Dual curricula (Bachelor and Master) combining electrical engineering with software, data analysis, and AI are also consistently requested. The potential demand from the semiconductor industry for such dual profiles is significant (around 13,500 new job positions per year across Europe), as most engineering roles now require software, data analysis, and AI skills.

Finally, **quality and reliability skills**, as well as **software, digital, and data analysis skills**, are required from the Bachelor level.

Basic notions of **hardware–software integration** should also be introduced at the Bachelor level, while advanced skills in this area are expected at the Master level.

DETAILED DESCRIPTION OF CRITICAL SKILLS

A detailed description of the most critical skills is provided in Annex 2.

IMPACT OF EMERGING TECHNOLOGIES ON SKILLS NEEDS

The diagram below shows the ranking of 10 technological fields by the stakeholders surveyed in 2025, answering the two following questions:

- Does the technology impact the skills required for the microelectronics workforce?
- Are the associated skills and knowledge currently difficult to find on the European job market?

Artificial intelligence, security, and Edge IoT/Edge AI have occupied the top three positions since 2020, both in terms of their influence on skill needs and their scarcity in the European job market

- Edge IoT and Edge AI encompass a broad range of skills, spanning from hardware-software integration, chip and system design, embedded software, testing and verification, and links with applications development.
- Cybersecurity skills are increasingly needed not only for dedicated specialists but also for software engineers and designers. Security is now considered as a cross-cutting requirement, embedded into all stages of design, development, and deployment.

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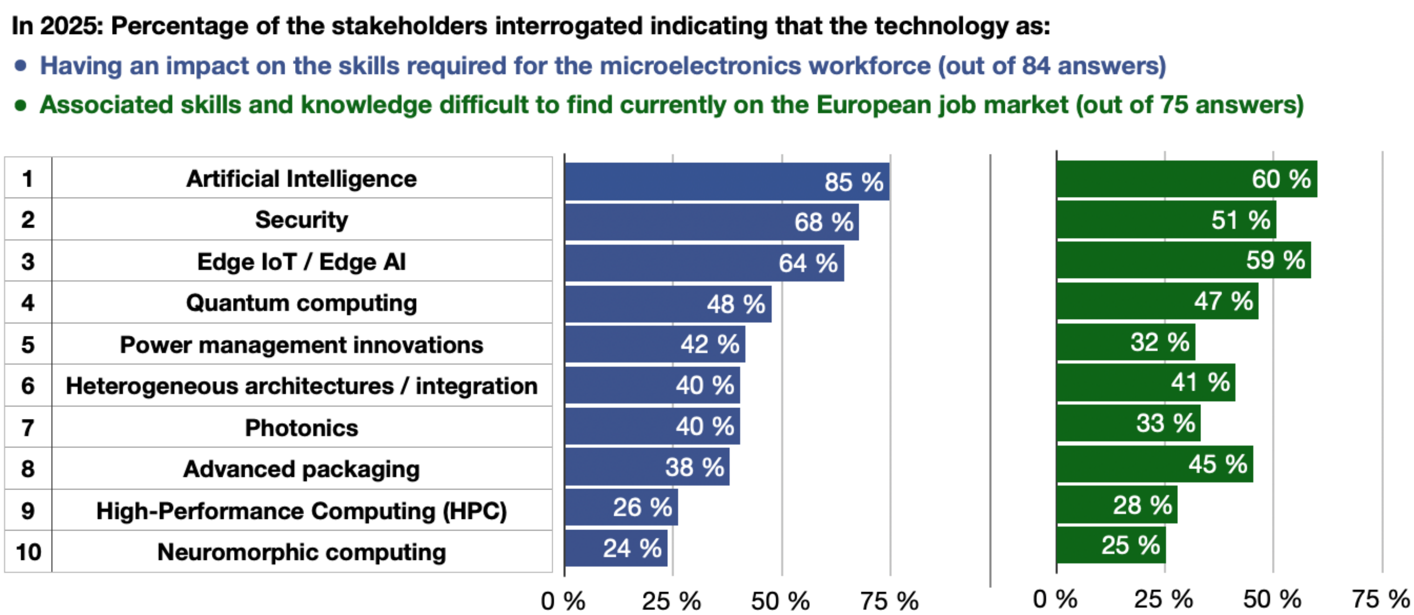
Quantum computing has gained significant momentum over the past two years and now ranks as the fourth most impactful emerging technology in terms of skills demand. It is also among the most challenging fields to recruit for. Quantum computing is reshaping skills needs by introducing a new paradigm across multiple domains, including HPC and machine learning, cybersecurity and secure chip design, analog/mixed-signal IC design, and system-level design and integration. The demand for quantum-related skills in Europe is growing, notably with the rollout of quantum chip pilot projects under the *Chips for Europe* initiative (Pillar 1 of the EU Chips Act). In 2025, the Chips Joint Undertaking selected six consortia under its quantum calls, supporting a range of quantum technologies (superconducting, trapped-ion, neutral-atom, photonic, spin-based, and diamond-based platforms) and building a European value chain from design to fabrication and testing.

Finally, hardware-software integration and advanced packaging skills seem to be particularly hard to find.

Figure 17: Technologies Shaping Skills Needs and Hiring Challenges in the EU Microelectronics Industry



Source: 2025 ECSA Survey / DECISION Etudes & Conseil

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RECOMMENDATIONS

PRIORITY RECOMMENDATIONS ISSUED BY THE PANEL IN 2025

In 2025, the priority recommendations from the 102 stakeholders surveyed are as follows.

SHORT-TERM

1. FUND UPSKILLING AND RESKILLING PROGRAMMES

First, funding upskilling and reskilling programmes are urgently required to address the evolving skill needs of the semiconductor and related industries.

Stakeholders emphasize the importance of **upskilling the existing workforce**:

• Notably enabling engineers to transition from digital design **towards analog or system design**

• And supporting manufacturing profiles to **operate new AI- and robotics-based tools** as well as to manage the associated data.

In parallel, **reskilling initiatives** should target workers from other industrial sectors, such as the automotive industry, in order to expand the talent pool available to the semiconductor ecosystem.

2. ATTRACT TALENT FROM COUNTRIES WITH LABOR SURPLUS

Second, stakeholders call for stronger efforts to attract talent from countries with a labor surplus, both within and beyond the EU.

At the intra-EU level, countries such as Spain, Croatia, Romania, Bulgaria and Greece are identified as potential sources of skilled professionals.

At the extra-EU level, cooperation should be reinforced with India, Africa and Asia.

To support this objective, the panel recommends:

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- Launching dedicated mobility programmes for students and workers
- Simplifying the administrative procedures governing mobility
- Fostering international cooperation with the most relevant partner countries

LONG TERM

1. INCREASE TRAINING CAPACITIES IN TARGETED FIELDS

In 2025, as has been the case consistently since 2020, respondents have identified as a top priority the need to **increase training capacities in targeted fields**. Two specific actions are recommended in this regard:

- **System designers, analog designers, and cybersecurity experts.** The EU faces shortages of 3,300 system designers, 2,100 analog designers, and 2,600 cybersecurity experts by 2030. These roles require highly specific training and experience, while the number of professionals to be trained remains relatively limited. The creation of <u>specialised training hubs across the EU</u> is essential to bridge this gap.
- **Electrical and electronic engineers in specific locations.** By 2030, the industry will require 53,400 professionals with electrical engineering backgrounds to support manufacturing, design, and testing. At the EU level, the main challenge is to attract existing STEM students to electrical engineering studies. However, <u>in certain countries or regions (e.g. in France and Italy), training capacities in electrical engineering appear insufficient and/or are declining</u>. There is an urgent need to expand these capacities in such areas. Short-term relief could also come from intra-EU mobility, leveraging countries with surplus graduates (Spain, Romania, Greece, Bulgaria, Croatia), and from extra-EU migration from regions such as India.

The panel insists on **the urgent need to strengthen the overall education and training ecosystem** for microelectronics across Europe.

- **Increase public education investment in microelectronics.** As education funding is being reduced in several Member States – directly affecting electrical engineering training capacities – stakeholders observe a parallel rise in “quick” or low-quality certificates aimed at short-term attractiveness. Such practices undermine the EU’s ability to compete in an increasingly complex global environment. <u>Coordination with national Ministries of Education is essential to ensure sustained public funding</u> for electrical engineering and microelectronics programmes in targeted geographical areas.

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This increased funding would also enable the development of modern digital and remote learning infrastructures – such as virtual classrooms, simulation environments, and collaborative online labs – that are indispensable for providing high-quality training across the EU.

- **Set up innovative training initiatives to support upskilling and reskilling.** Initiatives such as summer schools or accessible online training platforms, including recognized certification schemes, would enable professionals at different career stages to upskill or reskill efficiently.

2. ATTRACT 10,000 STUDENTS AND GRADUATES TO THE SEMICONDUCTOR INDUSTRY

The second major recommendation stresses the need to **raise awareness and strengthen guidance on education pathways** leading to careers in microelectronics. Beyond increasing training capacity, Europe must inspire young people – starting early – to discover opportunities in the semiconductor and electronics industries.

Several coordinated actions are recommended to achieve this goal:

- **Promote early engagement in STEM and microelectronics.** Stakeholders consistently stress that efforts must begin well before university level. Initiatives should start as early as primary and secondary education, building curiosity and enthusiasm for science and technology. Examples include hands-on robotics and electronics labs, hackathons using open-source design toolchains, and after-school activities encouraging students to experiment, tinker, and discover how electronic systems work. To sustain these efforts, Member States should integrate microelectronics topics into school curricula, introducing modules on electronics, programming, materials science, and emerging areas such as neuromorphic computing. These additions would help demystify technology and make microelectronics more tangible and attractive for pupils. Coordination with national education ministries from Member States is also crucial in this regard.
- **Train and support teachers.** Teachers play a pivotal role in stimulating young people's interest in technology, yet many lack access to updated materials and adequate training. Stakeholders recommend setting up dedicated "train-the-trainer" programmes to familiarize educators with the latest technological advances and pedagogical tools. Teachers should be equipped with centrally designed, up-to-date teaching materials, enabling them to confidently deliver engaging and relevant lessons in STEM and microelectronics.
- **Create structured orientation and outreach programmes.** Stakeholders recommend establishing accessible career orientation platforms tailored to younger generations and leveraging social

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media to reach a wide audience. Public awareness campaigns should highlight the diversity of career opportunities in microelectronics – ranging from engineering and design to sustainability, innovation, and digital creativity – and emphasize their concrete applications and contribution to Europe's technological sovereignty.

Experience sharing by industry experts through social media and outreach events can play a decisive role in inspiring students and demystifying technical professions.

3. ENSURE THE PARTICIPATION OF THE SEMICONDUCTOR INDUSTRY

The third major recommendation highlights the **need for active involvement of the semiconductor industry in education and training.** Beyond identifying skill needs, companies should play a proactive role in **developing and delivering training**, ensuring that learners acquire both the technical expertise and the practical understanding required by the sector.

Several actions are recommended to strengthen this cooperation:

- **Co-develop training and curricula with academia.** Stronger collaboration between industry and education providers is essential to align learning outcomes with industrial realities. Companies should contribute to course design and delivery (e.g., participating in summer schools). Universities and vocational institutions should regularly update curricula in collaboration with industry experts, reflecting advances in microelectronics design, manufacturing, packaging, and testing, and integrating new topics such as quantum computing, AI hardware, and sustainable manufacturing. These partnerships also provide opportunities for students to interact directly with professionals through lab visits, mentorship, and company events, helping them connect education with real-world practice.
- **Support internships and apprenticeships.** Stakeholders call for structured and financially supported internship and apprenticeship programmes within semiconductor companies, particularly SMEs and start-ups where hands-on experience can be most transformative. Such programmes should combine academic learning and industrial placement ("dual track" systems) to strengthen employability and foster long-term engagement with the industry.
- **Establish joint training centres and innovation hubs.** Stakeholders recommend creating joint training and competence centres co-developed by academia, industry, and public authorities. These hubs would act as focal points for advanced training, innovation, and technology transfer, enabling continuous upskilling and reskilling across the semiconductor value chain. They should offer hands-on courses, apprenticeships, and collaborative projects, ensuring that learners gain practical experience with state-of-the-art technologies. Such centres would also strengthen regional ecosystems, bringing together

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universities, research institutes, and companies to co-design programmes aligned with evolving industrial needs.

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Beyond these main recommendations put forward in 2025, the following chapters present the overall short-term and long-term recommendations to bridge the talent gap. Table 1 provides a comprehensive overview of the recommendations to address the talent gap. It was presented in the **ECSA Skills Strategy 2024**, building on the inputs gathered from more than **350 stakeholders** since 2020.

Like industrial policies, skills development is a long-term process, primarily because cultivating a new generation of graduates takes considerable time, necessitating both short-term (ST) and long-term (LT) responses. In the short term, it is essential to address immediate skill shortages and undertake targeted measures to meet current workforce demands. Concurrently, long-term planning is crucial to anticipate future industry needs and ensure that the education system is aligned with these evolving requirements. This comprehensive approach ensures a steady pipeline of skilled professionals.

Table 1: Summary of main recommendations – ECSA Skills Strategy 2024

Time horizon	Theme	Activity	Action
Short term response: optimise use of the available workforce	Upskilling and reskilling with life-long learning	Promote adult learning	Ensure the participation of semi-industry
			Improve information and access
			Promote Personal Training Accounts
		Promote continuing Vocational Education and Training (cVET)	Harmonise cVET quality across MS*
			Enhance attractiveness
			Provide incentives to employee/employer
	Favor intra and extra-EU mobility while retaining local talent	Facilitate intra-EU mobility	Harmonise skills certification in the EU
			Uniformise regulated professions between MS*
		Attract extra-EU skilled workers	Simplify visa process experts/students
			Facilitate immigration for skilled workers
			Scholarships to non-EU students
		Retain local talent	Facilitate placements in semi companies
			Raise remuneration beyond salaries
Long term response: anticipate future industry needs	Expand and adapt academic and iVET programmes	Increase training capacities	Increase training capacities in targeted fields
			Develop interdisciplinary STEM curricula
		Adapt training capacities	Incorporate transversal skills in curricula
			Ensure international and corporate experience
			Offer more English-speaking training programs
	Foster semiconductor ecosystems		Develop existing clusters
			Support SMEs
	Communication campaign to promote the semiconductor industry	Attract students to Semiconductor fields of study	Inform on education pathways and support
			Emphasize the contribution to society
		Encourage graduates to enter the semiconductor industry	Emphasize Work-Life Balance/ Flexibility
			Emphasize the contribution to society
			Promote career opportunities
		Launch events and networking opportunities	
	Improve data granularity		Enhance granular data on employment
			Enhance granular data on graduates

* MS stands for Member State.

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SHORT TERM RESPONSE: ADDRESSING THE CURRENT WORKFORCE NEED BY OPTIMIZING THE USE OF THE AVAILABLE LABOR SUPPLY

1. UPSKILLING AND RESKILLING WITH LIFE-LONG LEARNING PROGRAMMES

Reskilling and upskilling programmes can significantly reduce talent shortages in the short term in the EU semiconductor industry by quickly enhancing the skills of existing employees, allowing them to fill critical roles immediately. These programmes can be tailored to address specific industry needs, making them a more efficient solution than waiting for new graduates. Furthermore, reskilling and upskilling can facilitate workforce sharing within the semiconductor value chain, allowing labor to be temporarily utilized in more dynamic segments during periods of reduced activity in other parts of the industry. Workforce transfers can also come from other sectors experiencing reduced activity (e.g., the automotive industry). Additionally, offering adult learning opportunities can improve employee satisfaction and retention, as workers are more likely to stay with a company that invests in their development.

Promote adult learning. Continuing formal education, such as courses and certifications, or informal learning, like on-the-job training and self-directed study are not well integrated into EU education systems, with low participation rates and uneven progress across Member States. The underperformance of adult learning systems is mainly due to informational frictions and poor coordination among semiconductor companies, workers, and training organizations. Key issues include: (i) Mismatch in Skills Demand: Formal education systems, such as vocational schools and universities, do not have precise information about the skills companies need; (ii) Lack of Incentives for semiconductor industries: Companies may know their skill requirements but are reluctant to invest in training workers, fearing that these skills will benefit other companies; (iii) Challenges for Training Providers: High costs and insufficient information about the quality and effectiveness of training programmes discourage the development and scaling of high-quality training initiatives. A number of measures could be taken to stimulate adult learning in EU countries:

<u>Ensuring the participation of semiconductor companies in the adult learning strategy</u>: This can be achieved by ensuring sufficient funding from both public and private sources, offering tax incentives to companies, and improving the design and delivery of training programmes by actively engaging employers in their development, implementation, and financing. Initiatives such as Infineon's 'WeGrowOurselves', which provides employees with the opportunity to engage in continuous training at their own pace, should be encouraged.

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Improve information and access to adult learning programmes: Obstacles to training should be removed at the EU level by making information on adult learning programmes more easily accessible, clearly explaining funding opportunities, and offering flexible learning formats such as part-time, evening, weekend, online courses, or "Designer in Residence"/" Specialist in Residence" in summer schools, etc.

Promoting Personal Training Accounts: These funds could be used to allocate credits to meet personal training needs, giving EU citizens the freedom to choose appropriate programmes. France, for example, has a Personal Training Account (CPF) available to citizens, which automatically accumulates credits during periods of employment. The EU can support these initiatives through funding, technical assistance and by facilitating mutual learning between Member States.

Promote continuing Vocational Education and Training (cVET). Training systems differ widely among EU Member States, resulting in limited coordination and alignment. These programmes are inherently local, with distinct regional characteristics that vary from one Member State to another. cVET are organized differently across the EU, as is the extent of semiconductor companies' involvement in vocational training. The level of participation in cVET programmes is generally low across EU member States and sometimes, cVET programmes do not align with the needs of the semiconductor industries. Some measures could be implemented to encourage employees to engage with cVET:

Harmonize cVET quality across all Member States: This could be achieved by sharing best practices and establishing EU standards, for example, a "European quality assurance programme". By doing so, all programmes could meet high standards while allowing for regional specifics.

Enhance Attractiveness: Increase the appeal of cVET programmes for employees, employers, and society through targeted campaigns and partnerships.

Incentives to encourage employees and semiconductor industry participation: Offer scholarship, grant, and tax benefit programmes to make cVET more financially attractive for employees and employers.

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2. FAVOR INTRA AND EXTRA-EU MOBILITY WHILE RETAINING LOCAL TALENT

Facilitating intra-EU labor migration from Member States with surplus training capacities to EU countries where the demand is most urgent. Currently, over a third of EU graduates in semiconductor-related fields of study are located in Member States without significant semiconductor industry and 40% are outside the main semiconductor players (Germany, Netherlands, France, Italy, Ireland, Belgium, and Austria). Among countries with a relatively limited semiconductor ecosystem, Spain has the highest number of students in semiconductor-related fields, though other sectors strongly compete for these graduates. Following Spain are Romania, Greece, Bulgaria, and Croatia.

Improve and harmonize skills certifications: This involves an EU-wide recognition of diverse learning pathways, vocational training, and work-based learning. Certifications should be flexible, less dependent on formal education, and include micro-credentials (short, focused learning experiences that allow individuals to gain specific skills or knowledge in a particular area) and digital badges (badges that contain metadata providing details of the skills acquired through the micro-credentials).

Assessing Member States' (MS) regulated professions systems: While the professions in the semiconductor industry are less regulated than in other industries (aeronautics, energy, pharmaceuticals, etc.), some MS have regulations in place for specific roles, including chemical engineer, electrical engineer, and electromechanical engineer[1]. These regulations may be crucial for ensuring personal safety, but they can also act as a barrier to entry for workers from other MS. It is, therefore, essential to assess the necessity to uniformize these regulations.

Attracting more highly skilled workers from outside the EU. EU Semiconductor companies already employ a significant number of non-European workers to address the shortage of skilled professionals in Europe and to leverage the benefits of a diverse and inclusive work environment. As previously stated, in 2023, 39% of ASML employees in the EMEA region were non-EMEA nationals. China, India and the United States are the countries with the most STEM graduates, with the EU, but competition is intense as these countries are also developing their semiconductor industries. To a lesser extent, other countries also have a large pool of STEM graduates,

[1] https://ec.europa.eu/growth/tools-databases/regprof/professions/generic

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where competition is perhaps less intense. These include Russia, Indonesia, Brazil and Mexico. The following measures have been proposed to attract non-EU skilled workers:

Simplify visa process for experts and students: One potential solution would be the introduction of a specialized EU-wide entry visa for graduates, researchers and experts in the semiconductor field. This visa should feature clear eligibility criteria and a streamlined application process, minimizing bureaucratic obstacles.

Streamlined immigration for skills workers: This includes the acceleration of visa processing, and the issuance of residence permits to qualified professionals. It is asserted by respondents that these pro-immigration policies be combined with the protection of critical technologies (ITAR, export controls). This also encompasses the facilitation of installation for new arrivals, including housing options, and the formulation of a plan to assist and/or train spouses/husbands in securing employment in the destination country.

Providing scholarships to non-EU-students in semiconductor fields of study: Scholarships should be structured to address both merit and financial need. Encouraging private companies to co-sponsor these scholarships will ensure that the funding aligns with industry requirements, fostering a mutually beneficial relationship between academia and the private sector.

Retain local talent in highly skilled occupations. Over the years, Europe has become a major exporter of talent. It is estimated that around 10% of graduates in semiconductor related fields of study choose to work outside the EU either immediately after completing their studies or in the near future. Based on the model used previously to estimate the talent gap, it is estimated that retaining the talent currently leaving the EU after their studies would result in a 20% reduction in the talent gap over the period 2024-2030. Surveys of expatriate engineers show that the main reasons for choosing to work outside the EU are a better quality of life and working environment, a more open market and better opportunities, and higher salaries.

Facilitating student placements and graduate contracts within semiconductor companies: To keep skills in Europe at the early stages of careers, student placements and graduate contracts in semiconductor companies and research centres need to be facilitated across the EU. This requires placement services to link graduates with companies and research centres.

Raising remuneration: Beyond salaries, additional incentives to stay in the EU could be considered, including tax incentives and housing assistance. The shortage of affordable housing is particularly acute in technological clusters.

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LONG TERM RESPONSE: ANTICIPATE FUTURE INDUSTRY NEEDS

1. EXPAND AND ADAPT ACADEMIC AND IVET PROGRAMMES

Increase training capacities in semiconductor-related studies

It is anticipated that communication campaigns (see iii) could lead to an increase in the number of students pursuing studies in semiconductor-related fields (currently only 28% of STEM students graduate in this area). This would require an expansion of the number of initial education programmes in selected semiconductor-related fields of study. However, the results from the quantitative analysis and online survey demonstrate that additional training capacities are already required in hardware engineering -the primary contributor to the talent gap- and especially electrical engineering.

<u>Increase training capacities in targeted fields:</u>

An increase in training capacities in the EU is necessary in two key areas:

1. <u>Electrical engineering</u>. By 2030, the semiconductor industry in the EU will face a shortfall of nearly 53,400 graduates from electrical engineering programs. This talent gap could be alleviated if demand from other industries for electrical engineering graduates decreases by 2030. However, under the more likely scenario where this demand remains stable, the only solution to address the shortfall is to expand training capacities in electrical engineering. Feedback from universities in France, Italy, Ireland, and Belgium suggests that, so far, no such expansion is occurring overall. Instead, training capacities have remained stable or even declined, while the workforce of professors continues to age. Immediate action is essential to close the EU's talent gap in this critical field.
2. <u>Specialized Degrees for the Semiconductor Industry</u>. Current training capacities for certain specialized roles within the semiconductor industry are significantly below the sector's needs. For these profiles, which require high educational levels (EQF 7-8), and work experience to become productive, there is an urgent need to set up specific training hubs. The following three profiles are of particular concern:
    - <u>System designers</u>. By 2030, the EU will face a shortage of 3,300 system designers. These professionals must be trained in electrical engineering, semiconductor design, and system design (SoC, SiP, complex ASICs). Proficiency in data science and machine learning would be an advantage.
    - <u>Analog designers</u>. By 2030, the EU will lack 2,100 analog designers. These professionals need training in electrical engineering, RF, digital semiconductor design, and specifically, mixed

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signal/analog semiconductor design. Proficiency in data science and machine learning would also be beneficial.

- Experts in cybersecurity. The EU will face a shortfall of 2,600 cybersecurity experts by 2030. These professionals must possess expertise in electrical engineering, semiconductor hardware and software, and cybersecurity to address security-by-design in semiconductors and develop secure hardware and software architectures.

Develop interdisciplinary STEM curricula: The demand for new skills is growing rapidly in fields like data science and machine learning, creating opportunities for interdisciplinary joint curricula (Bachelor, Master) combining Electrical Engineering with these and other disciplines. The table below ranks these potential joint curricula based on projected job demand in the EU semiconductor industry by 2030.

For example, graduates with a joint degree in Electrical Engineering and Data Science could meet a demand of 70,000 jobs in the EU semiconductor sector by 2030. In contrast, joint programs combining Electrical Engineering with fields such as Marketing/Sales/Communication (2,200 job openings) or Biology/Natural Sciences (1,700 job openings, primarily in R&D, material, or application engineering) are projected to see much lower demand by 2030.

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Table 1: Proposals for interdisciplinarity or joint degrees in microelectronics

FIELD OF STUDY	PROPOSALS OF JOINT DEGREE					TOTAL demand for such profiles on EU soil 2024-2030 (number of job positions)
	1	2	3	4	5	
Microelectronics / Electro engineering / Mechanics / Mechatronics	**V**	**V**	**V**	**V**	**V**	
Data science / Software / Informatics / Data engineering / Data analysis	**V**					**70 000**
Artificial Intelligence / Machine Learning		**V**				**70 000**
Chemistry / Material science (Polymer etc.)			**V**			**29 400**
Marketing / Sales / Communication				**V**		**2 200**
Biology / Natural science					**V**	**1 700**

Source: 2025 ECSA Skills Strategy / DECISION Etudes & Conseil October 2025

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Adapt training capacities

Incorporate transversal skills into the regular STEM curriculum: Developing skills such as communication, teamwork, problem-solving, creativity, adaptability, resilience and emotional intelligence, and entrepreneurship education.

Ensuring that curricula include international and corporate experience: This can be achieved by facilitating student rotations abroad through simplified regulations, assisting companies in offering internships with mentorship and funding for bachelor's and master's students, aligning curriculum and internship constraints with industry requirements (preferably for four to six months), and making internships a mandatory part of the university curriculum.

Offer more English-speaking training programs: In order to facilitate workers mobility during their working lifetime.

2. FOSTER SEMICONDUCTOR ECOSYSTEMS

Especially when addressing the topic of skills, positive synergies emerge from the coexistence in the same geographical area of a complete semiconductor ecosystem, involving not only large companies, but also mid-cap and SMEs, research labs, Universities and VET providers.

Develop existing clusters:

The figure below illustrates the main semiconductor clusters in the EU.

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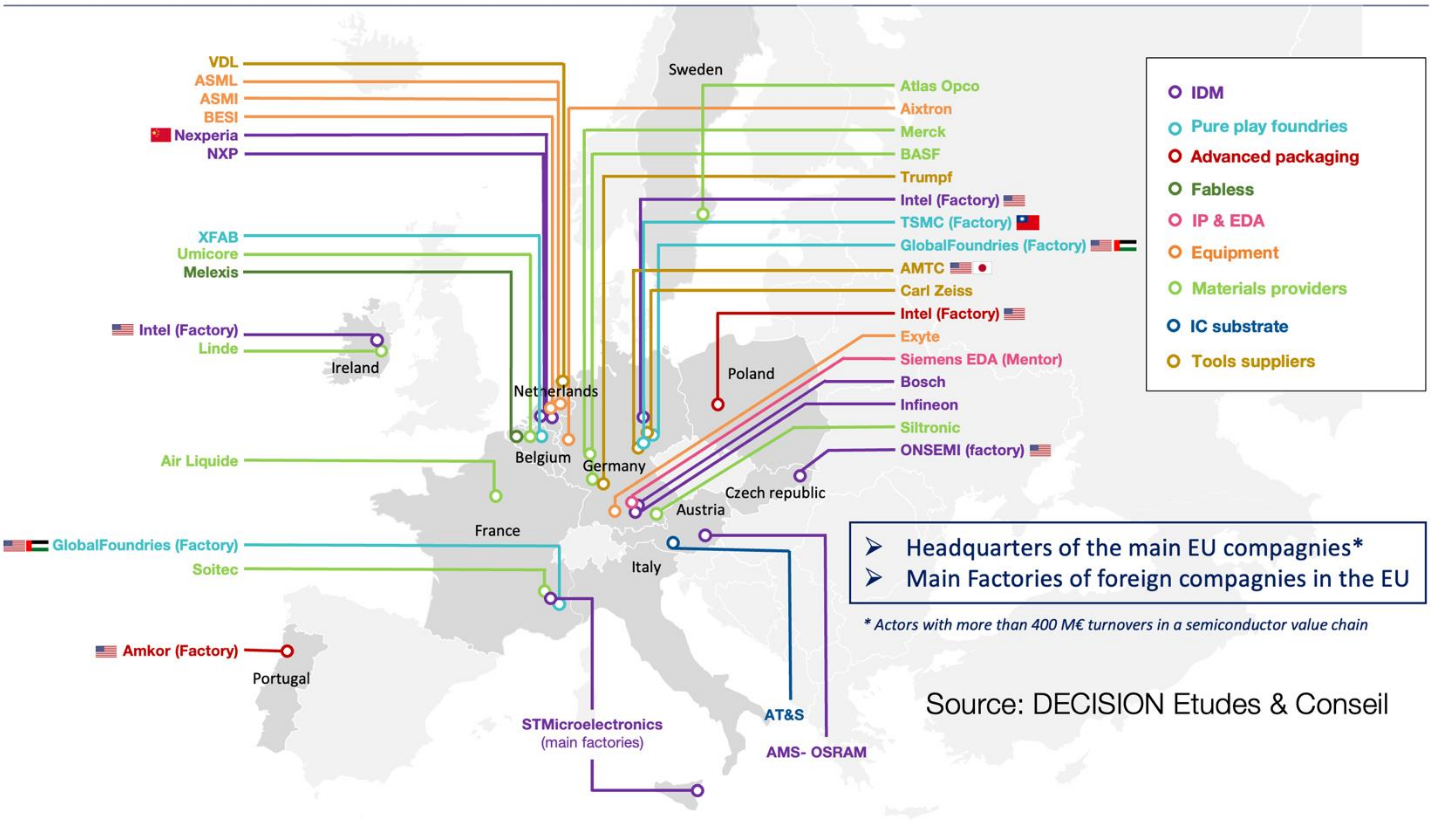
Figure 18: The main semiconductor cluster in the EU



As shown on the map, the main clusters on EU soil are the following: the axis Brussels-Amsterdam (Belgium – the Netherlands), the Dresden area / Saxony (Germany), the Munich area (Germany), the Grenoble area (France), the Dublin area (Ireland), the axis Graz-Vienna (Austria), and many more of medium size such as the Helsinki area (Finland).

Clusters are crucial for decreasing the talent gap as they concentrate resources, enhance collaboration between universities and companies, and foster innovation and knowledge sharing. They attract talent by offering numerous professional opportunities and support SMEs by providing access to training and development resources. Such environment fosters collaborative approaches such as sharing best practice, scaling common skills (e.g. AI, data engineering).

The EU policy to address the talent gap should be structured around the main EU clusters, addressing their specific needs at the regional / local levels.

Supporting SME: SMEs and startups often flourish in existing clusters. Providing SMEs with access to resources, mentorship, continuous learning opportunities at reasonable costs and advanced manufacturing tools appears crucial and is already a goal of the EU Chips Act's pilot lines and competence centers.

3. COMMUNICATION CAMPAIGN TO PROMOTE THE SEMICONDUCTOR INDUSTRY

As demonstrated in this study, the EU does not face a lack of STEM students overall. Within STEM studies, the number of graduates in semiconductor-related fields of study[2] is also overall more than sufficient to meet the needs of the semiconductor industry, in particular in ICT, benefiting from a strong growth in new graduates and training capacities[3].

However, only a limited percentage of graduates in semiconductor-related disciplines opt to enter the European semiconductor industry upon completing their studies. Many of these graduates redirect their engineering expertise towards unrelated sectors, such as the production of loaded electronic boards, electrical products, computer and optical devices, as well as industries like electricity and gas supply and wired telecommunications.

Additionally, a significant number pursue careers outside traditional engineering roles, venturing into fields such as finance, marketing, and communications.

As a consequence, in 2022, it is estimated that only about 9% of EU graduates specializing in semiconductor-related fields would join the semiconductor industry within the EU. Notably, the growth rate of graduates in semiconductor disciplines has remained relatively stagnant over recent years, particularly when contrasted with the broader trends observed in STEM fields. This trend raises concerns about the industry's ability to attract and retain talent in a rapidly evolving technological landscape.

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[2] Electronics and automation, mechanics, chemical and process, software and application developments, and database and network design and administration.

[3] In terms of training capacities, the main concern relates to electrical engineering, where the growth of graduates is not sufficient to meet the needs from the semiconductor industry. For this type of studies, communication campaigns will not be sufficient and expanding training capacities is also a need (see recommendation i).

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The percentage of graduates from semiconductor-related fields entering the European semiconductor industry is influenced by market size but also by the industry's perception and appeal. A significant number of respondents to online surveys have highlighted that the volume of talent moving into the semiconductor sector correlates with market size and enhancing the sector's competitiveness could indeed lead to more graduates choosing this career path. However, this is not the only factor at play. Many STEM graduates may lack awareness of the opportunities available within the semiconductor industry, which may not be marketed as effectively as other tech fields like software development or data science. Furthermore, technical roles, especially in manufacturing, can be demanding, often requiring long hours and operating in high-pressure settings. As a result, graduates might prefer industries that offer better work-life balance and more flexible arrangements. Additionally, the analytical and problem-solving skills honed during STEM studies are highly applicable to non-technical positions, allowing graduates to feel confident that their technical training can lead to success in diverse fields, including business and communication.

Attract students to semiconductor fields of study. Communication campaigns to attract more students to semiconductor-related fields of study should focus on the following thematic areas:

<u>Informing on educational pathways and support</u>: Provide clear information on educational pathways, including relevant degree programmes, certifications, and training initiatives. Emphasizing available financial assistance options, like scholarships for semiconductor studies, to help reduce economic barriers and empower students to envision a future in this dynamic field with confidence.

<u>Emphasizing the field's contribution to society</u>: Highlight the industry's crucial role in driving innovation and shaping future technologies, including artificial intelligence, the Internet of Things, and renewable energy. Showcasing diverse career opportunities to inspire students to pursue fulfilling careers that contribute to global advancements.

Encourage graduates to enter the semiconductor industry. Communication campaigns to encourage graduates to enter the semiconductor industry should focus on the following thematic areas:

<u>Emphasis on Work-Life Balance and Flexibility</u>: Encourage graduates to enter the semiconductor industry by emphasizing the sector's focus on work-life balance and employee well-being. Showcasing companies that offer flexible work arrangements and sharing testimonials from current professionals to counter the myths of high-pressure roles and highlight fulfilling career experiences.

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Emphasizing the field's contribution to society: Present success stories of thriving companies, illustrating the significant contributions the semiconductor sector makes to technological advancements and societal improvements. This approach will inspire graduates by demonstrating the potential impact of their work in this dynamic field.

Promote career opportunities: Emphasizing the increasing demand for skilled professionals in the industry and highlighting the industry's commitment to continuous learning and career advancement. This message will encourage graduates to explore various paths that align with their interests and skills.

Launch events and networking opportunities. Promote networking opportunities and events (workshops, career fairs, summer schools…), that connect students and graduates with industry professionals, offering insights into real-world applications of their education. Furthermore, introducing mentorship programmes that pair students with seasoned experts would provide valuable guidance as they navigate their career paths in the semiconductor industry.

4. IMPROVE GRANULARITY OF EMPLOYMENT AND GRADUATES' DATA

To create effective skills policies, it is vital to enhance the availability and reliability of skills data both at the EU level and within Member States (MS). Such data is crucial for identifying skills shortages and strategizing funding for training programmes, enabling governments to make informed investment choices. While new data sources are emerging, their adoption in policymaking is still limited. To tackle this, an EU-wide initiative should be launched to gather and standardize skills information, collaborating with private sector entities for accurate insights. The initial focus should be on data collection at the Member State level, with the Commission establishing a common standard to facilitate comparability and usability for local policymakers. Additionally, local organizations must be trained to effectively utilize this data in planning skills policies. Key priorities for any data enhancement initiative should include:

Enhancing granular data on employment by occupation at EU and MS levels: Eurostat produces employment data by industry but not by occupation. Cedefop has made efforts in this direction, but the disaggregation by occupation is not yet sufficiently detailed. The availability of disaggregated data varies greatly from one MS to

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another. The U.S. Bureau of Labor Statistics provides a good example to follow, with a very detailed Occupational Employment database which, to our knowledge, does not exist in any MS at such a detailed level[4].

Improving the granularity of graduates' data and undertaking graduate tracking surveys: The data on graduates and students at the European level is based on the International Standard Classification of Education (ISCED). While this classification already provides a high level of granularity by field of study, there is potential for further improvement. To provide an example, the ISCED offers a four-digit breakdown of academic disciplines, while the Classification of Instructional programmes (CIP) from the National Centre for Education Statistics (NCES) in the United States provides a six-digit disaggregation. Moreover, there is currently no graduate tracking survey at the European or Member State level. A few universities such as TU Graz, and engineering associations, have initiated their own surveys. Other non-European countries have implemented such surveys at the national level, including the United Kingdom and the United States. The Member States could benefit from drawing inspiration from these examples.

[4] https://www.bls.gov/oes/current/oes_nat.htm

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ANNEXES

ANNEX 1 - METHODOLOGY NOTE OF 2025 EDITION OF THE ECSA SURVEY

The qualitative analysis was carried out based on the results of the 2025 edition of the ECSA Survey 2025. This year's survey follows the structure of past years surveys that have been carried out in the ECSA and METIS projects. This allows for a continuous monitoring of the answers from the stakeholders involved to follow the skills trends in the EU semiconductor industry. As previous years, the stakeholders were invited to answer questions on:

- New emerging profiles and skills that they identified
- The impact of specific events on the hiring policies (EU Chips Act, Fabs investments…)
- Specific job profiles that are sought after and/or in shortage
- Specific skills that are critical to find
- Emerging technologies and their impact on the skills market
- The stakeholders' hiring plans compared to the previous year
- The perception of the skills shortage compared to the previous year

In 2025, 102 stakeholders from 21 different countries participated in the survey. The statistics on the geographic location of the stakeholders is given in the figure below. The survey has covered 16 member-states alongside the UK, Switzerland and Ukraine in Europe, as well as a few respondent from the US, Israel and Malaysia (5% of the total). Within the EU, the coverage was overall well-balanced between the member-states.

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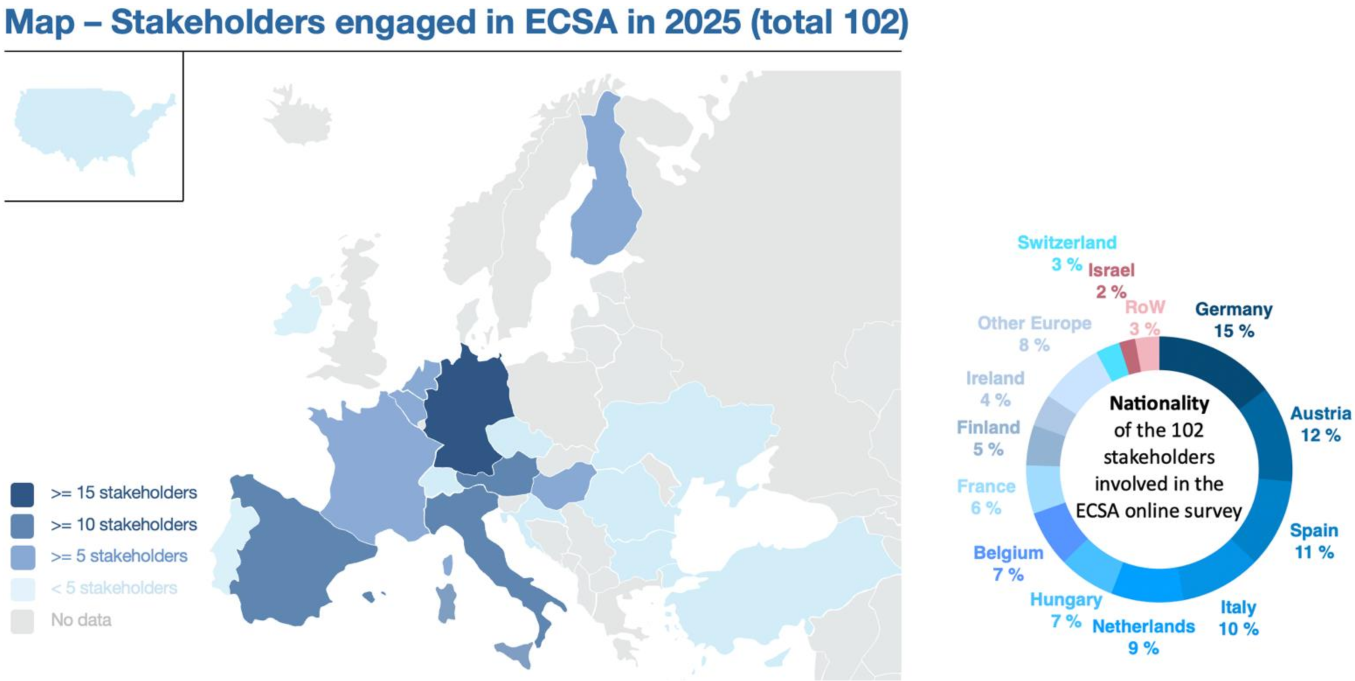
Figure: Geographic distribution of stakeholders engaged in the 2025 ECSA Survey



Source: DECISION Etudes & Conseil

This year's survey gathered responses from 75 different organizations, with a balanced distribution of SMEs, large companies, universities and RTOs.

An in-depth analysis of the stakeholders is given in the pie charts below.

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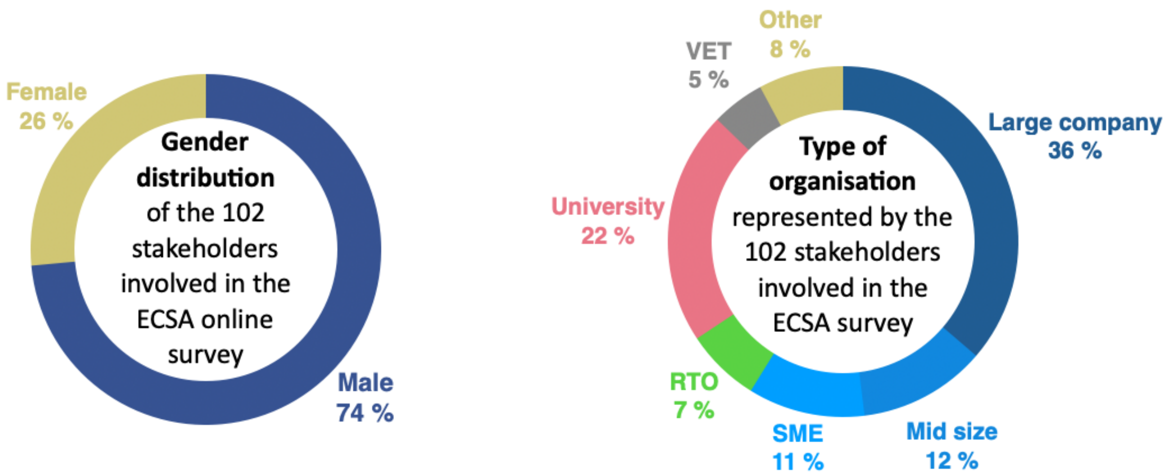
Figure: Distribution of the gender and type of organization involved in the 2025 ECSA Survey



Source: 2025 ECSA Survey, DECISION Études & Conseil

The 2024 ECSA survey includes stakeholders from the entire semiconductor value chain: 52% semiconductor companies (IDMs, fabless & IP, equipment and tools, or materials), 26% respondents related to Education & Training, 6% respondents from end-user electronics systems or services, 7% semiconductor Research & Technology Organizations (RTO), and 10% from other organizations.

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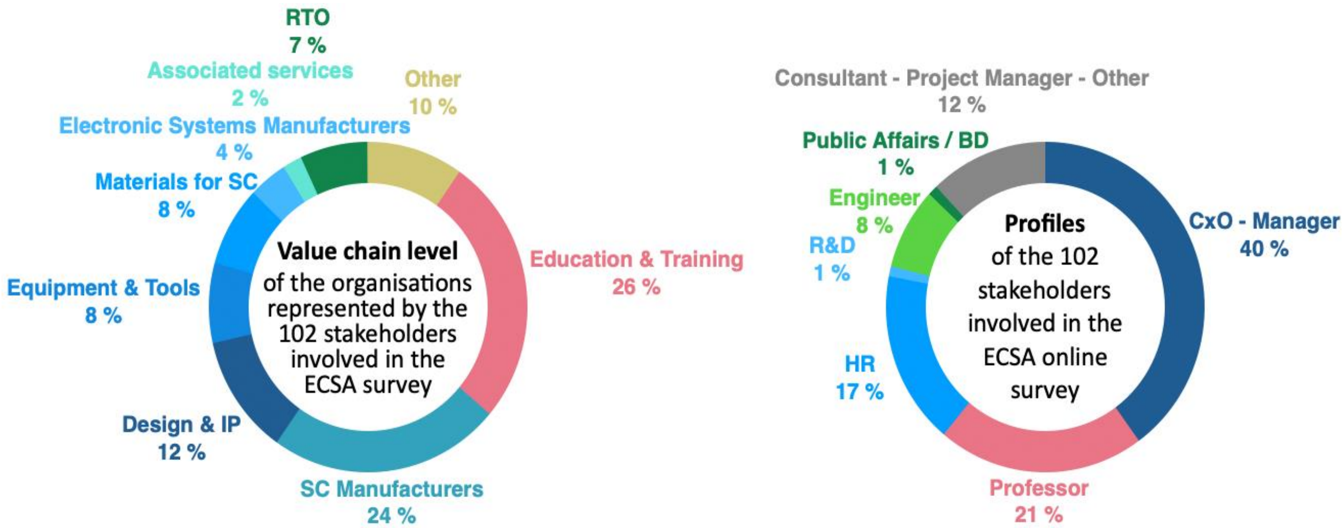
Figure: Distribution of the organization's position in the value chain and profiles of the stakeholders participating in the 2025 ECSA Survey



Source: 2025 ECSA Survey, DECISION Études & Conseil

Finally, in terms of profiles of respondents: 40% are CxO, 21% professors, 17% Human Resources, 8% engineers, 1% researchers, 1% public affairs / Business Development, and 12% others (consultants, project managers…).

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ANNEX 2 - HOW ARE ARTIFICIAL INTELLIGENCE, AUTOMATION AND DATA ANALYSIS IMPACTING SKILLS IN THE SEMICONDUCTOR INDUSTRY?

The Artificial Intelligence (AI) trend has a dual impact on the EU talent gap in the semiconductor industry.

AI increases the talent gap by:

- **Rising demand for chips**: The expansion of data centers across the cloud-to-edge continuum, driven by AI applications, increases global demand for chips. However, this effect remains limited in Europe, as most European players are not strongly positioned in AI-related products or downstream user industries.
- **Emergence of new AI-related job profiles**: The growing use of AI and data analytics is creating new professional categories that are increasingly sought after by the semiconductor industry, including:
  - ➢ Data specialists (analyst, engineer, scientist, machine learning engineer) – managing, analyzing, and interpreting large datasets generated throughout design, manufacturing, and testing processes.
  - ➢ Machine learning engineers – Software engineers designing, training, and optimizing machine learning models, with a solid understanding of hardware constraints such as memory, latency, and energy efficiency. They ensure that AI algorithms can be efficiently deployed on target devices (CPU, GPU, NPU, or ASIC) and collaborate with hardware engineers to co-optimize models and architectures. Also referred to as *AI algorithm engineers*.
  - ➢ AI hardware engineers – Specialists developing and implementing hardware solutions optimized for AI workloads. They design architectures and circuits enabling efficient acceleration of machine learning models, focusing on compute performance, data movement, and power efficiency. Also known as AI hardware specialists.
  - ➢ AI applications engineers – Professionals integrating AI-based functionalities into semiconductor products to better address the requirements of specific end-user industries while balancing market and technical constraints.
  - ➢ Automatic Design Generation engineers – Engineers transforming traditional chip-design workflows by leveraging AI tools to accelerate and enhance design efficiency (e.g. training neural networks for electrical implementation or sizing).

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- AI system designers / architects – Senior professionals managing multidisciplinary teams responsible for the design, manufacturing, and material sourcing of complex chip systems (SoC, chiplet, ASIC) embedding AI capabilities.
- New profiles are also emerging to address the legal aspect of AI (legal experts in the ethics of emerging technologies), and the sustainability of AI chips.

By enhancing productivity, AI reduces overall workforce needs but intensifies upskilling requirements.

Conversely, AI tools enhance productivity across many existing profiles, reducing the total number of professionals required while increasing the need for upskilling.

The profiles currently most affected by this transformation include:

- **Software engineers**, who increasingly rely on AI-assisted coding and debugging tools.
- **Chip designers**, using AI-enhanced EDA (Electronic Design Automation) software to accelerate and optimize design flows.
- **Test and verification engineers**, leveraging AI-driven solutions for automated test generation, fault detection, and reliability analysis.

However, manufacturing-related roles are also increasingly being reshaped by the introduction of AI-powered automation and predictive analytics:

- **Process and automation engineers and technicians**, now responsible for managing intelligent production systems.
- **Quality and reliability engineers**, using AI to monitor process variations and improve yield prediction.
- **Operators**, the job category most at risk as across both Front-end and Back-end processes, the industry is progressively reducing operator roles through automation. Consequently, operators increasingly need to upskill toward technician-level positions, supervising and maintaining automated manufacturing tools.

The table below summarizes the direction and intensity of AI's impact across key job profiles in the semiconductor industry.

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Job profile impacted		Nature of the impact
Data specialist	**Data specialist**	Data specialists emerged within the course of 2010s as a set of job profiles including data scientists, data analysts, data engineers and machine learning engineers. They are today involved in most aspects of engineering and manufacturing tasks and work with the vast majority of engineers and a rising number of technicians.
	Data analyst	Focuses on analyzing data, creating visualizations, and generating insights that inform business decisions. They work extensively with statistical tools, visualization software, and often perform exploratory data analysis. Typically holds a bachelor's degree.
	Data engineer	Builds and maintains data pipelines, data architectures, and ETL (Extract, Transform, Load) processes. They ensure data is structured and accessible for analysis and machine learning tasks, optimizing data flows and system performance. Typically holds a bachelor's degree.
	Data scientist	Responsible for developing statistical models and performing complex data analysis to make data-driven predictions. They work on identifying patterns, building predictive models, and often play a crucial role in strategic decision-making. Typically holds a master's degree, sometimes a PhD.
	Machine learning engineer	Emerged in the early 2020s as a job profile required in the semiconductor industry. Skilled in algorithms, data modeling, and software engineering with a focus on building, deploying, and optimizing machine learning models. Typically holds a master's degree, sometimes only a bachelor. Data scientists can be machine learning engineers.
Software engineer		Software engineers continue to gain importance in the semiconductor industry. Of course, it is one of the profiles the most impacted by AI. In addition to machine learning skills, the industry increasingly requires embedded software / firmware programming skills and coding skills in languages such as: Python, Git, Bash… A rising number of companies are involved in RISC-V development, requiring more compiler specialists.
Application engineer		Existing applications (automotive, industrial, health...) are being disrupted by AI capabilities. Semiconductor application engineers are at the forefront of this revolution and need to build a deep understanding of AI capabilities for end-user industries, as well as the technical constraints linked to AI in semiconductor design, processes, and materials used. **New profile: AI applications engineer:** AI is impacting the profile of application engineer to the extent that a new profile of AI application engineer is emerging as a sub-profile of application engineer. AI application engineer works with software engineers, designers and data scientists, advising on when AI solutions are suitable, which AI algorithm to chose, on which suitable HW platform, to support a specific end-user application (automotive ADAS…).
Designer	**Designer**	**AI is revolutionizing the way chips are designed**: generative AI is used to support design, generating automatically building blocks and/or IP blocks. AI tools can interface with typical IC design tools (e.g. Cadence Virtuoso software). AI engineers or designers write parametrizable generator scripts that automatically generate entire layouts and schematics, perform the layout-versus-schematic (LVS), post-layout extraction (PEX) and automatically optimize the design. This implies that AI technics increase the re-usability of past design.
		New profile: AI hardware designer. Designers have to design specialized AI chips, leading to a new profile: AI hardware designer or engineer / Edge AI designer. These engineers focus on designing and optimizing hardware architectures specifically for artificial intelligence and machine learning applications (neural network accelerators…). They have the knowledge of AI and ML algorithms but are specialized in implementing them on hardware platforms.
	Analog designer	**New profile: Automatic Analog Design Generation engineer.** This profile merges in-house Analog IC Design experience with advanced software skills and Artificial Intelligence to build state of the art analog circuits automatically.
	Systems designer	**New profile: AI system designer / architect**. Corresponds to a senior profile capable of managing a team of ML engineers and designing the whole architecture of a complex AI microelectronics system.
Test & verification engineer		Since the early 2010s, test engineers have needed increasingly more software engineering skills while maintaining strong foundational skills in electrical engineering. As more functionality is integrated into a single device, these devices become increasingly complex and, consequently, more challenging to test efficiently. Test programs for semiconductors can now consist of hundreds or thousands of individual tests implemented in tens of thousands of lines of software code. To better manage and optimize these complex test programs, test engineers are also developing AI skills enabling them to leverage AI for more efficient and accurate testing processes.
Process engineers		AI tools are increasingly integrated with big data technologies to enhance computer vision, advanced real-time statistical process control and optimization, as well as predictive maintenance.
Robotic / Automation engineers & technicians		
Maintenance engineers & technicians		
Quality & reliability engineers: Reliability engineer / Functional safety engineers, failure analysis engineers, quality expert		AI-powered inspection systems can detect defects in wafers or components at a level of precision far beyond traditional methods. This helps quickly identify and address defects that could affect yield.
Process technicians & Operators		Modern fabs are reaching such a degree of automation that even fab operators works increasingly with automatized tools and needs the associated skills.
Material engineers		Material engineers are impacted by edge AI as they need to develop new class of materials for more efficient AI at the edge.
Quantum experts		Combining quantum with AI technologies opens new doors for innovation.

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ANNEX 3 - DETAILED DESCRIPTION OF CRITICAL SKILLS

1) Machine learning / Artificial Intelligence

Knowledge and skills associated with machine learning are increasingly required for the majority of the profiles of the microelectronics industry today and will become more and more important, especially in line with the development of I4.0. These are especially important for software engineers that must be trained to a diversity of AI tools so that they have a wide view of the topic. The main coding languages that are suitable for AI-related applications and technologies: Python, Java, C++, and Julia. These languages particularly involve libraries like Scikit-learn, Keras, TensorFlow, Torch, etc.

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

Associated job profiles:

- Main profiles concerned: Software engineers and Data scientists/ Machine learning engineers/ etc.
- But overall, every job profile listed earlier is impacted by this skill.

Content / sub-skills and sub-knowledge:

- Ability to identify/ select/ implement the machine learning toolsets for manufacturing (design, automation, etc.), and/or ERP.
- Mathematical knowledge in probability theories and statistics, which is the foundation for machine and deep learning, and AI models in general.
- General introduction course on AI (at EQF 4-5): Fundamental knowledge and understanding of AI tools.
- Understanding how to replace basic skills in production by machine learning algorithms to increase competitiveness and to facilitate innovation.
- Understanding of the impact of AI applications: anything related to AI Ethics.

Beyond AI and machine learning, software skills are becoming more and more important for most microelectronics job positions: Robotic engineers, materials engineers, process engineers, power electronics engineers, RF engineers, etc. For instance, for RF and hardware engineers, software programming has become a very basic requirement in job descriptions currently. Up until the early 2000s, microelectronics technological developments were very hardware intensive, which shifted towards software in the early 2020s. In certain

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technologies (e.g., AI), software may be even more important than hardware in the semiconductor sector. However, many people may still not value skills in software as much as hardware, considering software as easier to learn whereas it covers a very wide range of skills and knowledge.

2) System architecture

System architecture traditionally regroups the skills and knowledge associated with microelectronics systems: System-on-Chip (SoC), System-in-Package (SiP) and System-on-Package (SoP).

- A System-on-Chip (SoC) consists of a series of blocks (processor, memory and caches, wireless system interfaces, network interfaces, sensor and actuators) integrated on the same die. SoC designs also include application software and runtime systems.
- System-in-Package (SiP) has evolved as an alternative approach to SoC for electronics integration because this technology provides advantages over SoC in many market segments. Sip provides more integration flexibility, faster time to market, lower R&D cost, lower NRE cost, and lower product cost than SoC for many applications. SiP is not a replacement for high level, single chip, silicon integration but should be viewed as complementary to SoC. For some very high-volume applications SoC will be the preferred approach.
- System-on-Package (SoP)[5] goes one step beyond the other approaches in overcoming both the fundamental and integration shortcomings of SoC and SIP, which are limited by CMOS processing and the shortcomings of current packaging. While silicon technology is great for transistor density improvements from year to year, according to Moore's Law, it is not an optimal platform for system integration of RF, optical, and certain digital components, as stated above. The SoP is akin to Moore's Law for integrated circuits, integrating transistors: it integrates thin film components at microscale in the short term and nanoscale in the long run for mixed-signal electronic and bioelectronics systems.

Educational level (EQF): Trainings to be provided in EQF 7-8 and requires 1-5 year(s) of work experience.

[5] "Packaging: Past, Present and Future", Rao R. Tummala, *Endowed Chair, Professor & Director of NSF-ERC, Packaging Research Centre, Georgia, Institute of Technology, Atlanta, USA. ©2005 IEEE. 2005 6th International Conference on Electronic Packaging Technology.*

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Associated job profiles:

- System design engineer.
- Design engineer.
- SoC architects
- 3D systems architects

System designers now face new challenges due to the increasing complexity of semiconductor technologies. As traditional scaling slows, advancements like 3D integration, heterogeneous integration and chiplet-based architectures have emerged as solutions to continue enhancing performance, efficiency, and functionality. This has driven the creation of new specialized sub profiles within system design:

- Design-to-Technological Co-Optimization architect (DTCO): DTCO architects play a critical role in ensuring that chip designs are optimized for manufacturing technologies. They leverage new tools, such as advanced Electronic Design Automation (EDA) software and machine learning algorithms, to collect data from microelectronics fabrication steps and optimize design choices. By balancing performance, power consumption, and manufacturing constraints, DTCO architects help bridge the gap between design and process technology. These profiles emerged along with the trend of Design for Manufacturability (DFM).
- System-to-Technological Co-Optimization architect (STCO): The emergence of STCO architects reflects the industry's need for holistic optimization at the system level. STCO architects translate high-level system specifications into technological requirements. This role involves close collaboration with R&D teams and uses modelling tools and iterative design methods to ensure that system-level performance is achieved within the technological constraints of current or emerging fabrication processes.
- 3D Integrated System Architect: This role focuses on the high-level system partitioning and architectural design of 3D systems. The 3D Integrated System Architect determines how to best divide a system's functions across multiple chips and layers, considering different technology choices for interconnects, packaging, and integrated circuit (IC) technologies. This architect compares different system configurations, evaluating trade-offs between performance, cost, power, and thermal management. Their work involves the conceptual design of the 3D architecture and sub-block specifications, requiring expertise in simulation tools to analyse power, thermal, and signal integrity. Their primary responsibility is to ensure that the overall architecture of a 3D system delivers optimal performance by selecting the best possible technological solutions and design strategies.

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- 3D Physical Implementation Designer: While the 3D Integrated System Architect focuses on high-level system architecture, the 3D Physical Implementation Designer works at a lower level of abstraction, translating these architectural decisions into physical layouts. This role involves the detailed physical design of partitioned systems, specifically ensuring that the chosen chiplet system is successfully implemented in terms of inter-chip communication, thermal dissipation, power distribution, and signal integrity. The 3D Physical Implementation Designer uses specialized EDA tools to address the multi-physical challenges that arise from stacking chips, such as managing heat flow and ensuring robust interconnects between dies. Their focus is on practical implementation, ensuring that all physical and technological constraints are respected, and the system is manufacturable without compromising the performance targets set by the 3D Integrated System Architect.

The rise of new specialized roles reflects a global trend in the semiconductor industry, where traditional boundaries between design, system architecture, and technology development are increasingly blurred. System designers must now be proficient not only in circuit and system design but also in emerging technologies, advanced design tools, and multi-disciplinary integration strategies to meet the demands of rapidly evolving applications.

Content / sub-skills and sub-knowledge:

- Knowledge of systems architectures: system-on-chip and system-in-package. Interdisciplinary understanding of how the various system levels are interlinked and affect the overall performance.
- Understanding of the whole design and product life cycle.
- Ability to design ICs, ASICs, systems-on-chips, system-in-package and system-on-package, etc.
- Ability to optimize architectures.
- Ability to link and adapt design architectures to the end-using applications of systems (automotive, I4.0, etc.).

3) Knowledge of applications

Content / sub-skills and sub-knowledge:

- Ability to link and adapt technical aspects of a product (materials to use, design architecture, type of connectivity tools to integrate, etc.), to its end-user market(s) and application(s) (I4.0, automotive, etc.).

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- Knowledge of applications and associated technical requirements, to build solution-oriented products.

Illustrations:

A good knowledge of ADAS tools, other automotive developments or Industry 4.0 applications can be required for system engineer experts but also for software engineers.

A good knowledge of automotive applications and associated technical requirements is required for the development of magnetic sensors development for the automotive industry: Safety, standards, Requirement Management and Change & Configuration Management.

A material engineer needs to be able to link specific requirements on new materials with applications (e.g., high quality of images).

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

Associated job profiles:

- Application engineer.
- Materials engineer.
- System design engineer.
- Design engineer.
- Software engineer.
- Every profile in general

4) Hardware / Software integration

HW/SW integration is a skill depicted as very difficult to find and long to acquire (many years) by many stakeholders. Hardware and software co-design will become more and more important especially in line with the development of IoT and I4.0.

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

Associated job profiles:

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- System design engineer.
- Design engineer.
- Software engineers.

5) Knowledge of new materials

New materials are becoming increasingly important in microelectronics: polymers, shape-memory materials, composites, materials for additive manufacturing, garbitol, etc. Microelectronics engineers must have knowledge not just on traditional material engineering, but additionally on chemical and physical sciences (e.g., nanostructures).

<u>Educational level (EQF):</u> Trainings to be provided from EQF 7 to EQF 8.

These knowledge and skills are required for process engineers and especially material engineers and involve:

- A greater understanding of new semiconductor materials beyond silicon, such as gallium nitride (GaN) and silicon carbide (SiC), which are crucial for high-power and high-frequency devices.
- Physical-Chemical properties of new materials.
- Material compliance with EU regulations (for material engineers).

<u>The main skills and knowledge associated are:</u>

- <u>Knowledge of new materials</u>: polymers, shape-memory materials, composites, materials for additive manufacturing, garbitol, gallium nitride. etc. Understanding of material properties, and the need to modify the integration flow.
- <u>Knowledge in chemical and physical sciences</u> (e.g., nanostructures). Basic knowledge in chemistry (missing in many curricula).
- <u>Environmental awareness</u> associated to traditional and new materials.
- <u>Ability to link a material with production processes, product(s) specification(s) and end-user applications.</u>

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6) Data analysis

Data analysis skills and knowledge are increasingly required for nearly all profiles of the microelectronics industry today. Several companies report a lack of software engineers with good skills in data analysis.

<u>Educational level (EQF):</u> Trainings to be provided from EQF 4 to EQF 7. Every graduate at EQF 6-7 should have received initial training in this field.

<u>Associated job profile:</u>

- Nearly all profiles.
- Data driven profiles in general, which can provide support to direct semiconductor-related job profiles:
- Data analyst: provides statistical analysis and insights to different teams within the company, who can be mainly related to business aspects.
- Data scientists: leverage statistical/ data modelling to solve various manufacturing challenges. Often works in collaboration with expert profiles which provide the insights. Data scientists also have knowledge in machine learning.
- Data engineers: manages the data architecture within the semiconductor company, building the pipelines to make available any type of data for the different teams.

<u>Content / sub-skills and sub-knowledge:</u>

- <u>Data management</u>: SQL, Cloud-based knowledge, etc.
- <u>Data visualization</u>: Tableau, Power BI, Dash, etc.
- <u>Data integrity</u>: Ability to ensure integrity of data, particularly when using large volume of data. Knowledge of the techniques to assess the quality of data.
- <u>Data Security & Privacy by design</u>: Ability to ensure security of data & data privacy. Including IP protection.
- <u>Data analysis</u>: Ability to interpret and make sense of large volume of data.
- <u>Machine learning / Artificial intelligence</u>.
- <u>Algorithm optimization</u>. This skill is increasingly sought-after by industrials.

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- Performance Data Analysis: Analysing performance data.

7) Quality / reliability

Knowledge associated with quality / reliability (manufacturing quality control) is more and more needed by the microelectronics industry, especially to transfer prototypes into mass production. For instance, reliability and functional safety are two of the four main domains where increased skills are required for microelectronics engineers in line with the development of automotive electronics, with security and cost management (according to the focus group on automotive organized by METIS).

- Reliability: There is a strong focus on improving the reliability of components, systems, and designs, even equaling the drive for innovation itself. This makes system design increasingly challenging and requires advanced testing systems to assess the reliability of components. As a result, the roles of test technicians and engineers, along with their associated skills, are becoming more critical for microelectronics companies, particularly those serving the automotive, aeronautics, and defence sectors, where reliability is an important aspect.
- Functional Safety (Quality): Vehicle safety is an aspect linked to the improvement of reliability and led to the introduction of Functional Safety and the ISO 26262.

Educational level (EQF): Associated skills and knowledge must be acquired for graduates at EQF level 6 (and above depending on the profile).

Associated jobs:

- QA/ Reliability engineers
- System and design engineers
- Test technicians and engineers

The main skills and knowledge associated are:

- Basic knowledge on quality engineering.
- Quality assessments (skill): Knowledge of the methodology of quality (Quality 3.0 and 4.0), and ability to use Quality tools (including quality tools associated to I4.0).

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- Reliability analyses: Multidisciplinary knowledge in failure analyses, physics of failure.
- Robustness of microelectronics: Electromagnetic compatibility (EMC), electromagnetic interference (EMI), electrostatic discharge (ESD), aging, radiation hardness...
- Deep understanding of measurements and a physical sense of statistics.
- Analytical knowledge in reliability.
- Functional safety.

8) Analog design

Analog design is one of the skills, and related profile, for which the involved stakeholders are noticing the greatest shortage since its introduction. A progressive but very significant shortage has emerged in the industry during the past 20 years for this profile, due to the aging workforce and the lack of new graduates trained in analog design, as explained earlier. Even though there is the trend of digitalizing as fast as possible, there remains the complementary analog side, where there are too few experts available within every company.

The shortage is particularly high for the job profile as it takes a particularly long time to develop analog design skills and more than ten years to become good analog designer. This cannot only be done by education, but there are also many practical skills needed through experience.

Educational level (EQF): Trainings to be provided from EQF 6 to EQF 7.

Associated job profiles:

- Analog design engineers.
- Design engineers.

Content / sub-skills and sub-knowledge:

- Signal Processing: Proficient with analog and digital electronic design, noise, signal integrity, etc.

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9) Security

The cybersecurity knowledge and skills, increasingly required, span several areas:

- Cybersecurity-by-Design (especially for designers, test engineers, and software engineers): Security-by-Design focuses on embedding security features directly into hardware and software during the design phase, rather than retrofitting security measures later in the product lifecycle.
- Secure Connectivity: Expertise in designing and maintaining secure network infrastructures is essential, including proficiency in encryption, secure communication protocols, and vulnerability management in connected environments.
- Regulatory Compliance: Professionals must navigate evolving EU cybersecurity regulations that increasingly address hardware security. The EU Cybersecurity Act (effective June 27, 2019) establishes a certification framework for ICT products, including semiconductor hardware, requiring security to be integrated during design. The NIS2 Directive (effective by October 2024) expands cybersecurity requirements to include critical sectors like automotive and healthcare, where semiconductors play a key role. Additionally, the upcoming Cyber Resilience Act (expected to enter into force in 2025) focuses on ensuring high cybersecurity standards for products with digital elements, including hardware, throughout their lifecycle. Compliance with these frameworks is essential for ensuring the security and resilience of semiconductor systems used in critical applications.

Educational level (EQF): Trainings to be provided from EQF 6 to 7.

Associated job profiles:

- Experts in cybersecurity and IT technicians.
- Software engineers.
- Digital design engineers.
- System architects.
- Hardware/ software integration engineers
- Test engineer.

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Content / sub-skills and sub-knowledge:

- Combined knowledge between hard and software necessary.
- Security by design (Especially important for IoT and I4.0.): Know-how and applicability of secure protocols necessary.
- Skills used for cyber-physical (production) systems like diagram a network for security.
- Cybersecurity:
- Advanced intrusion detection and prevention.
- Advanced skills in forensics.
- Reverse engineering for the prevention of industrial spying (especially for test engineers).
- Ability to investigate the possible failures originated from improper use of malicious codes (highly for robotic engineers). Identify risks, issues, potential defects, or defects in any phase of the software life cycle, managing them through closure
- Data integrity: Ability to ensure integrity of data, particularly when using large volumes of data, and align with regulations.
- Data Security & Privacy by design: Ability to ensure security of data & data privacy. Including IP protection.
- Safety issues.

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