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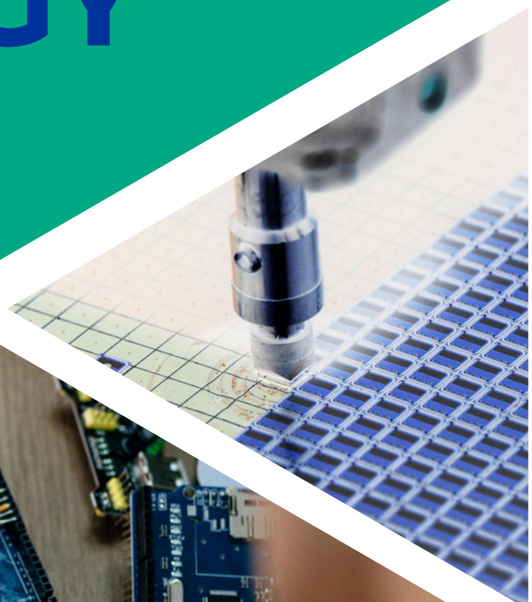

ADDRESSING THE TALENT GAP IN THE EU SEMICONDUCTOR ECOSYSTEM

Written by:
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EXECUTIVE SUMMARY

Employment and skills dynamics in the semiconductor sector closely mirror European semiconductor production and global market trends. The market experienced robust growth of 10 % CAGR from 2016 to 2022 but faced a downturn in 2023 due to market cyclicality and economic pressures. Recovery is expected in 2024, driven by stabilization in the PC, smartphone, and data centre markets. Long-term growth is forecasted by 2030. In response to this projected strong demand, the EU Chips Act is driving major investments, which should increase production capacity on EU soil by 70% by 2030, despite potential delays in planned projects.

The quantitative analysis of workforce needs suggests that employment growth is expected to accelerate significantly in line with the projected surge in demand and production. In 2023, the European semiconductor industry employed approximately 382,200 people. Of these, around 263,000 worked directly in semiconductor production or design, with the rest involved in equipment and material supply, design software, and research. Employment in the sector is highly concentrated, with the top 25 employers accounting for 40% of the workforce. Most jobs are technical, such as technicians, hardware engineers, software engineers, and data specialists. The projected production growth could lead to a significant employment growth of 5,0 % CAGR by 2030, potentially adding 155,900 new jobs by 2030, despite the rapid pace of automation -especially in back-end activities. Alongside replacement hires, this could result in 271,400 job openings, primarily in core technical roles.

At the same time, it is expected that the number of graduates entering the EU semiconductor industry will not accelerate significantly. The European Union ranks third globally in producing STEM graduates, with 1.13 million in 2022, ahead of the U.S. but behind China and India. Of these graduates, around 320,000 (28%) specialize in semiconductor-related fields. Despite this large pool, the EU semiconductor industry struggles to retain talent. Approximately 10 % of graduates in semiconductor-related fields of study opt to work outside the EU. Of these, only 6 % will specifically join the EU semiconductor industry. The number of semiconductor-related graduates has remained stagnant in recent years, even as the broader STEM field has seen growth. Projections suggest that the supply of graduates entering the semiconductor industry will grow modestly by 2030 (1% CAGR), limited by slow enrolment growth and demographic trends.

Consequently, the current talent gap in the EU semiconductor industry is expected to widen annually by 2030. The semiconductor industry already faces a significant labor shortage, with an increasing number of job openings and a stable number of graduates, resulting in an average of 3,830 unfilled positions annually between

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2021 and 2023. To fill this gap, companies rely on non-European workers. While employment is expected to grow at a 5% CAGR by 2030, the supply of graduates is only projected to increase by 1%, leading to a talent shortage of 75,390 positions by 2030. This shortfall will affect hardware engineers, technicians, and ICT professionals (software engineers, and data specialists).

As with industrial policies, the implementation of a skills strategy to address this talent shortage is a long-term process, primarily because cultivating a new generation of graduates takes considerable time, necessitating both short-term and long-term responses. A number of recommendations were made by respondents to the survey or derived from the quantitative analysis. **In the short term**, addressing immediate skill shortages is essential by optimizing the labour supply through measures such as upskilling and reskilling through lifelong learning programs, particularly enhancing adult learning and continuing vocational education and training (cVET). Facilitating intra-EU labor migration can help address the gap, as over a third of EU semiconductor-related graduates are in countries without significant industry, which demands harmonizing skills certifications and regulated professions systems across Member States.

Attracting more highly skilled workers from outside the EU by simplifying visa processes, streamlining immigration, and offering scholarships in semiconductor fields is also crucial. Additionally, retaining local talent by reducing post-study emigration through initiatives like student placements and incentives could decrease the talent gap by 20%. **In the long-term**, addressing industry needs involves expanding academic and initial vocational education and training programs (iVET) in targeted fields. Curricula must be adapted to integrate transversal and interdisciplinary skills, and international experience. Communication campaign should be conducted to promote the semiconductor industry in targeted fields, focusing on attracting students to semiconductor-related fields and encouraging graduates to enter the industry. Enhancing employment and graduate data is crucial for informing better investment and policy decisions, making it an essential step in addressing the talent gap effectively.

In addition to these cross-cutting measures, certain professions need customized strategies tailored to their specific skill requirements:

Addressing the ICT talent shortage through a focus on attracting existing graduates and workforce to the semiconductor industry. By 2030, the EU semiconductor industry will face a shortage of 12,500 ICT professionals, including software engineers, machine learning engineers, data engineers, data analysts, and data scientists. However, these profiles are already well-represented in the EU job market, and EU universities are

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expanding their capacity to train these future professionals. The solution to this talent gap does not lie in further expanding training programs but in attracting the existing workforce to the semiconductor sector. This can be achieved through communication campaigns promoting the semiconductor industry and offering competitive wages and working conditions to incentivize career shifts.

Tackling the shortage of system designers, analog designers, and cybersecurity experts by establishing specialized training hubs across the EU. The EU semiconductor industry also faces a significant shortage of 3,800 system designers, 2,400 analog designers, and 3,000 cybersecurity experts. Unlike the ICT roles and even other semiconductor roles, these profiles require highly specific training -from Bachelor's to Master's degrees- followed by significant work experience. Currently, very few training programs in the EU cater to these specialized roles, creating a critical gap between industry needs and available talent. Moreover, relying on foreign workers is not a viable solution due to global shortages of these profiles. Therefore, establishing specialized training hubs across the EU will be essential to address this skills gap effectively.

Closing the Gap in Electrical and Electronic Engineering Talent by expanding training programs as well as attracting more graduates in this field. By 2030, the EU semiconductor industry will need 54,000 professionals with electrical engineering degrees to fill positions in manufacturing, design, and testing of semiconductors, and other engineering roles. To address this talent gap, the EU must increase the number of electrical engineering graduates interested in the semiconductor sector. Two key actions are needed: (1) expanding Bachelor's and Master's programs in electrical engineering and (2) launching communication campaigns to encourage students to pursue careers in this field. Additionally, short-term solutions like facilitating intra-EU migration could be beneficial. Countries like Spain, Romania, Greece, Bulgaria, and Croatia have a surplus of electrical engineering graduates relative to their semiconductor ecosystems. Extra-EU migration could also help, especially from regions like India to meet design and testing needs.

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INTRODUCTION – ECSA WORK PACKAGE 3

ECS ACADEMY

ECS-Academy's is an initiator of a large-scale and durable endeavour that will foster innovation and resilience of the microelectronics sector. It will bridge the gap between education, training, and industry to tackle Europe's skills and talent shortages. ECS-Academy will 1) implement and operationalise the Pact for Skills 2) establish the first-of-a-kind decentralised academy for microelectronics, linking industry, research, HE and VET currently operating in isolation 3) develop innovative training and curriculum to provide reactive and proactive response to the skills needs of the sector.

ECS-Academy is a robust Alliance, with 18 partners, 30+ organisations endorsing the project, and covering the whole of the EU Educational Area. The consortium represents the value chain of microelectronics and the full spectrum of education and training. The consortium will reach 984,706 direct contacts in valorisation activities.

WORK PACKAGE 3 (WP3)

Among all the seven ECS-Academy's working packages, WP3 – "European Chips Skills Academy: Skills Anticipation, Skills Strategy and Educational Programme" develops, initiates the implementation of the ECS-Academy through the Pact for Skills and validates in real operational settings the decentralised pan-European Academy for the microelectronics sector and ecosystem.

The objective of WP3 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 decentralised 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. European Chips Skills Academy: Skills Anticipation, Skills Strategy and Educational Programme (WP3) will lead to 6 main deliverables:

- D3.1 "Skills Anticipation Methodology" develops the common methodology to assess, anticipate, monitor evolution of Microelectronics with a focus on skills and competences.
- D3.2 "Skills Strategy" frames the scope of microelectronics from microelectronics to end-user systems, assesses qualitative needs of EU microelectronics from early stages of the microelectronics value chain

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to microelectronics skills required in end-user industries, and assesses quantitative needs of EU microelectronics.

- D3.3 "ECS-Academy institutional arrangements (governance and functioning)" defines institutional arrangements (governance and functioning) of the ECS-Academy. Partners define overarching model of the decentralised academy, describing its governance and defining the operational and implementation aspects.
- D3.4 "ECS-Academy Operational Features and Tools" defines all the core elements of the decentralised Academy from an academic/pedagogical/ operational perspective.
- D3.5 "ECS-Academy Educational and Pedagogical Aspects" relies upon the results of WP2, Skills Anticipation Mechanisms and Skills Strategy to gauge the evolving nature of jobs in microelectronics and inform the ECS-Academy curricula and teaching/learning methods. Another key element of T3.3 is to develop and update microelectronics ESCO profiles
- D3.6 "ECS-Academy Implementation and Validation Plan" establishes the ECS-Academy and implement the Pact for Skills for microelectronics and chips.

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

OBJECTIVE

In D3.1 partners develop the common methodology to assess, anticipate, monitor evolution of Microelectronics with a focus on skills and competences 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;
- 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.

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This methodology will then be used by the Secretariat, the Board, the Pact for Skills and the Partners to produce the Microelectronics Skills Strategy produced yearly and that will culminate into the long-term action plan, with clear recommendations for the operational features and especially for the programme of the Academy to address the skills needs.

SCOPE

The sectoral scope of 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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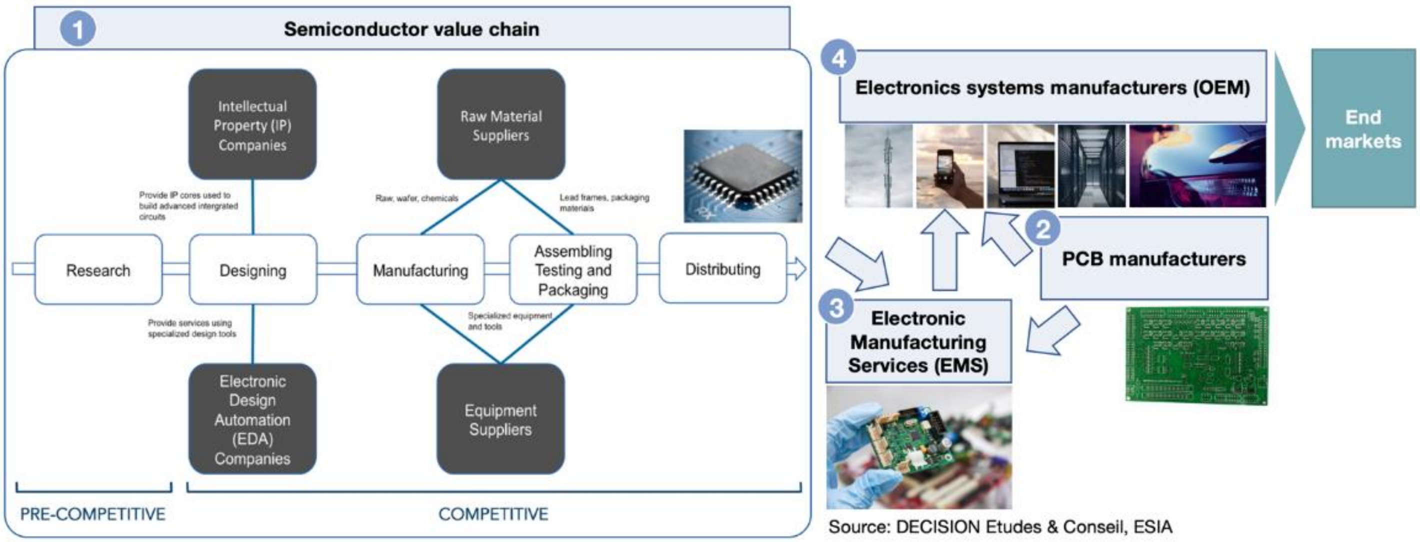
Figure 1: The semiconductor value-chain



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INTRODUCTION: MAPPING THE EU SEMICONDUCTOR VALUE CHAIN

The employment and skills dynamics within the semiconductor sector closely align with the European semiconductor production trends. Consequently, this chapter provides a concise overview of the EU semiconductor ecosystem, covering aspects related to production, demand, and economic outlook up to 2030.

THE SEMICONDUCTOR INDUSTRY IN THE EU

The European Union (EU) hosts to a number of leading companies in the global semiconductor industry. Notably, the EU is the base for three significant European integrated device manufacturers (IDMs): STMicroelectronics, Infineon and NXP. In addition to these European IDMs, the EU also benefits from the presence on its territory of a number of major foreign IDMs, including Intel, ON SEMI and Samsung. The contribution of pure-play foundries to the European ecosystem remains limited, despite the presence of the European XFab and the American GlobalFoundries. The EU also hosts to some of the largest and most prominent fabless companies, including the European Melexis and the American Qualcomm and Nvidia. Furthermore, ASML, the global leader in photolithography, has a strong presence within the EU. The EU benefits from a comprehensive ecosystem surrounding ASML, including organisations such as TNO, Trumpf and Carl Zeiss. The EU also hosts to three leading research and technology organisations (RTOs): IMEC, CEA-Leti and Fraunhofer. Soitec, a leading producer of epitaxial wafers, is leveraging its technological leadership in FD-SOI.

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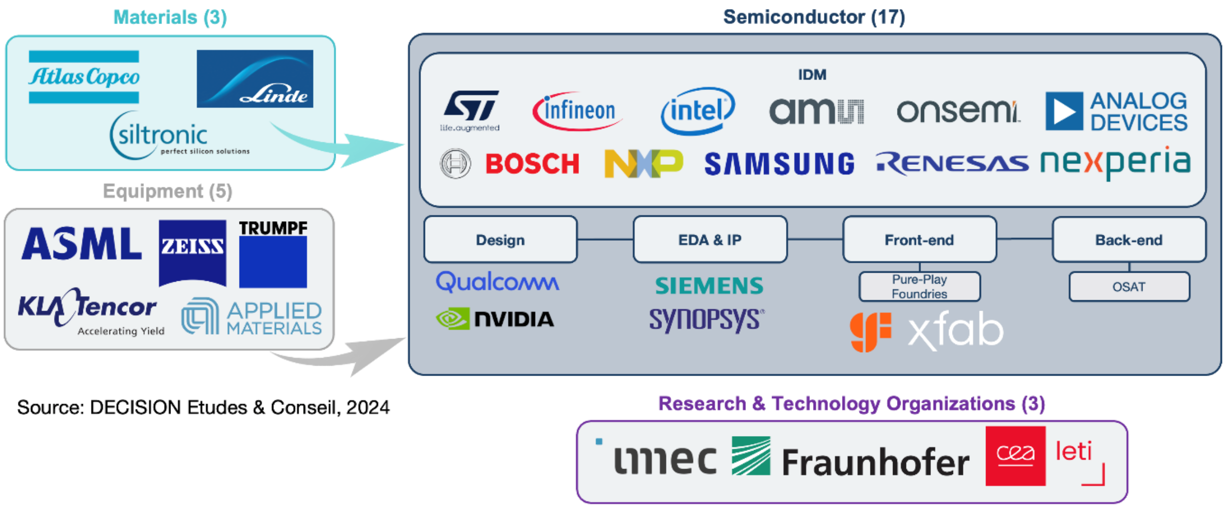
Figure 2: The TOP 28 employers on EU soil across the semiconductor value chain

These are the 28 organizations which employs 2000 persons or more on EU soil in semiconductor topics.



In terms of end- markets, European suppliers are the 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. In terms of global market share, EU companies hold 34% of the automotive semiconductor market. Additionally, the EU holds 27% of the global market in chip production for embedded systems in the automotive sector, 22% of production for aerospace, defence and security, and 20% of production for industrial and robotics.

RECENT DEVELOPMENT OF THE GLOBAL SEMICONDUCTOR MARKET

The semiconductor market has experienced significant growth in recent years driven by the growing demand for cutting-edge technology that relies on semiconductors across all sectors of the economy. From 2016 to 2022 the compound annual growth rate for the total semiconductor market was an impressive 10,1 %[1]. This period witnessed significant expansion, including a surge in DRAM and flash memory markets in 2017 and 2018, as well as strong post-COVID recovery in 2020 and 2022.

[1] Sources : WSTS historical sales converted in euro.

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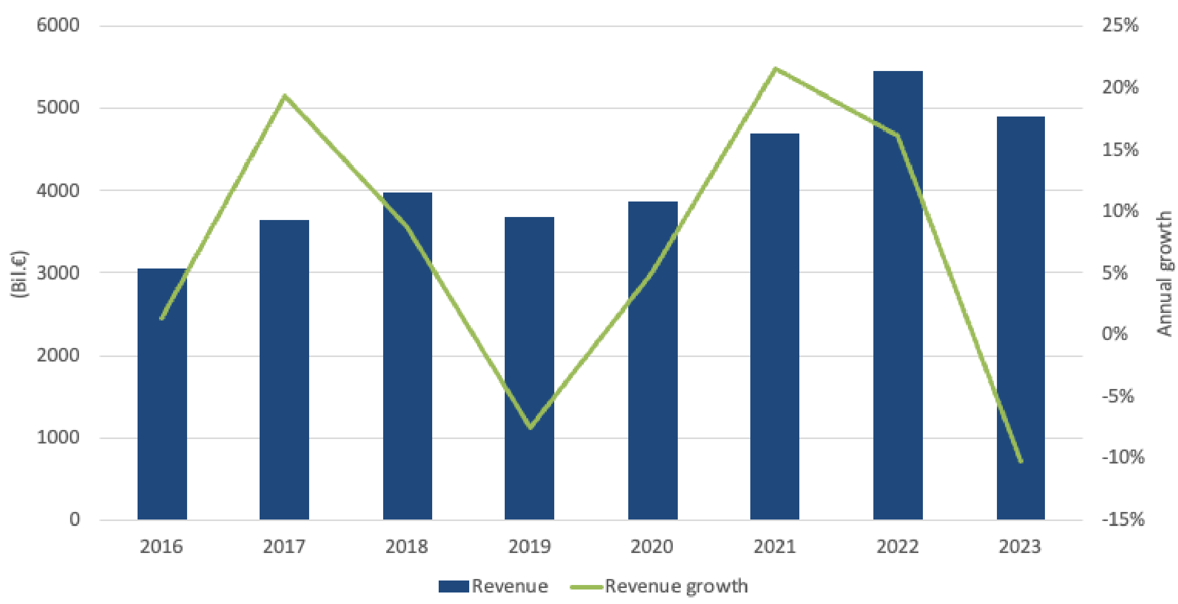
The semiconductor industry faced a substantial revenue decline in 2023, but there are signs of recovery. Market cyclicality played a crucial role in this downturn. The industry goes through periodic cycles of growth and decline, and 2023 was no exception. As is often the case, the memory chip market was the most volatile, explaining the 10.2 % decline in the market in 2023. Demand for DRAM and NAND flash memory weakened considerably, especially in smartphones, PCs, and servers, while the logic, analog and discrete markets have remained relatively flat. Beyond cyclical factors, the global economic downturn placed pressure on consumer disposable income, which in turn affected spending on electronic products such as PCs and smartphones where sales began falling in early 2022.

Figure 3: World semiconductor industry revenue



Source: WSTS

However, the global semiconductor market experienced a turnaround in the second quarter of 2023. The market grew by 6 % compared to the first quarter of 2023, marking the first positive quarter-to-quarter change since the fourth quarter of 2021. Global semiconductor sales demonstrated continued growth throughout the remainder of the year, reflecting a gradual recovery within the industry.

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THE ECONOMIC OUTLOOK

Although faced with challenging market conditions in 2023, the market is projected to rebound in 2024. Anticipated factors driving this recovery include the stabilization of PC, smartphone, and general-purpose data centre markets. While industrial outlook weakens, positive unit growth is expected for PCs and smartphones after two years of decline post-2021 peak due to pandemic impact. Furthermore, these markets were the first to reach normalised inventory levels since they were the first to correct post-Covid. Additionally, cloud data centre revenues are set to grow as enterprise confidence in the macroeconomic landscape returns. Cloud computing companies have also absorbed substantial inventory and now need to reinvest to meet robust demand. In the first quarter of 2024, the market demonstrated a growth rate of 17,8 % compared to the same quarter of the previous year. Projections indicate that the market will continue to expand, with an anticipated growth rate of 16 % in 2024[2]. These forecasts have been revised upwards, reflecting stronger-than-anticipated performance in the third quarter of 2023 and the first quarter of 2024, particularly in computing end-markets.

In the longer perspective, the market is projected to experience robust growth in all major end-use market by 2030. Anticipated compound annual growth rate (CAGR) stands at 6 %, with a forecasted value of €866 billion by 2030. Historically, Information & Communication Technologies (ICT) has been the largest end-market in value for the semiconductor industry.

[2] Sources : WSTS forecasts (June 2024)

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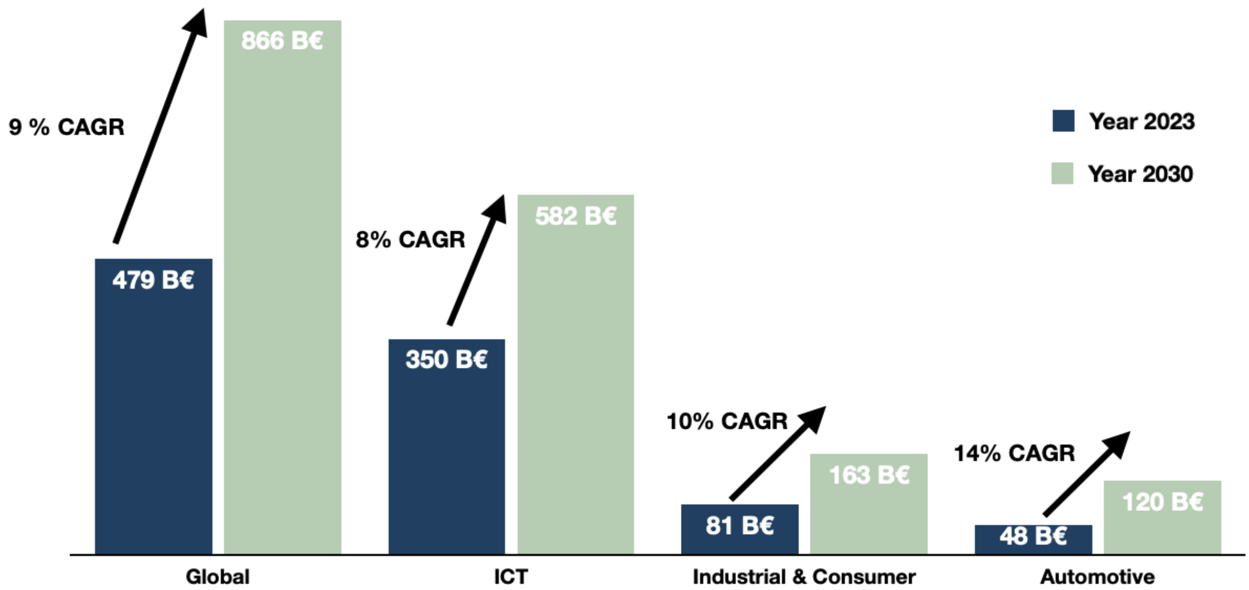
Figure 4: Evolution of key end-markets by 2030



Source: DECISION Etudes & Conseil, WSTS

This trend will likely continue, as ICT still represents the highest growth prospects in absolute terms with a growth of annual sales of +232B€ from 2023 to 2030, driven by the exploding computing and storage demand due to generative AI, 5G/6G and edge computing developments. The greatest growth is however expected in the automotive sector, where the semiconductor market is forecasted to reach €120 billion in 2030 (with a CAGR of 14 % from 2023). The key drivers of automotive semiconductors through the end of the decade are electric vehicles (EVs), driver-assistance systems, autonomous-driving, and infotainment systems.

In response to the projected surge in demand, production in the semiconductor sector is forecasted to increase significantly over the next few years, supported by continued investment growth. While most investment remains concentrated in Asia and the United States, there has been a noticeable uptick in funding for European projects as well. Thanks to the adoption of the EU Chips Act, several semiconductor industry projects have already been initiated all over the EU (see the map below). The most important investments include Intel's foundry in Germany (17 B€) and Ireland (12 B€), TSMC's joint venture with Bosch, NXP, and Infineon in Germany (more than 10 B€), and STMicroelectronics' co-investment with GF in France (7.5 B€). Infineon has also begun the construction of a €5 billion chip plant in Germany while STMicroelectronics plans to open a new megafab in Italy (5B€). Bosch also plans to invest €3 billion through 2026 to expand semiconductor

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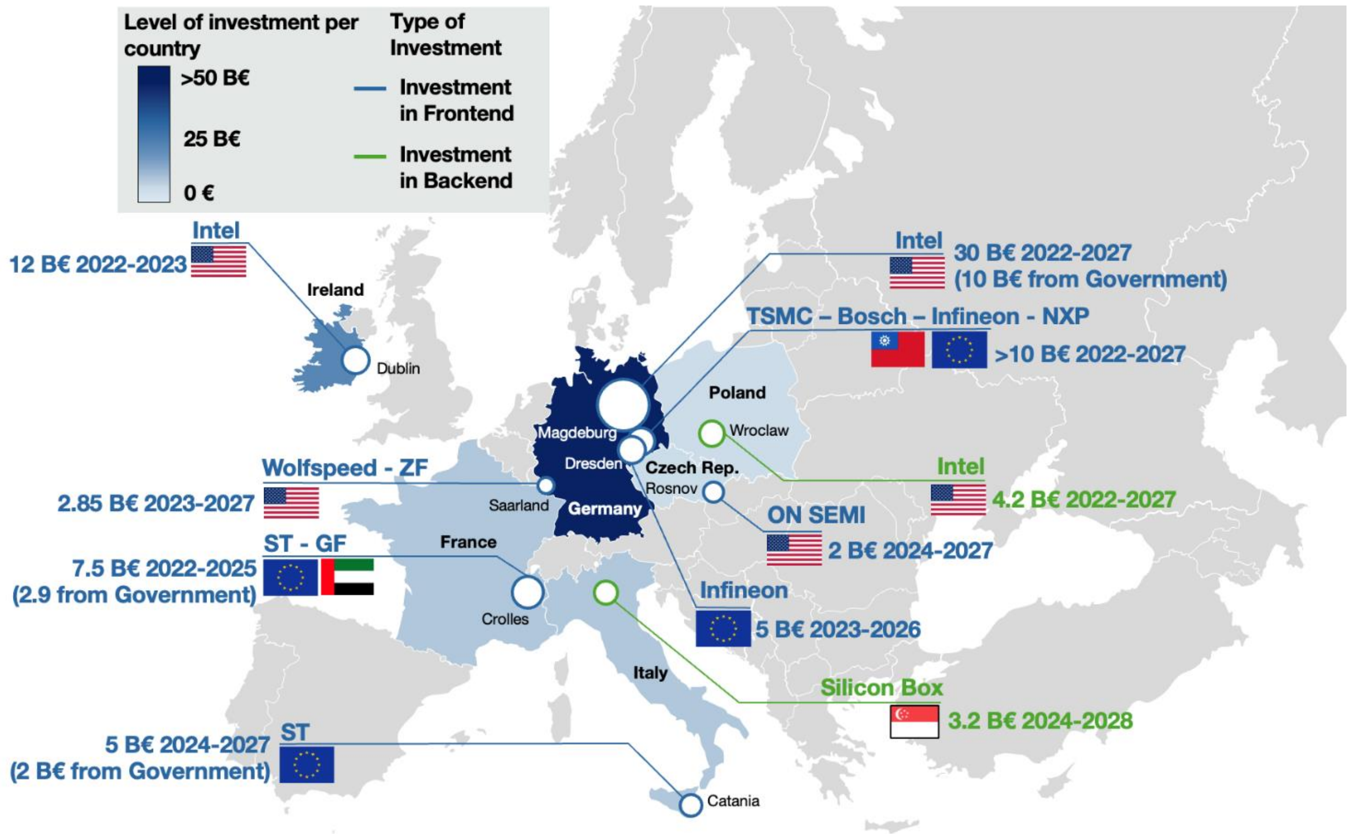
production, aligning with the EU's IPCEI funding program. It is expected that more projects will move forward as EU Chips Act funding continues to flow. Strategically allocated investments across EU production infrastructure are poised to yield substantial benefits in the coming years. By bolstering production capacity through targeted capital expenditures and considering robust demand projections, a transformative impact is anticipated, that could result in 70 % growth in semiconductors production volume by 2030[3].

Figure 5: Ongoing investment plans in semiconductor in the EU, November 2023



Source: DECISION Etudes & Conseil

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[3] Production forecast is estimated based on SEMI's latest forecasts (June 2024) of installed production capacity for the period 2024-2027 (Installed capacity in 200mm equivalent wafers per month at end of each year).

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The semiconductor industry is exposed to a number of economic and geopolitical risks surrounding this economic outlook. When considering production growth forecasts, a key risk factor is the potential for delays in planned investments across the EU. Notably, some projects have already experienced setbacks. For instance, Intel's chip fabrication facility in Germany and Poland, originally scheduled for completion in summer 2024, has been postponed by approximately two years due to weaker than expected anticipated demand. Similarly, Wolfspeed's 8-inch SiC fabrication plant in Ensdorf, Saarland, initially planned for construction in summer 2024, has been delayed until 2025. The trajectory of investment trends in the semiconductor industry will also be influenced by interest rate developments. While the European Central Bank's key interest rates reached their peak in 2023 and are projected to gradually decline over the next few years, uncertainty surrounds the future path of interest rates. This trajectory hinges on the assumption that inflation will gradually return to the targeted 2% level set by central banks. However, several factors could potentially impede or reverse the downward trend in inflation.

Regarding market growth forecasts, the primary risk lies in the uncertainty surrounding demand recovery. Growth forecasts for the PC and smartphone markets in 2024 rely on a global consumption rebound, driven by reduced inflation and improved household purchasing power. Nonetheless, additional factors are likely to affect consumption, notably in China, due to the crisis in the property market, and in the United States with the expected depletion of pandemic-related excess savings. The semiconductor market also continues to face significant geopolitical risk as a result of ongoing tensions between the United States and China. It is anticipated that the United States will implement further policies and export control measures directed at China, which could have a detrimental impact on both Western suppliers that have a considerable revenue exposure to China, including EU companies such as ASML, and Chinese technology companies that rely on Western suppliers. In particular, there is a likelihood of increased restrictions and penalties if China progresses with advanced chip production utilising foreign equipment and materials.

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QUANTITATIVE ANALYSIS : ESTIMATING THE TALENT GAP

JOB DEMAND

In 2023, the European semiconductor industry boasted a robust workforce of approximately 382,200 employees[4]. In this regard, the European semiconductor sector represents a significant source of employment, although it remains a relatively minor contributor to the overall economy, accounting for less than 1% of EU manufacturing jobs. Among the semiconductor workforce, around 263,000 individuals were directly involved in semiconductor production, either manufacturing chips at integrated device manufacturers (IDM) like Infineon or pure-play foundries such as XFab or designing semiconductors in fabless companies like Melexis. Additionally, certain employees of Original Equipment Manufacturers (OEMs) like Valeo or Philips, Electronics Manufacturing Services (EMS) like Zollner or Scanfill, Printed Circuit Boards (PCB) Companies like Schweizer Electronic, along with end-users in the automotive (e.g., Stellantis), industrial equipment, and aerospace/defense/security sectors, are occasionally engaged in semiconductor manufacturing or more commonly in semiconductor design. Apart from those directly involved in semiconductor production, approximately 61,000 people worked in companies supplying equipment for semiconductor fabrication (e.g., ASML), 27,100 in material supply (industrial gases, process chemicals, and metals), and wafers such as Air Liquide and Siltronic. Another 11,340 employees specialized in developing design software (EDA) and Intellectual Property (IP) at firms like Synopsys, while the remaining workforce of 19,760 was employed in research and technology organizations (RTOs) like IMEC.

[4] All employment figures included in this section cover both payroll and temporary employees.

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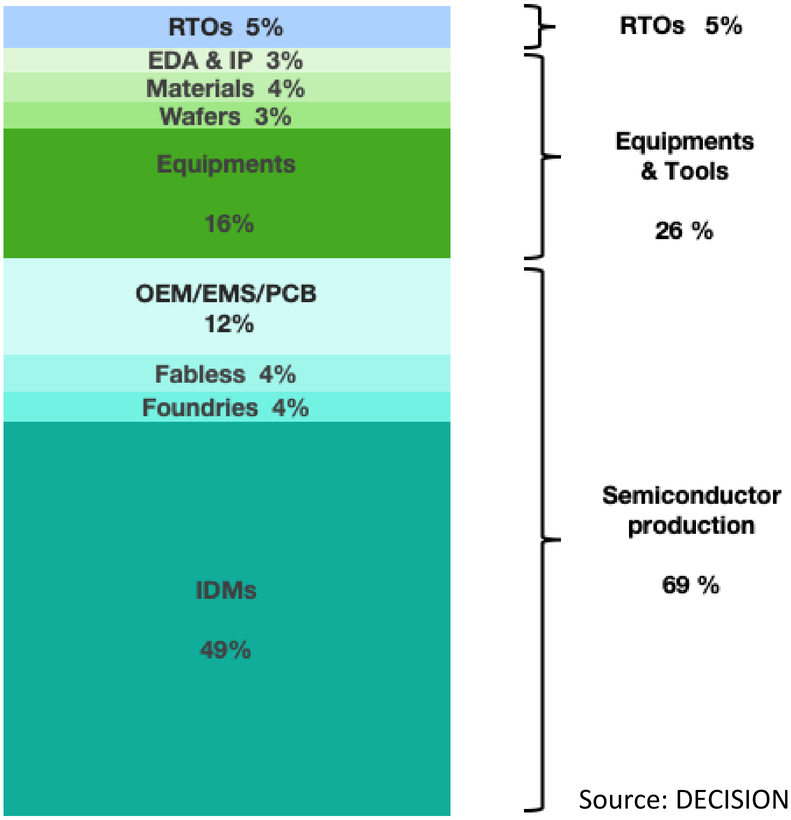
Figure 6: "Core technical workforce" in the EU semiconductor industry, 2023



Source: DECISION Etudes & Conseil

Employment in the semiconductor industry exhibits a pronounced concentration, with the top 25 employers collectively hiring over 150,000 individuals in the EU, equivalent to approximately 40% of the industry's total workforce. Nearly half of these leading employers operate as Integrated Device Manufacturers (IDMs). ST Microelectronics and Infineon emerge as the dominant players, representing the top two employers in the semiconductor industry and jointly contributing more than 14% to the overall employment figures. Meanwhile, Intel and AMS-OSRAM secure their positions as the fourth and fifth largest employers in the sector. Beyond IDMs, the second largest group of leading employers are equipment manufacturers. ASML, a key player in this segment, ranks as the third largest employer across the semiconductor value chain, employing 6% of the total workforce. Over the past 15 years, ASML has doubled the size of its EU workforce, representing the most substantial growth across the Union. Additionally, Carl Zeiss features prominently in this category. The equipment segment is the most concentrated, with ASML alone accounting for over two-thirds of employment in the segment.

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Table 1: Top 25 employers in the EU semiconductor value chain in 2023

Rank	Name	Value chain	Employees	% total	% Value chain
1	ST	IDM	25,118	8,0%	14%
2	Infineon	IDM	21,182	6,4%	11%
3	ASML	Equipment	21,072	6,3%	35%
4	intel	IDM	8,018	3,4%	4%
5	ams	IDM	6,600	2,8%	4%
6	ZEISS	Equipment	5,841	2,7%	10%
7	BOSCH	IDM	5,729	2,6%	3%
8	NXP	IDM	5,696	2,3%	3%
9	imec	RTO	5,364	2,0%	27%
10	Fraunhofer	RTO	4,933	2,0%	25%
11	Qualcomm	Fabless	4,146	1,9%	25%
12	onsemi	IDM	3,480	1,9%	2%
13	SAMSUNG	IDM	3,372	1,9%	2%
14	Atlas Copco	Material	3,355	1,8%	23%
15	GF	Foundry	3,297	1,6%	23%
16	Linde	Material	3,216	1,4%	22%
17	SIEMENS	IP & IDA	2,858	1,2%	25%
18	siltronic	Wafers	2,702	1,1%	22%
19	xfab	Foundry	2,635	1,1%	18%
20	TRUMPF	Equipment	2,565	1,1%	4%
21	KLA Tencor	Equipment	2,537	0,9%	4%
22	ANALOG DEVICES	IDM	2,421	0,9%	1%
23	RENESAS	IDM	2,282	0,8%	1%
24	NVIDIA	Fabless	2,258	0,8%	13%
25	synopsys	IP & EDA	2,164	0,8%	19%
	TOTAL		**152,842**	**40%**	

Source: DECISION Etudes & Conseil

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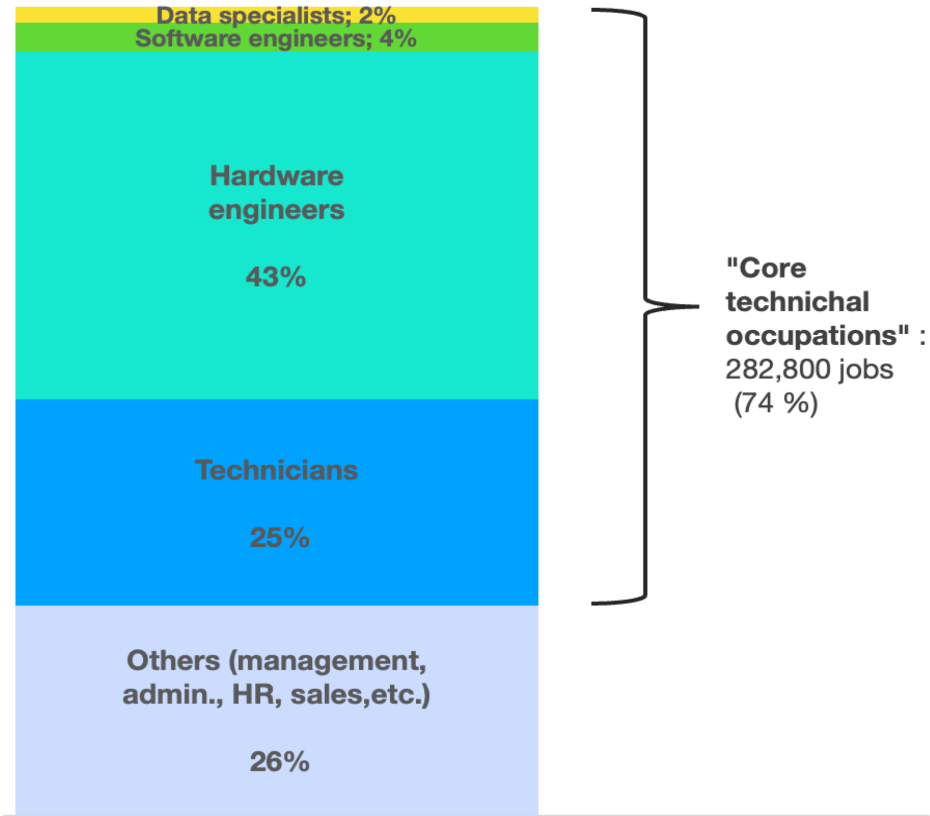
The semiconductor workforce is mainly composed of core technical occupations, accounting for more than three-quarters of the total employment. Recent research has identified more than 21 different technical roles in the semiconductor sector[5]. These roles spanned technicians (approximately 97,200 employees) who operate and troubleshoot equipment used in semiconductor component manufacturing, hardware engineers (around 164,400 employees) engaged in research and enhancement of semiconductor devices and fabrication processes, software engineers (approximately 13,900 employees) designing and developing software solutions and computer systems for semiconductor-based technologies, and data specialists (about 7,300 employees) leveraging data generated during the whole IC design flow to improve efficiency [6]. Additionally, supporting roles, such as management, administration, human resources, and sales, account for the remaining one-fourth of the workforce. The proportion of each occupation in the total workforce varies significantly depending on the specific segment

Figure 7: "Core technical workforce" in the EU semiconductor industry, 2023



Source: DECISION Etudes & Conseil

[5] DECISION (2021), "Skills and Occupational Profiles for Microelectronics", METIS project.

[6] See Annex 1 for an overview of the distribution of detailed technical roles across the four main categories of occupation.

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concerned within the semiconductor ecosystem[7]. For instance, technicians constitute a larger proportion of the technical workforce in foundries, while in RTOs (Research and Technology Organizations), the proportion of technicians is lower. Similarly, software engineers are more prevalent in Electronic Design Automation (EDA) companies compared to other segments.

Employment in the semiconductor sector has grown significantly in recent years, despite a slowdown in 2023. Even before the implementation of the EU Chips Act, the EU semiconductor workforce has been growing steadily, with 3 % CAGR between 2016 and 2021. The demand for semiconductors in the main end-user markets (ICT, industrials & consumer, automotive, etc.) and the resulting production growth have driven this expansion. Following a peak in 2022 with a growth rate of +7.3 %, the workforce experienced a slowdown in 2023 due to the market downturn. Notably, while employment decelerated during that year, it did not decline as global sales did. Among the top employers that experienced a slowdown in employment growth in 2023 and managed to avoid outright declines, notable examples include STMicroelectronics (+ 2.3% increase compared to 6% in 2022), Infineon (+ 8.4% compared to 9.8%) and ASML (+ 10.1% compared to an impressive + 23.4% last year). However, the overall landscape remains varied, as certain employers faced employment reductions. For instance, Intel witnessed a decline of 5 %, while AMS Osram experienced a more substantial decrease of 13.1 %. One reason for the relative preservation of employment is that the sharp drop in 2023 sales is mainly concentrated in IC memory for PCs, smartphones and servers, while European suppliers are more in the lead in 'embedded systems'. Another reason may be the incentives so far expected from the EU Chips Act. Finally, it should be noted that despite the positive trend in recent years, employment growth in the semiconductor sector has remained below the growth rate for the EU manufacturing industry as a whole (+4.3% CAGR between 2016 and 2021).

Of interest is the observation that the United States experienced a comparable trend in employment over the same period[8]. There was a moderate growth in employment in the semiconductor sector between 2016 and

---

[7] The distribution of the four main occupations within each specific segment was calculated based on data provided by the human resources departments of major companies in those segments. These figures were then aggregated globally.

[8] Comparisons with US employment figures should be made with caution. The semiconductor manufacturing sector in the EU is defined by NACE code 2611, which is not an exact match for NAICS code 334413 in the US nomenclature.

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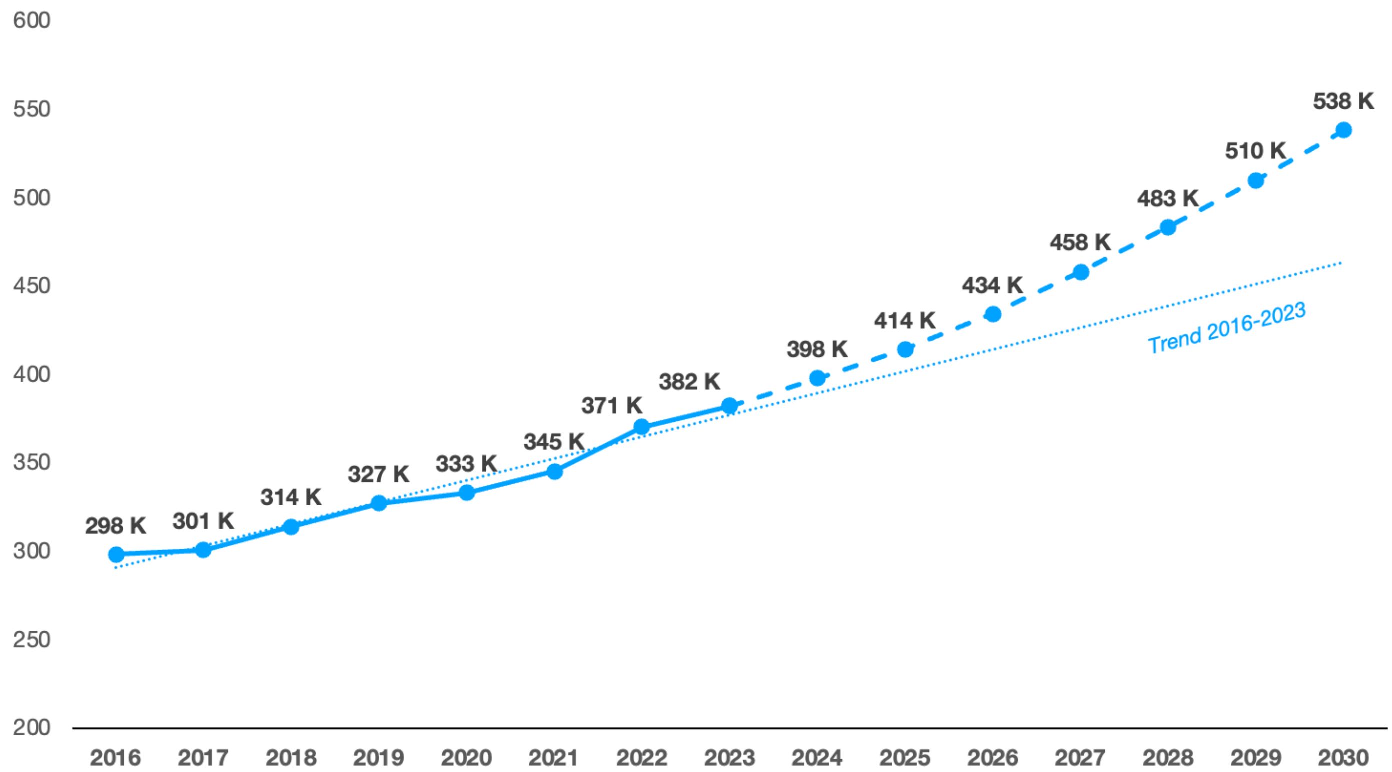
2021, followed by a sharp rise in 2022. In 2023, there was a slowdown but no decline, with the number of jobs in the manufacturing segment reaching approximately 203,000 jobs[9].

Figure 8: Workforce in the EU semiconductor industry



Source: DECISION Etudes & Conseil

Over the next few years, employment growth is expected to accelerate significantly in line with the projected surge in demand and production. The projected robust production growth (see 5.1.2) could lead to significant employment growth of 5,0 % CAGR by 2030, despite the significant ongoing rapid pace of automation in the

[9] See “U.S Semiconductor Jobs are Making a Comeback”, The White House, March 20, 2024

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semiconductor industry, especially in back-end activities[10]. After experiencing a slowdown in 2023, employment growth is anticipated to rebound in 2024 and 2025, reaching average levels observed in recent years. Employment growth is then projected to accelerate significantly in 2026 and 2027, maintaining a robust pace until the end of the forecast period[11]. This growth trajectory could result in the creation of approximately 155,900 new jobs over this period across all segments of the value chain. In addition to these new jobs, the semiconductor industry will require the hiring of replacement workers (around 115,500 workers) between 2024 and 2030 to accommodate for the natural turnover of the existing workforce[12]. In total, this will result in an estimated 271,400 new job openings (new and replacement jobs) over the period, 76 % of which will be in the core technical workforce (technicians, hardware engineers, software engineers, data specialists). Of the 206,700 new job openings planned for the core technical workforce, it is estimated that 69,000 will be technicians, 116,730 hardware engineers and 20,970 software engineers and data specialists.

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[10] See for example Challenges and Strategies to achieve full automation in semiconductor assembly and test, SEMI and the robust projected growth in the global semiconductor robotic automation market. Our projections incorporate the influence of technological progress by assuming an annual increase in labour productivity of 0.9% throughout the forecast horizon. This aligns with the observed trend from 2015 to 2019 within the EU (see European Economic Forecast, Spring 2024). We exclude the years 2020 and 2021 due to the distorting effects of COVID-related employment support measures on productivity metrics. Empirical research shows that a 10% increase in productivity results in a 1% decrease in employment (see for example OECD policy papers). In the long term, higher productivity allows firms to increase competitiveness, expand output, employment and wages. However, in the short term, it reduces the number of workers needed to produce a given amount of output, which may reduce the demand for labour (For a discussion, see for example ECB Forum on central banking).

[11] Employment forecasts are estimated based on SEMI's latest forecasts (June 2024) of installed production capacity for the period 2024-2027 (Installed capacity in 200mm equivalent wafers per month at end of each year). SEMI's forecasts of installed capacity are based on information provided by SEMI members regarding current approved investment projects and implementation dates. Employment elasticity, e.g. the percentage change in employment associated with a 1 % increase in installed capacity, is estimated using historical employment data from DECISION database and historical installed capacity data from SEMI.

[12] The replacement rate is calculated using the Cedefop's 'Skills forecast database. The 4% replacement rate derived from this calculation is aligned with the 'Rate of staff departure' reported in the companies' sustainability reports. (See, for instance, the Infineon Sustainability Report.)

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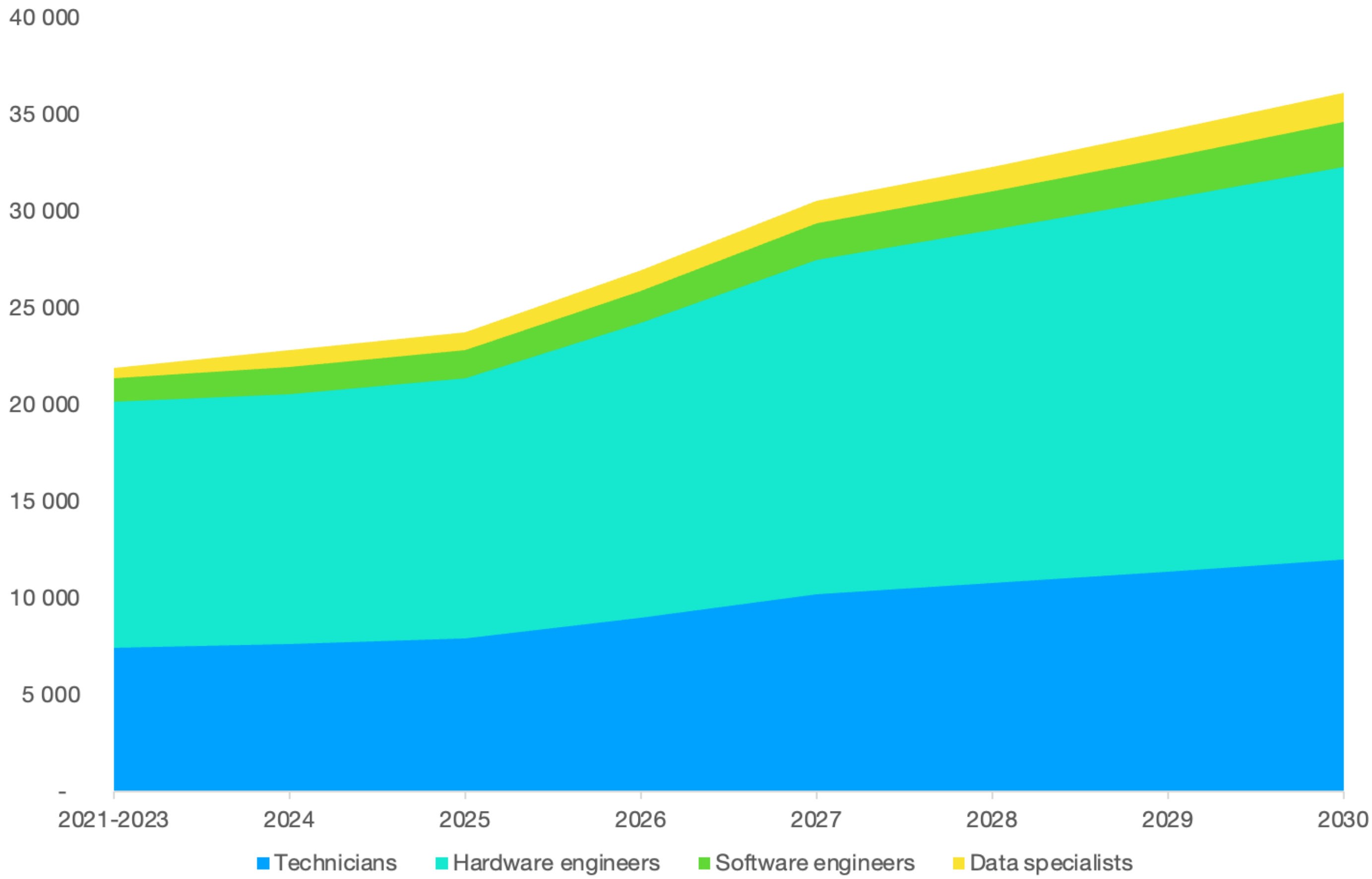
Figure 9: Annual projected job openings in the EU semiconductor industry (2024-2030)



Source: DECISION Etudes & Conseil

JOB OFFERS

The European Union benefits from a significant number of graduates in Science, Technology, Engineering and Mathematics (STEM), ranking third globally, ahead of the United States but behind China and India. Until the early 2000s, the United States, the EU (in particular Germany and France), as well as Russia and the United

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Kingdom, were considered the global centres of STEM education[13]. Over the past few decades, new competitors have emerged on the scene. In Asia, countries such as China, India and South Korea have rapidly expanded their STEM education programmes, resulting in a significant number of graduates in STEM fields. In 2022, the EU had 1,131 thousand STEM graduates, up from 1,095 thousand in 2021. This puts it ahead of the United States, which had 836 thousand STEM graduates in 2021, but far behind China and India, which had 3,570 thousand and 2,550 thousand STEM graduates in 2020, respectively[14]. While the EU still has a higher number of STEM and engineering graduates than the US, the gap is narrowing over time as the US is experiencing a faster growth in the number of STEM graduates. Between 2013 and 2021, the number of STEM graduates grew at an average annual rate of 4% in the United States, compared with 2% in the European Union.

Of the total number of graduates from the STEM programme, approximately 28%, representing approximately 320,000 students, graduate with a semiconductor-related field of study. In 2022, 104,341 EU graduates entered the labour market in electronic engineering[15], 79,333 in mechanical engineering, 73,559 in software engineering and 31,129 in Database and Network design. Of these graduates, 62,693 held a short higher education qualification (20%), 153,767 a bachelor's degree (48%), 95,988 a master's degree (30%) and 7,133 a doctorate (2%).

[13] STEM is a common abbreviation for four closely connected areas of study. The fields are often associated due to the similarities that they share both in theory and practice. It brings together the following three ISCED fields of study: "Natural sciences, mathematics and statistics", "Information and Communication Technologies", and "Engineering, manufacturing and construction".

[14] Last data available form OECD stat for the US, Eurostat for the EU, statistical yearbooks for China and India.

[15] The data on graduates in the European Union is sourced from the Eurostat database, which classifies fields of study according to the International Standard Classification of Education (ISCED). The term 'electronic engineering' is used in the ISCED classification, but in practice, it is not a recognised field of study in the training programmes delivered by technological universities. This ISCED category includes the following semiconductor-related fields: electrical and electronic engineering, control engineering, robotics and computer engineering. Annex 2 provides the correspondence table between ISCED fields of education and master's Degrees Programmes related to the semiconductor industry, as proposed by European Universities of Technology.

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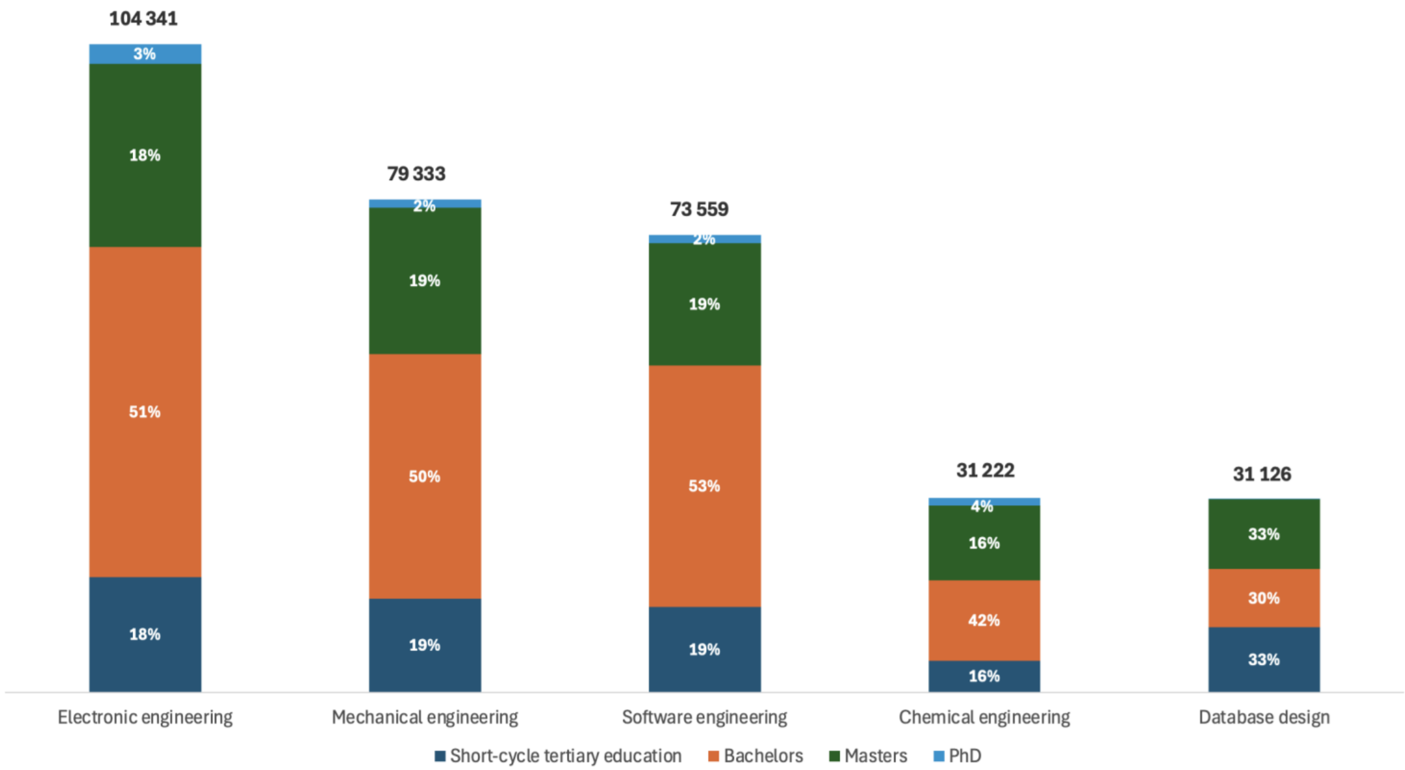
Figure 10: EU graduates in semiconductor-related field of studies, 2022



Source: Eurostat

Despite this large pool of graduates, the EU semiconductor industry struggles to retain and attract more graduating talent. Approximately 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[16]. Among these non-EU workers, a significant proportion opt to work in Europe, like in the United Kingdom or Switzerland. Of the graduates in semiconductor-related fields of study who choose to work in the EU, only a minority of graduates

[16] This estimation is calculated on the basis of national surveys carried out by engineering associations on the number of engineers working outside the EU (see Société des ingénieurs et scientifiques de France) and graduate surveys carried out by technical universities on their former students (see TU Graz).

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specifically join the European semiconductor industry upon graduation. Some pursue engineering careers in other electronics domains (manufacture of loaded electronic boards, electrical products, computer and optical products, electricity and gas supply, wired telecommunication, etc.) while others explore positions beyond traditional engineering sectors (finance, marketing, communication, etc.). It can be generally observed that the higher the degree of direct relevance between the field of study and the semiconductor industry, the higher the proportion of graduates who are employed in the semiconductor sector. For instance, 15 % of electronic engineering graduates find direct employment within the semiconductor sector, whereas only 3 % of mechanical engineering, 2 % of chemical engineering, and 1 % of software engineering graduates do so[17]. Overall, it is estimated that approximately only 6 % of EU graduates in semiconductor-related fields, representing 17, 853 graduates, were expected to enter the EU semiconductor industry in 2022.

[17] These estimations are calculated on the basis of national surveys carried out by technical universities on their former students. These surveys provide invaluable insight into the integration of students into the labour market according to the international NACE classification of economic activities. For example, these surveys indicated that 11 % of chemical engineering graduates work in the "production of computer, electronic, and optical products" (NACE code C26) (see Master's Programme "Chemical Engineering"). Meanwhile, Eurostat data reveals that the semiconductor industry (C2611) accounts for 22% of total employment within C26, which allows to estimate the proportion of chemical engineering graduates employed in the semiconductor industry (11 %*22 %=2%).

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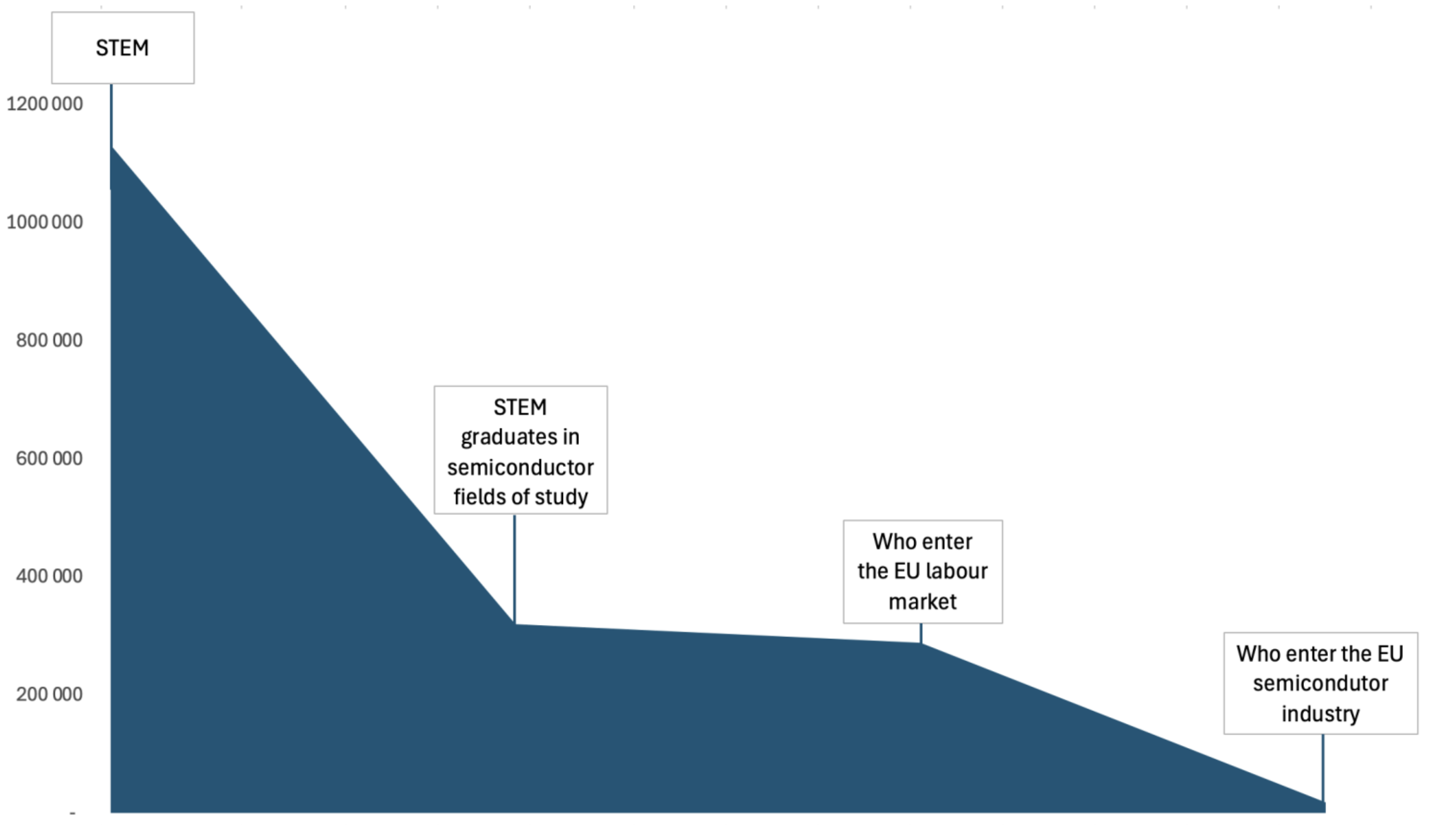
Figure 11: EU graduates entering the EU semiconductor industry, 2022



Source: Eurostat, DECISION Etudes & Conseil

Yet, over the past several years, the growth in the number of graduates specializing in semiconductor-related disciplines has remained surprisingly low, especially when compared to the broader field of STEM. Following a period of stagnation until 2018, the number of STEM graduates experienced a significant increase, with an average annual growth rate of 3.5 % CAGR between 2019 and 2022. However, this growth was driven by ICT and natural sciences and mathematics graduates, while the number of graduates in engineering, manufacturing and construction remained stable over the period. A closer examination of the engineering sector reveals that the number of graduates in semiconductor-related engineering studies (Electronic, Mechanical, and Chemical engineering), has shown only marginal growth since 2016 and has remained relatively static since 2019. In contrast, non-semiconductor engineering fields, such as automotive and aerospace engineering, experienced robust growth during the same period. The stagnation in the number of graduates in semiconductor-related

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fields, as evidenced by national-level data, aligns with the evolution of graduates registered by most Technological Universities[18].

Figure 12: EU STEM Graduates, 2016-2022 (index 100=2016)

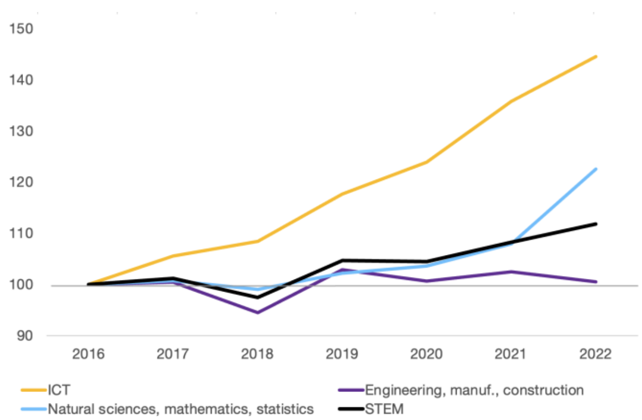
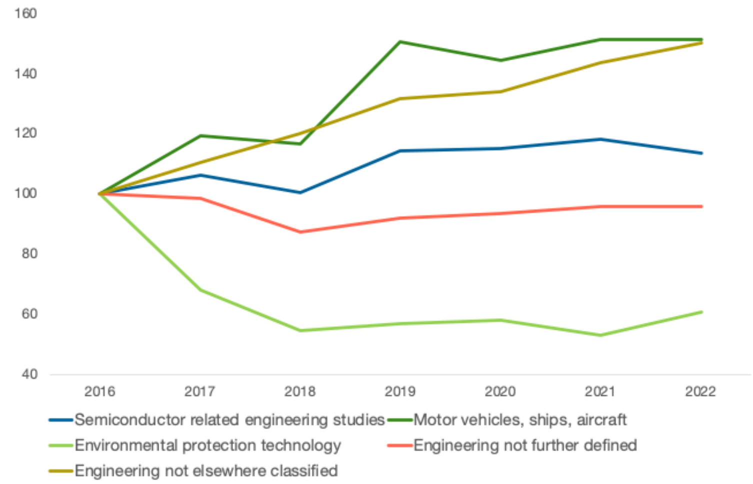


Figure 13: EU Engineering Graduates (index 100=2016)



Source: Eurostat, DECISION Etudes & Conseil

It is expected that the number of graduates entering the EU semiconductor industry will not accelerate significantly in the next few years, raising questions about the education system's capacity to meet the increasing demand. By 2030, the number of graduates expected to work in the EU semiconductor industry is projected to exhibit modest growth, mirroring the approximately 1.0% CAGR observed in recent years (2019-2022). The projected growth in the number of graduates is likely to be constrained by the limited expansion in enrolments over recent years, which has increased by a mere 1.2% between 2019 and 2022, even declining in 2022[19]. This enrolment trend directly impacts the pool of graduates in the short-term. Looking ahead, an

---

[18] See for example : TU Graz, Facts&Figures , TU Delft, Facts&Figures

[19] This is growth weighted by the weight of each field of study in the total number of graduates expected to work in the EU semiconductor industry. Electronic engineering graduates make up a large majority of graduates entering the EU semiconductor industry, and enrolments in this field have remained stable over the period.

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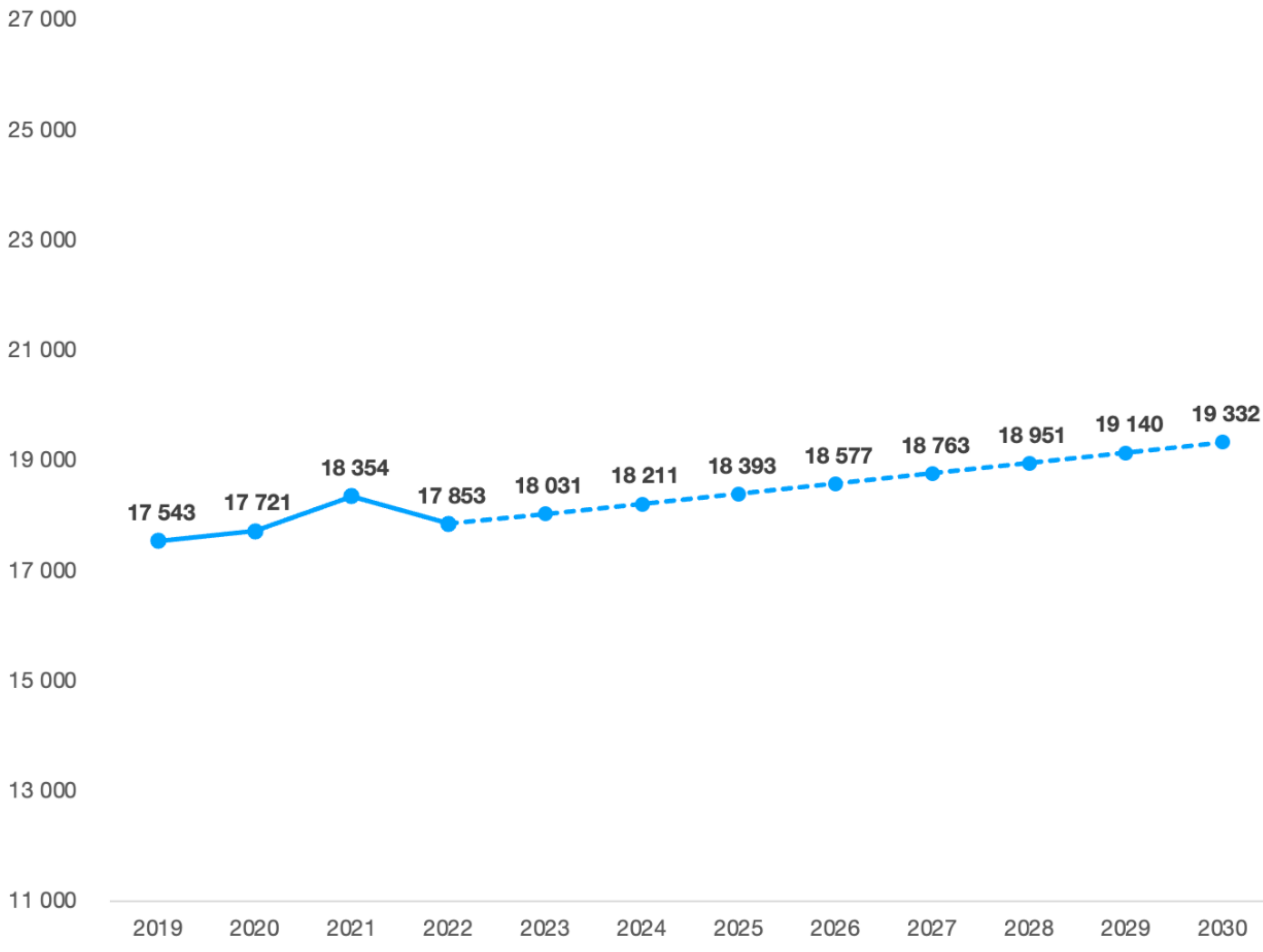
important factor in the enrolment and graduate projections is the expected change in the population of 18- to 30-year-olds. The number of 18- to 24-year-olds, who form the majority of post-secondary students, is predicted to grow by approximately only 1.0 % annually between 2023 and 2030, while the number of 25- to 30-year-olds would remain stable. It may be reasonably assumed that the anticipated growth in the semiconductor industry to generate increased interest among students studying related disciplines, but empirical data challenges this assumption. Despite sustained industry expansion over the last few years, there has been no commensurate rise in the number of graduates.

Figure 14: Annual projected EU graduates entering the EU semiconductor industry (2022-2030)



Source: DECISION Etudes & Conseil

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ESTIMATING THE TALENT GAP

The talent gap in the semiconductor industry is calculated by subtracting the labour supply from the labour demand. The labour supply is represented by job openings from semiconductor companies, including the new jobs that are created each year over the period, plus the replacement jobs, which are the jobs to be replaced each year due to retirement or people leaving the labour market for other reasons. The labour demand is represented by graduates entering the labour market each year, but two adjustments are required to estimate the number of graduates available for the EU semiconductor industry. First, we exclude graduates who will leave the EU labour market after graduation. Second, we remove those with semiconductor-related degrees who are unlikely to work in the semiconductor industry.

For operational purpose and training program development, precise estimation of the talent gap by occupational category is essential. To achieve this, a crosswalk is necessary, aligning fields of study and levels of education with the four main broad occupation categories previously identified (see section 5.2.1). In constructing this crosswalk, we rely on insights from industry surveys conducted under the METIS project. These surveys furnish valuable information regarding the specific academic profiles sought for each job type.

- Semiconductor technicians are typically hired from graduates who have completed a semiconductor-related degree at the short-cycle tertiary education (ISCED 5) and at Bachelor level (ISCED 6).
- Semiconductor hardware engineers are primarily hired from graduates who have completed a semiconductor-related degree, excluding software engineering and information and computer engineering, at Bachelor (ISCED 6), Master (ISCED 7), or PhD level (ISCED 8).
- Semiconductor software engineers are typically hired among graduates who have completed a software engineering degree, at Bachelor (ISCED 6), Master (ISCED 7), or PhD level (ISCED 8).
- Data specialists are mainly hired from graduates in information and computer engineering, at Bachelor (ISCED 6), Master (ISCED 7), or PhD level (ISCED 8).

The semiconductor industry is already facing a significant labour shortage, driven by a surge in job openings that outpaces the growth in graduates. Between 2017 and 2023, job openings in the semiconductor industry expanded at an average annual growth rate of 11 % supported by a robust employment growth, while graduates

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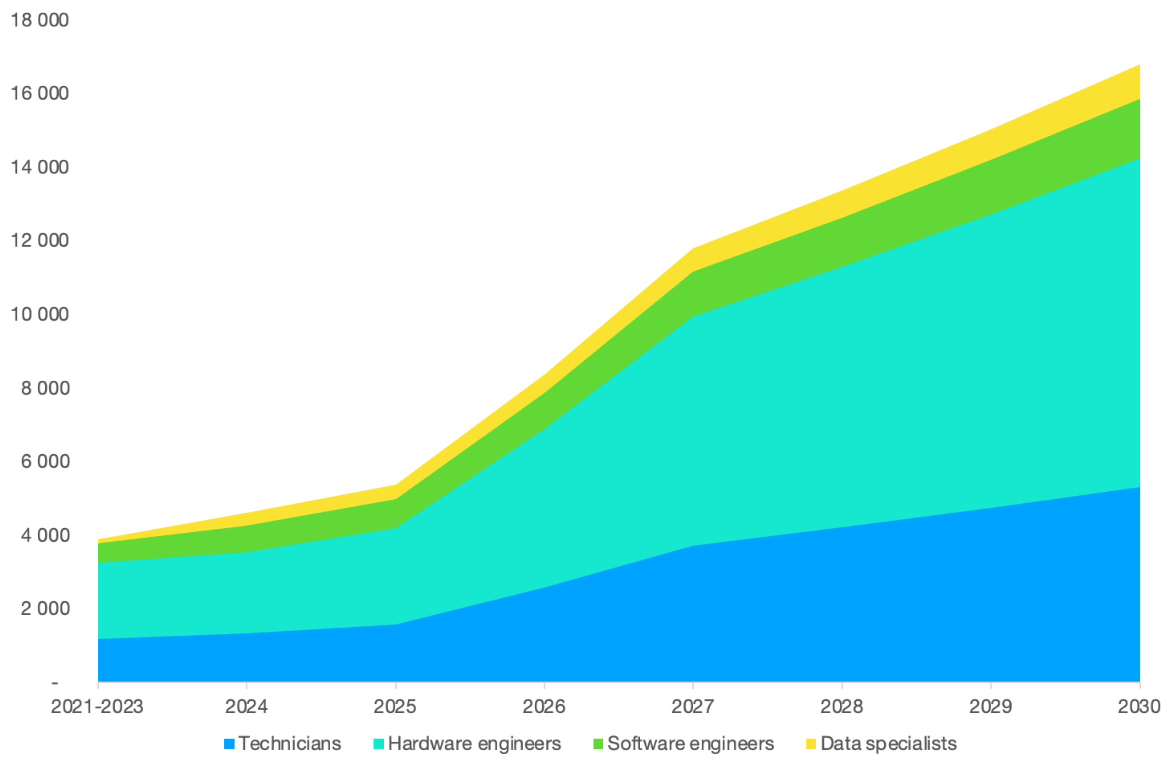
in semiconductor-related fields of study remained relatively stable. This has resulted in approximately 3 830 jobs remaining unfilled on average over the recent period 2021-2023. These include 30 % for technicians, 54 % for hardware engineers, 13 % for software engineers and 3 % data analysts. These findings align with qualitative surveys conducted between 2020 and 2022 with stakeholders in the semiconductor industry as part of the METIS project, which already highlighted labour shortages in these critical roles. To bridge this gap, companies turn to non-European workers. For instance, in 2023, 39% of ASML employees in the EMEA region were non-EMEA nationals[20].

Figure 15: Annual projected semiconductor workforce gap (2024-2030)



Source: DECISION Etudes & Conseil

[20] Source : ASML annual report 2023

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The talent gap in the semiconductor industry is expected to widen annually in the coming years due to the implementation of the EU Chips Act. Annual job openings in core technical occupations are projected to rise significantly, increasing from an average of approximately 18,000 over the past seven years to an average of 29,500 in the next seven years. This growth is driven by an accelerated employment rate, with a 3.5 % CAGR observed from 2017 to 2023, expected to further accelerate to a 5,0 % CAGR by 2030. On the other hand, considering historical trends and demographic changes, the availability of graduates for the European semiconductor industry is expected to remain modest, with only 1,0 % CAGR until 2030. Consequently, the shortage of talent in the semiconductor sector is projected to widen slightly each year, reaching around 5,310 jobs for technicians by 2030, 8,930 for hardware engineers, and 2,550 jobs for software engineers and data scientists. In total, the talent shortage across the entire sector is projected to quadruple, resulting in approximately 16,800 unfilled positions by 2030.

Overall, the anticipated talent shortage in the semiconductor industry from 2024 to 2030 is projected to reach approximately 75,390 positions. This shortfall corresponds to 36 % of the overall industry demand, indicating that the estimated supply may cover only 64 % of the expected demand. Of the total estimated technical workforce gap of 75,390, we anticipate that approximately 31 % (roughly 23,480 jobs) will be in technician roles, 52 % (39,370 jobs) in hardware engineering occupations, 11 % (8,140 jobs) in software engineering occupations, and 6 % (4,400 jobs) in data specialists. When it comes to employee numbers, the talent gap for software engineers and data specialists is notably smaller than that for technicians and hardware engineers. However, this does not imply that these professions are experiencing any less of a labour shortage. On the contrary, the supply-to-demand ratio stands at only 37 % for software engineers and 46 % and data specialists, compared to 66 % for technicians and 66 % for hardware engineers. This underscores the heightened challenge of labour shortages in these occupations.

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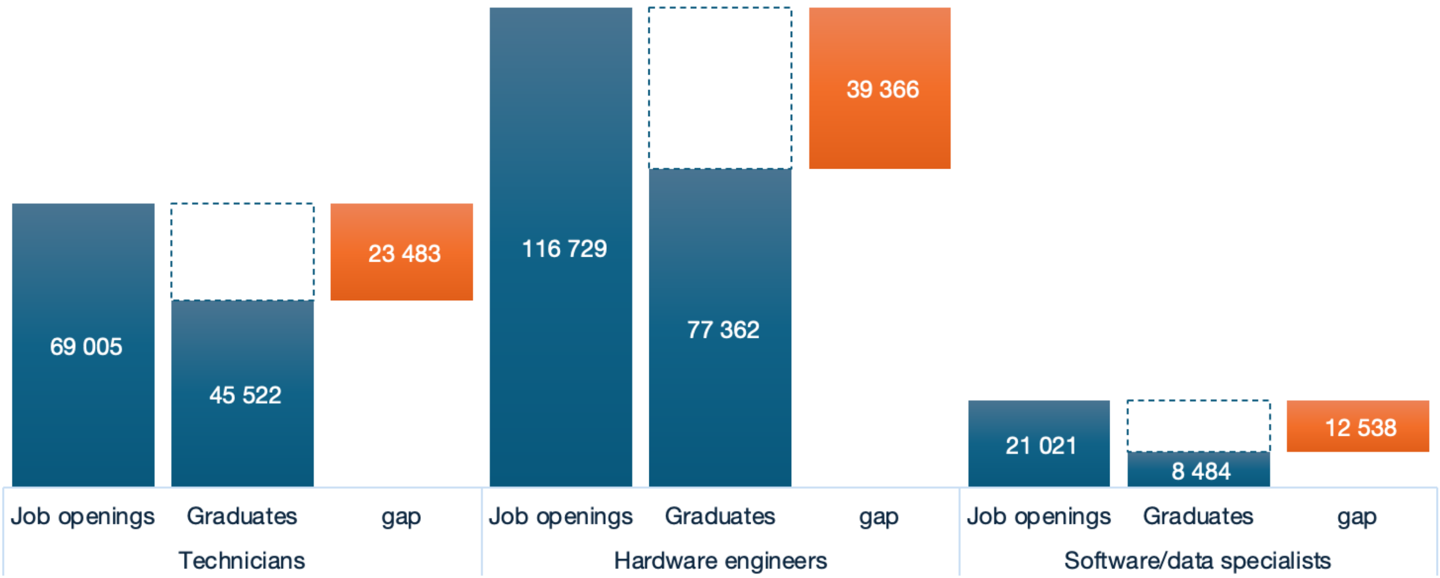
Figure 16: Total projected semiconductor workforce gap (2024-2030)



Source: DECISION Etudes & Conseil

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QUALITATIVE ANALYSIS

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. Furthermore, it allows for a more nuanced exploration of the reasons behind the current tension in these professions.

This qualitative analysis has been initiated in the METIS project and is carried 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 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 3 provides a comprehensive overview of the methodology employed in the online survey.

In 2024, 130 experts from 79 organisations have participated in this work.

KEY EVOLUTIONS IN 2023

WHAT NEW JOB PROFILES AND SKILLS ARE EMERGING IN THE EU SEMICONDUCTOR INDUSTRY IN 2024?

As 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 2024 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 2024. Professionals looking to remain competitive in the semiconductor industry should consider developing expertise in these areas.

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Artificial Intelligence (AI), data and programming

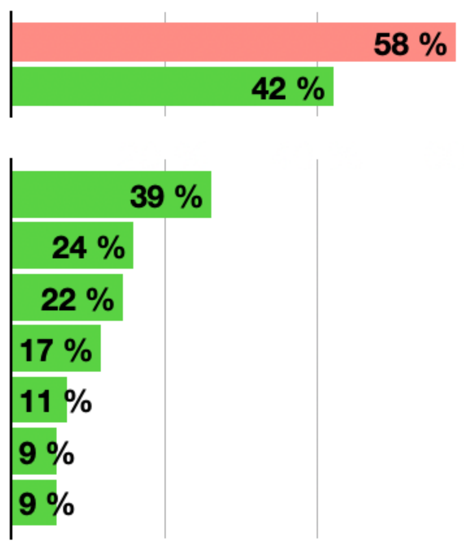
As it is the case since 2022, machine learning engineer comes in first position as emerging job profiles, followed by data specialist. 39% of respondents experience a new need for machine learning engineers in their working environment in 2024 (24% for data specialists).

Similarly, and continuously for the past three years, AI-related skills (large language models, prompt engineering to NLP models -including bias analysis and AI objectivity-…), come in first position as emerging skills, followed by data analysis related skills. 55% of respondents experience a new need for AI-related skills in their working environment in 2024 (21% for data analysis skills).

Skills related to AI and programming are getting increasingly important in most engineering fields. Data is taking considerable importance in semiconductor companies, and the statistical skills are required including at basic engineering level even in a rising number of technicians positions (analytics, skills and knowledge needed to draw conclusions and make classification and predictions). The table in annex 4 provides a detailed overview of how the different profiles are impacted across the semiconductor industry.

Figure 17: New profiles and skills noticed by the stakeholders

Since mid-2023, have you observed new profiles emerging in microelectronics? (new job positions that did not exist before)	
No	58 %
Yes	42 %
If yes, can you list and describe them?	
Machine learning enginer	39 %
Data specialist	24 %
Systems designer	22 %
Cybersecurity specialist	17 %
Environmental-related job profiles	11 %
Automatic Analog Design Generation engineer	9 %
Quantum specialist	9 %



Panel: 109 answers

Source : 2024 ECSA Survey, DECISION Études & Conseil

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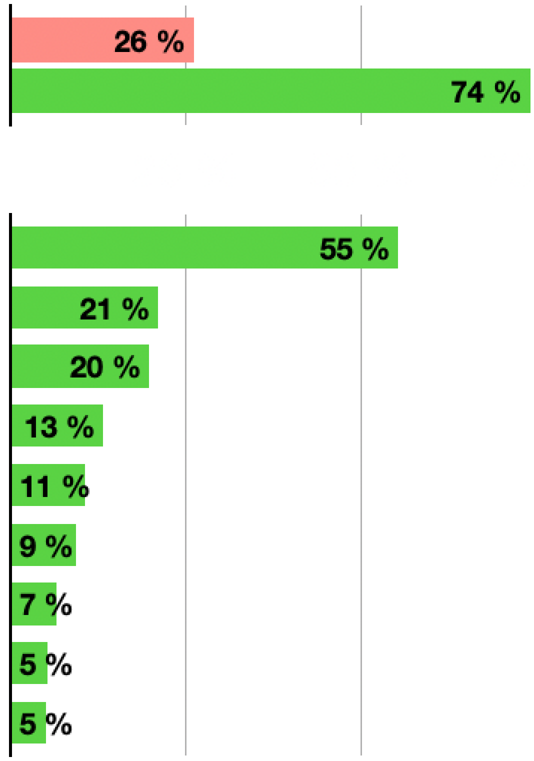
Since mid-2023, have you observed new skills needs emerging in microelectronics?	
No	26 %
Yes	74 %
If yes, can you list and describe them?	
Artificial Intelligence / ML	55 %
Data analysis	21 %
Software / Digital / Programming	20 %
Sustainability	13 %
Cybersecurity	11 %
Quantum	9 %
New materials	7 %
Advanced packaging	5 %
Photonics	5 %



Panel: 103 answers

Source : 2024 ECSA Survey, DECISION Études & Conseil

Beyond AI and data analysis, the main job profiles & or skills that are emerging in the EU semiconductor industry in 2024 are the following:

System designers

In 2024, 22% 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

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harsh environments: smart sensors for automotive ADAS, systems for zonal car units, Industry 4.0, health & care, aerospace-Defense, etc.

Security / Cybersecurity specialists

In 2024, 11% of respondents globally report an emerging need for cybersecurity-related skills in their working environments, and 17% report an emerging need for a new profile of cybersecurity specialist.

Cybersecurity specialists must ensure the security of hardware and software systems throughout their lifecycle, from initial design to decommissioning. They must be familiar with hardware attack vectors, cryptography, and possess experience in applying secure hardware and software design principles.

Sustainability / Environmental-related job profiles

In 2024, 13% of respondents globally report an emerging need for sustainability-related skills in their working environments, and 11% report an emerging need for new environmental-related job profiles, such as:

- Electronic Waste Recycling Specialist (EQF 7-8), in charge of reducing waste production and optimizing waste recycling in semiconductor fabrication.
- Lifecycle Analyst (EQF 7), in charge of assessing the environmental impact of microelectronic products throughout their lifecycle.
- ESG expert (Environmental, Social, and Governance) (EQF 6-7), in charge of evaluating and advising organizations on sustainable practices, ensuring compliance with ESG criteria to enhance long-term value and mitigate risks. They play a crucial role in integrating ethical, environmental, and social considerations into business strategies and operations.

Sustainability in this context refers to finding solutions that maintain efficiency without harming the environment. The range of sustainability knowledge and skills increasingly required for engineering and manufacturing roles includes:

- Energy Efficiency and Management: Knowledge of ISO 50001 standards, focused on improving energy performance.
- Sustainable Manufacturing Processes: Proficiency in selecting and using environmentally friendly equipment and materials, particularly for process technicians and engineers.

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Quantum

In 2024, 9% of respondents globally report an emerging need for quantum-related skills in their working environments, with an equal percentage indicating a demand for a new profile of quantum specialists.

This reflects a significant shift toward expertise in the fabrication and testing of quantum devices, related instrumentation, and software controls. The quantum knowledge and skills required span several areas, including quantum mechanics, quantum error correction, and quantum hardware experience. Additionally, familiarity with cryogenics and superconducting circuits is becoming increasingly relevant. Specific roles such as Quantum Computing Engineers, who specialize in quantum microelectronics, and Post Quantum Security Architects, tasked with defining quantum-resistant security algorithms, are emerging.

Automatic Analog Design Generation Engineer

In 2024, 9% of respondents globally report an emerging need for a new profile of Automatic Analog Design Generation Engineer. This role combines expertise in analog integrated circuit (IC) and physical (layout) design with advanced programming and AI skills. The objective is to automate the creation and optimization of cutting-edge analog circuits, accelerating design processes and improving performance through AI-driven tools.

New materials

In 2024, 7% of respondents globally report an emerging need for skills related to new materials in their working environments.

Advanced packaging

In 2024, 5% of respondents globally report an emerging need for skills related to new materials in their working environments.

The knowledge and skills related to advanced packaging, and increasingly required, span several areas:

- Process integration (3D-stacking), including thermal management in stacked chips.
- Heterogeneous Process integration, including WBG technologies like SiC or GaN.
- Packing (ICs, SoC, chiplets).

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Photonics

In 2024, 5% of respondents globally report an emerging need for skills related to photonics in their working environments. It involves the design and fabrication of photonics devices, understanding of optoelectronic principles, and experience with integrated photonics.

Other profiles and skills on the spot

Amongst the other job profiles and/or skills reported as emerging, one can find:

1. Data governance specialists to handle advanced packaging. The development of advanced packaging raises many questions related to IP-transfer, but also insurance and responsibility of the different suppliers involved in the manufacturing of a complex system. The industry has therefore a rising need for data governance specialists that can judge and operationally manage which information flows (which IP, which technologies), and determine responsibilities in the event of failures.

2. Supply Chain and Operations. Since the COVID crisis, followed by the semiconductor shortage, a greater need emerged for supply chain and logistics professionals to manage complex semiconductor production and distribution.

3. Strategic and Business Acumen. Business development and strategic planners are sought to navigate the ever-complex market trends and the EU Chips Act implications.

4. Global Talent Acquisition Teams. In line with the expansion of recruitment efforts internationally to attract top talent.

5. Skills Development Manager. In charge of creating in-house training material and organizing in-house training activities.

6. There is a gradual convergence between the roles of marketing engineers and applications engineers. There is a growing trend to make sales roles more technically proficient, enabling sales teams to address basic customer issues independently. Simultaneously, application engineers are becoming more customer-facing and collaborating closely with sales teams.

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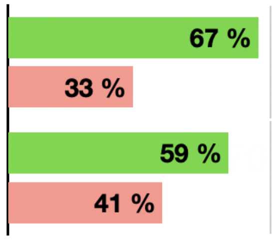
IMPACT OF INVESTMENT IN SEMICONDUCTOR FABS IN THE EU AND SPECIFICALLY OF THE EU CHIPS ACT ON HIRING PLANS IN EUROPE

As in every year since 2020, respondents were asked whether they experienced any concrete and significant impact on their hiring plans in Europe based on two key factors:

1. The exponential increase in investment in semiconductor fabrication plants on EU soil (fabs).
2. The EU Chips Act, launched in early 2022.

Figure 18: Share of the stakeholders that have experienced an impact of the rise in global investment in semiconductor fabs and the EU Chips Act

In 2024, do you experience the impact of the following elements on your recruitment policies?		
The exponential rise of global investment in semiconductor fabs	Yes	67 %
	No	33 %
The EU Chips Act launched in early 2022	Yes	59 %
	No	41 %



Panel: 81 answers

Source: 2024 ECSA Survey, DECISION Études & Conseil

Since 2021, most respondents have reported a significant impact of fab investments on their hiring plans. This trend continues, with 67% indicating such effects in 2024. These investments have driven increased demand for talent, exacerbating the existing skills shortage. The focus on front-end fabs has particularly intensified the need for roles such as process, maintenance, and quality technicians and engineers, as well as operators. This long-term increase in demand is further compounded by the short-term need for workers to build or expand the factories.

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Companies are finding it increasingly difficult not only to attract new talent but also to retain existing employees. To enhance their appeal in the competitive labour market, companies are raising salaries and refining their employer branding strategies to better present themselves to potential candidates.

The competition for engineering roles now spans across Europe, making these positions harder to fill compared to technician roles, where competition remains more regional or local.

Finally, with the rise of advanced front-end fabs in Europe, such as those from Intel, TSMC, and GlobalFoundries, the demand will rise for expertise in the latest wafer technologies, including sub-nanometre nodes, and advanced test and assembly processes.

In 2024 and for the first time, 59% of respondents reported a significant and tangible impact of the EU Chips Act on their hiring plans in Europe. In 2022 and 2023, only 30% and 34% of respondents, respectively, reported experiencing the impact of the EU Chips Act, primarily through increased demand for project managers to handle funding applications.

However, some companies in specific segments report not experiencing the impact of fab investments nor of the EU Chips Act. These typically include fabless companies, EDA & IP firms, as well as packaging businesses, which have expressed concern over the heavy focus on front-end semiconductors in the EU in recent years. This group also includes materials and tools providers, many of whom report not yet feeling the concrete impact of fab investments on their operations.

Finally, many stakeholders report a disconnect between the current investment surge and the corresponding development of training capacities. As a result, companies are facing challenges in meeting their hiring needs. To address this gap, many firms are establishing talent management teams dedicated to assessing training requirements, identifying suitable training partners, and developing or scaling up specialized in-house training programmes.

HIRING TRENDS

Driven by increasing demand, technological advancements, and substantial investment, including from the EU Chips Act, 36% of the respondents are expecting to hire more in 2024. Some companies are ramping up their operations, including building new fabs, creating additional R&D teams, and addressing specific markets for emerging technologies. The global rise in semiconductor investment and competition also plays a role, with organizations needing to scale up their workforce to meet rising customer demand and support new projects.

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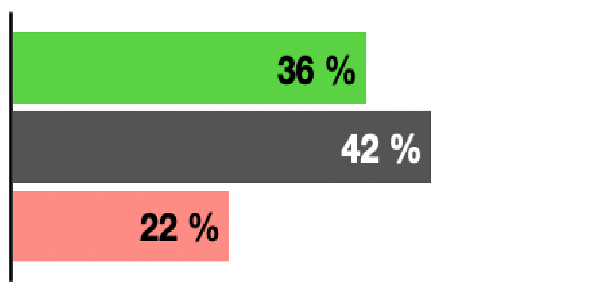
However, considering ongoing economic uncertainty, 42% of stakeholders expect to maintain current staffing levels. While some foresee positive developments, such as new EU fabs and emerging technologies, they are waiting for clearer market signals before expanding their workforce, stabilizing their workforce or limiting new hires to replacement positions only. In the education sector, with a decreasing number of students and budget constraints, hiring has remained stable, and some teaching positions have even been reduced.

The 22% of respondents planning to hire less in mid-2024 largely attribute their decisions to the economic constraints and market uncertainty that stem from the significant downturn in 2023. The semiconductor market experienced a sharp decline that year, with a 10.3% contraction overall[21]. This decline led to widespread inventory corrections and weak demand across key customer industries like automotive, which forced companies to cut costs and limit hiring. Additionally, some organizations had significantly expanded during the semiconductor boom of earlier years, and now, with a more cautious outlook for recovery, they are stabilizing their workforce and focusing on optimizing operational costs for 2024.

Figure 19: Distribution of the hiring strategy of stakeholders in 2024 compared to 2023

In 2024, do you expect to hire more or less on EU soil compared to 2023?	
Hire more	36 %
Remain the same	42 %
Hire less	22 %



Panel: 123 answers

Source: 2024 ECSA Survey, DECISION Études & Conseil

[21] Source: WSTS.

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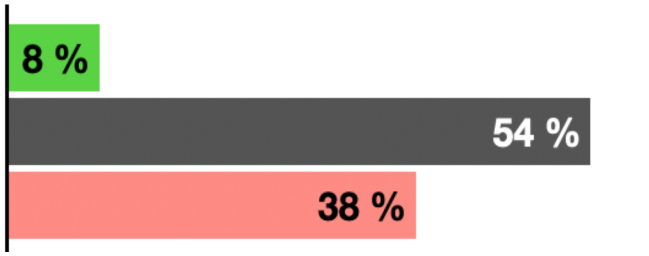
SKILLS SHORTAGE EVOLUTION

When asked about the evolution of the skills shortage in the EU in 2024, the overall feeling is that it has remained the same or even worsened, with 92% of the answers.

Figure 20: Distribution of the perception of stakeholders towards skill shortage in 2024 compared to 2023

In 2024, the skills shortage within your organization has	
Improved	8 %
Remained the same	54 %
Worsened	38 %



Panel: 130 answers

Source: 2024 ECSA Survey, DECISION Études & Conseil

38% of respondents have seen the skills shortage worsen in 2024. Geopolitical factors, such as Brexit and immigration restrictions, have compounded the issue by limiting the flow of skilled workers into the EU. Additionally, an aging workforce, with retirements outpacing the number of new entrants, and ongoing brain drain to regions offering more competitive salaries, like the U.S. and Asia, are exacerbating the problem. The rise in demand for specific skills, such as cybersecurity and data expertise for instance, the increasing competitiveness from other sectors, alongside the increasing complexity of semiconductor technology, has led to a talent crunch, making it even more difficult for companies to fill open positions.

However, most respondents report that the skills shortage has remained unchanged. This is largely due to delayed effects of initiatives like the EU Chips Act, which have not yet significantly impacted the talent pool. Respondents also note that universities are slow to adapt their programmes to meet industry requirements, leaving a persistent gap between the skills being taught and those needed in the workplace. While some companies have benefitted from layoffs in high-tech industries, allowing them to recruit skilled workers (especially software engineers or data specialists), this has not been enough to shift the overall talent landscape.

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Furthermore, the semiconductor downcycle has temporarily reduced hiring pressure, but respondents expect the skills shortage to continue as the market recovers.

Finally, a small portion of respondents have seen improvements in the skills shortage, often due to reduced hiring needs caused by economic uncertainty or specific hiring successes. However, these improvements seem localized and situational, tied more to market fluctuations than a systemic resolution of the broader skills gap within the industry.

MOST CRITICAL JOB PROFILES

1) DEMAND AND SHORTAGE ON THE JOB MARKET IN 2024

As in the previous METIS Yearly Monitoring, stakeholders have been asked to identify 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).

Results are illustrated in the figure below.

Following past years' trend, software and design engineers remain in the top 2 profiles that are the most sought after in the EU with 61% and 56% of the answers respectively. The demand for software is driven by trending and emerging technologies (IoT, Edge computing, Cloud computing & AI integration), the increasing need for automation in companies and factories, and by innovation in specific markets such as the development of the software defined vehicle in automotive.

Within the design position, system designers and analog designers are the most sought-after specific profiles. Both profiles need broader skills and competencies, often acquired through multiple years of experience.

- System designer positions require skills from device to system architecture, including specific skills in SoC and SiP that are increasingly needed.
- Analog designers are required to design RF and sensing chips. They specialize in continuous signal processing, noise management, and design optimization for performance across a range of harsh operating conditions. Collaboration with digital designers and system architects is often necessary to integrate analog components into broader systems.

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Compared to last year, Data specialists are the 3rd most in-demand profiles with 52% of the answers, replacing the Process engineer profiles that end up at the 7th position.

Less in-demand, support profiles such as Supply Chain/ Logistics experts and Marketing engineer have been identified by respectively 15% and 9% of the stakeholders as the most sought-after in 2024. Yet, the figures for Marketing engineers are higher by 4 percentage points compared to last year.

This year, the category “other” has been identified as in-demand from 16% of the stakeholders. This involves job profiles such as verification engineers, patent engineers, engineers with knowledge in power components, physicist with knowledge in optics and lithography, as well as overall product / project managers.

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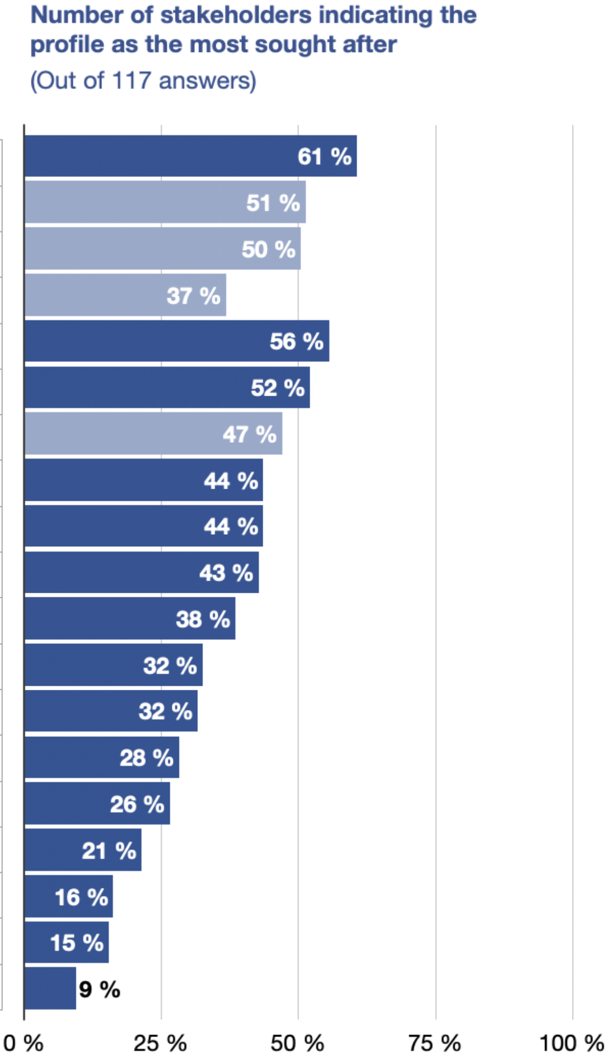
Figure 21: Ranking of the job profiles indicated as the most sought-after in 2024

2024: The 15 job profiles identified as the most sought after in the European microelectronics industry

1	**Design engineer**
1.1	System design engineer
1.2	Analog design engineer
1.3	Digital design engineer
2	**Software engineer**
3	**Data specialist**
3.1	Machine learning engineer
4	**Test engineer**
5	**Expert in cybersecurity**
6	**Maintenance technician**
7	**Process engineer**
8	**Applications engineer**
9	**Process technician**
10	**Test technician**
11	**Operator / Inspector**
12	**Robotic engineer**
13	**Other**
14	**Supply Chain expert/ Logistics specialist**
15	**Marketing engineer**



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 ECSA Survey / DECISION Etudes & Conseil

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According to 38% of the 106 respondents in 2024, expert in cybersecurity is the most difficult position to fill within the semiconductor industry. This shortage is due to a combination of high and growing demand across various sectors, with other industries often being more competitive in attracting talent through higher salaries and better recognition. There is also an insufficient education and training pipeline producing too few qualified graduates. These profiles are not traditional cybersecurity specialists; they require proficiency in electrical engineering, chip design, security-by-design, and secure hardware. Ideal candidates must therefore combine expertise in both cybersecurity and electrical engineering, which presents a unique and challenging skill set to develop. Experts in cybersecurity are followed by design and software engineers, with 37% and 28% of the answers respectively, which have been consistently in the top 3 most difficult profiles to find for the past four years. The shortage of design engineers is due to a declining number of young engineers entering the field, and the necessity for specialized skills—such as specific product design knowledge and CAD proficiency.

The shortage of both analog design engineers and system design engineers can be attributed to a weak education pipeline and the complexity of these roles. Over the past 20 years, universities have reduced their focus on analog design, resulting in fewer training programmes and a decline in interest among students. The role's high demand, complexity, and need for extensive experience in mathematics and physics make it even harder to fill these positions. System design engineers face similar challenges, with current graduates necessitating in-house training. The situation is further exacerbated by a wave of retirements, reducing the already scarce pool of experienced professionals. These roles are traditionally filled by experienced senior profiles from abroad, which are increasingly difficult to attract considering the competition with other regions.

Maintenance technicians play a critical role in ensuring smooth equipment operation and minimizing downtime. However, the shortage of qualified professionals, coupled with the need for advanced on-the-job training, makes this a challenging field. Process technicians are equally essential, supporting production lines and maintaining efficiency as the industry invests in new technologies and fabs, particularly in Europe. The complexity of modern semiconductor manufacturing has increased the need for skilled process technicians who must continuously adapt to new materials and especially to the ever digitization of manufacturing processes, increasingly implying analytical tools.

The overall statement from the respondents is that there are too few skilled graduates to fill these positions. Moreover, this scarcity of graduates is exacerbated by the intensified competition from other sectors and regions offering higher compensation.

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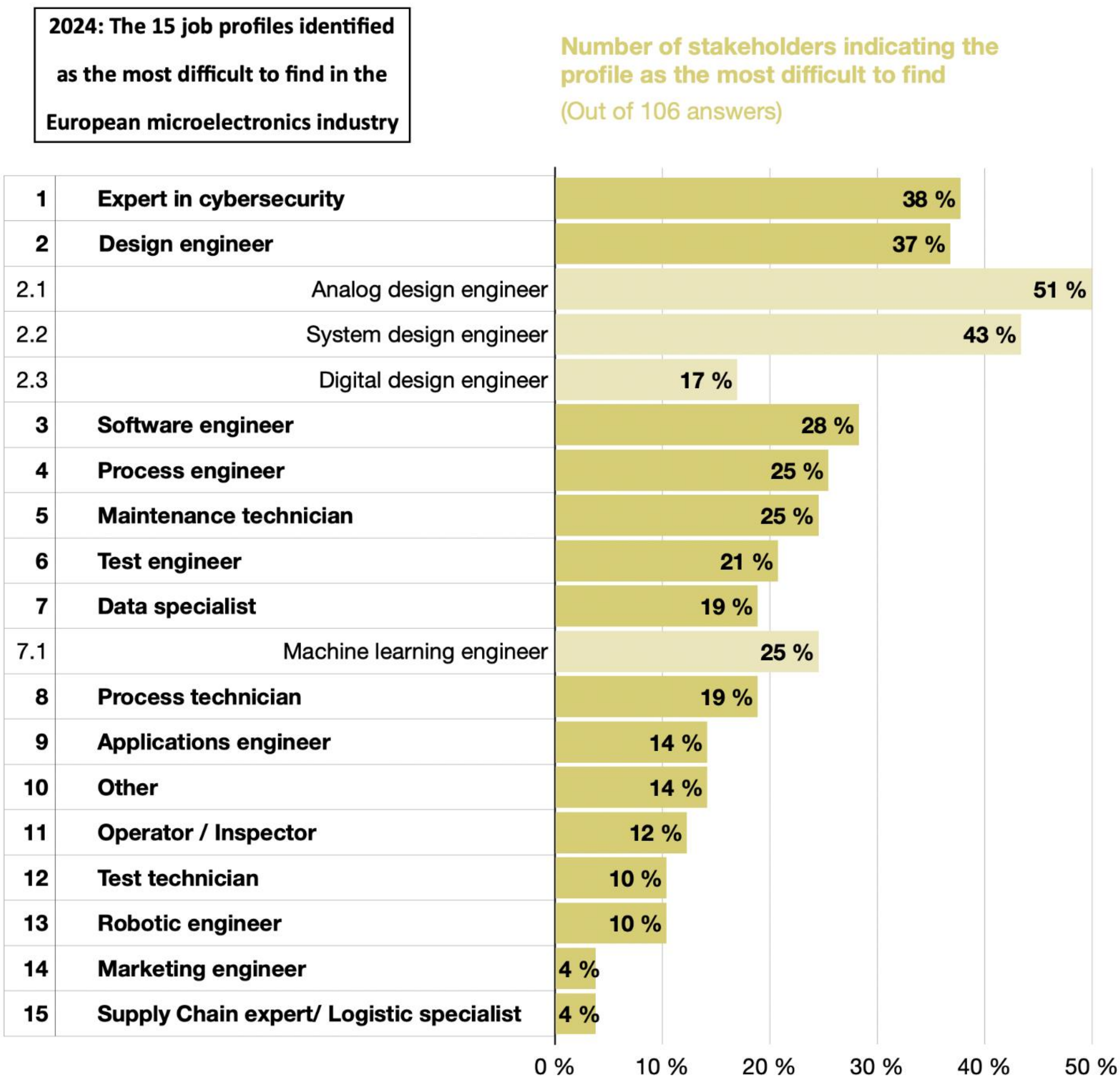
Figure 22: Ranking of the job profiles indicated as the most difficult to fill in 2024



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 ECSA Survey / DECISION Etudes & Conseil

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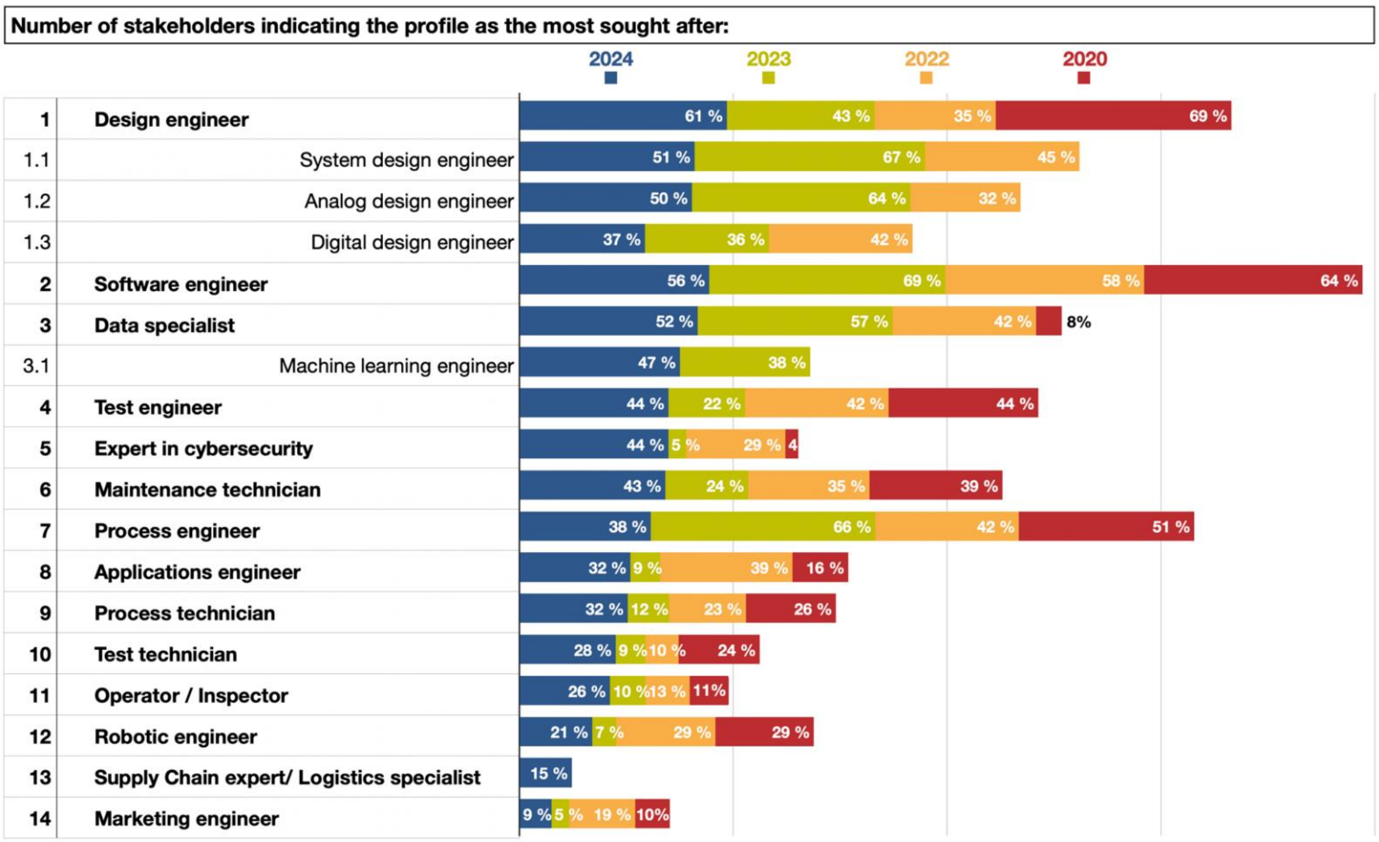
FROM 2020 TO 2024: EVOLUTION OF THE DEMAND OF JOB PROFILES ON THE EUROPEAN JOB MARKET

The figure below compares the answers provided by respondents to the survey every year since 2020 to the same question “indicate the job profiles that are the most sought-after on the EU job market”:

Figure 23: Share of the stakeholders over the past years indicating the profiles as 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 ECSA Survey / METIS Yearly Monitoring Report 2023 / DECISION Etudes & Conseil

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Design engineers and software engineers' profiles have constantly been in the top 2 most in-demand profiles over the past 5 years.

In third position overall during the 2020-2024 period, the demand for process engineers has remained high and stable.

However, Machine learning engineers and data specialists have become much more critical over time, showing the rising integration of AI, big data, and advanced analytics in semiconductor manufacturing, driving the need for their expertise in optimizing processes, improving efficiency, and enabling data-driven decision-making.

The demand for technician profiles—maintenance technicians, process technicians, and test technicians—was the highest in 2024, illustrating the ramping-up of fabs investments in the frame of the EU Chips Act.

Marketing engineers and supply chain specialists have the lowest demand overall, with a stable percentage of answers over the years.

MOST CRITICAL SKILLS

TECHNICAL SKILLS

This chapter summarizes the skills and knowledge identified as the most critical for the European microelectronics industry from 2020 to 2024. A critical skill is one that is both in high demand and difficult to find in the job market.

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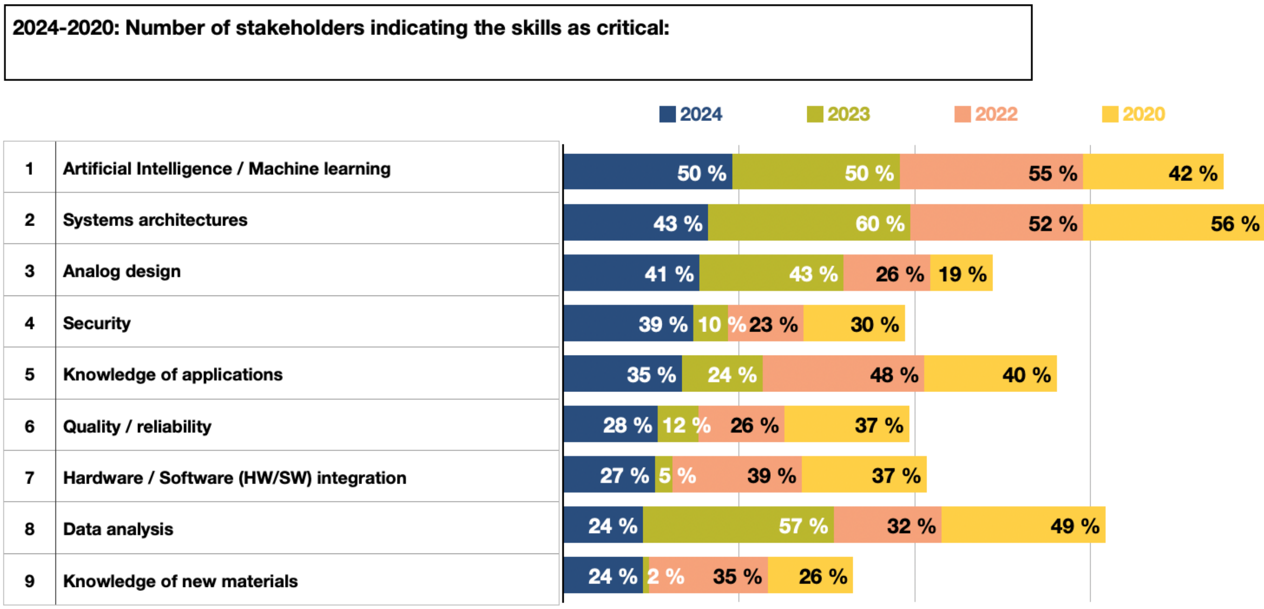
Figure 24: From 2020 to 2024: Share of stakeholders indicating the profile as critical



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 ECSA Survey / METIS Yearly Monitoring Report 2023 / DECISION Etudes & Conseil

Aligning with current trends in job profiles, AI/ ML[22] was indicated as amongst the most critical fields of skills required by 50% of the stakeholders that participated in the survey in 2024. In contrast, data analysis skills, though still sought after, are less considered as a critical skill this year compared to last year.

Over the entire 2020-2024 period, system architecture remains, on average, the most critical field of skills. There is a shortage of skilled systems architects in Europe, and the need for senior professionals is pressing as these roles demand broad, advanced knowledge, spanning from devices to systems.

[22] Artificial Intelligence and Machine Learning.

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Analog design is becoming increasingly critical over the years, reflecting the worsening of the shortage of analog designers. Many experienced engineers are retiring, and the dominance of digital design has led to a scarcity of skilled talent in analog design with fewer students pursuing this path.

With an average of 37% of the stakeholders’ answers over the past years, knowledge of applications is a field of skills that remains critical, especially considering it is mostly acquired through professional experience.

Finally, as observed since 2020 and mentioned in other reports[23], soft skills also proved to be important skills that new graduates are lacking. This involves especially:

- Teamwork, communication, and ability to describe complex topics in simple terms.
- Creativity, imagination, and innovation capability, especially for R&D positions.
- Project management.

MINIMUM EDUCATIONAL LEVEL

The table below describes the minimum education level at which the mastering of a field of skills is required. For example, 78% of stakeholders indicate that knowledge of new materials is required only at the Master or PhD level (EQF 7 or 8), which is the highest rate in the survey results. On the contrary, 71% of respondents indicate that proficiency in hardware / software integration is required from the Bachelor level (EQF 6).

[23] Electronics Sector Resources Skills Needs”, Midas, 2021

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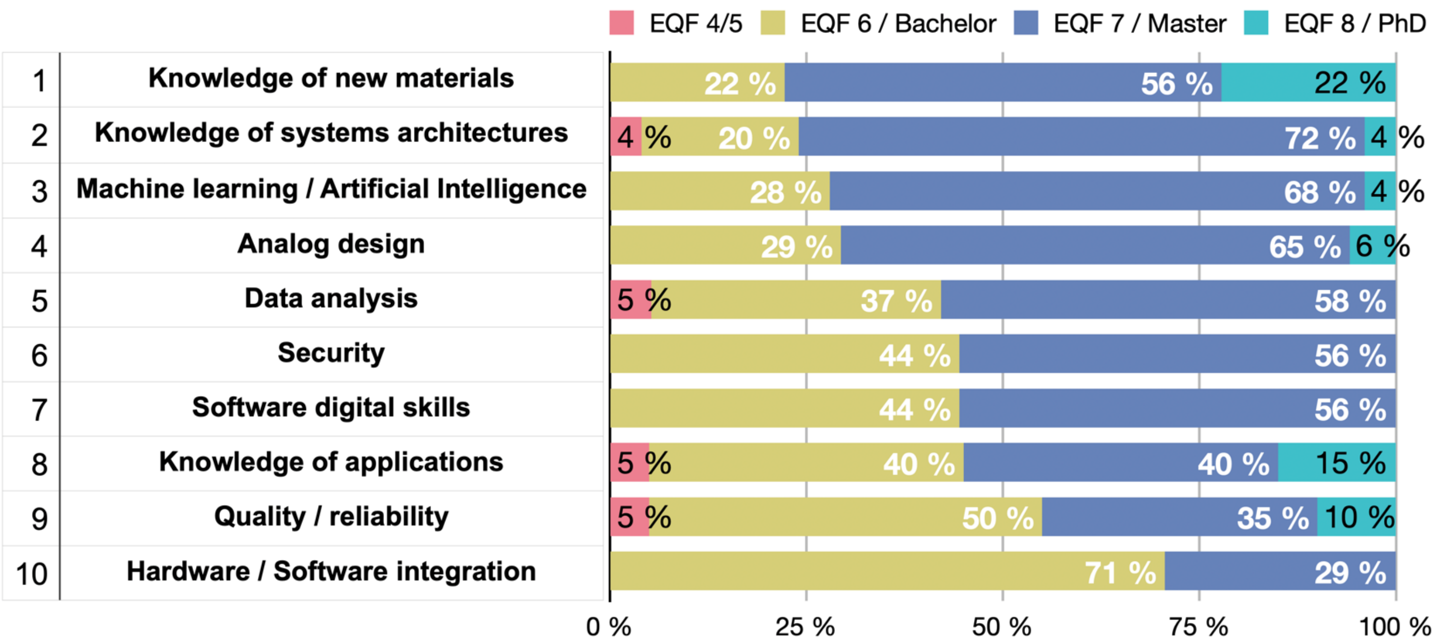
Figure 25: Share of stakeholders over the past 4 years indicating the minimum educational level from which the skill is required



From the answers 31 stakeholders interviewed in 2022, 2023 & 2024.

The first assessment of the minimum educational level from which the skill is required was done in 2022. Since then, the format remained the same for the 2023 Metis Yearly Monitoring and the 2024 ECSA survey and are therefore presented in an aggregated form.

Source: 2024 ECSA Survey / METIS Yearly Monitoring Report 2023 / DECISION Etudes & Conseil

Finally, regardless of the minimum education level, certain skills are also acquired through experience in the semiconductor industry. This concern especially expertise in system architectures, analog design, knowledge of applications, and security. Even recruiting at EQF 8 level is not a guarantee to get skilled workers in these areas.

The talent gap that will be the most difficult to fill concerns these advanced skills. Indeed, specializations that require the most education to fully comprehend are overall the same as those considered the most difficult to fill by stakeholders: System designers, analog designers, experts in cybersecurity… benefiting from additional knowledge in machine learning and/or advanced programming.

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DETAILED DESCRIPTION OF CRITICAL SKILLS

A detailed description of critical skills is provided in Annex 5.

IMPACT OF EMERGING TECHNOLOGIES ON SKILLS NEEDS

The microelectronics sector and the skills required for its workers have evolved drastically in the last years due to innovation waves. This trend will carry on in the coming decades. Moore's Law has been the most impactful technological trend for the past 50 years, leading to cost reduction of computational power and miniaturization of microelectronics. For instance, in 2001, 8-bit microprocessors with 64 kb of memory were used in white goods. In 2011 those figures were 1 GHz for TV with 4 GB of memory. However, Moore's Law is slowly approaching to its end with ever rising investment and R&D costs required to progress in Moore's Law. Advanced packaging technics appears as solutions to pursue the Moore's law and continue the miniaturisation process, from manometers to angstroms. Over the coming decade and for Europe especially, innovation drivers for the microelectronic sector should come from "More than Moore" developments.

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Table 2: Technologies assessed since 2020 within ECSA and METIS

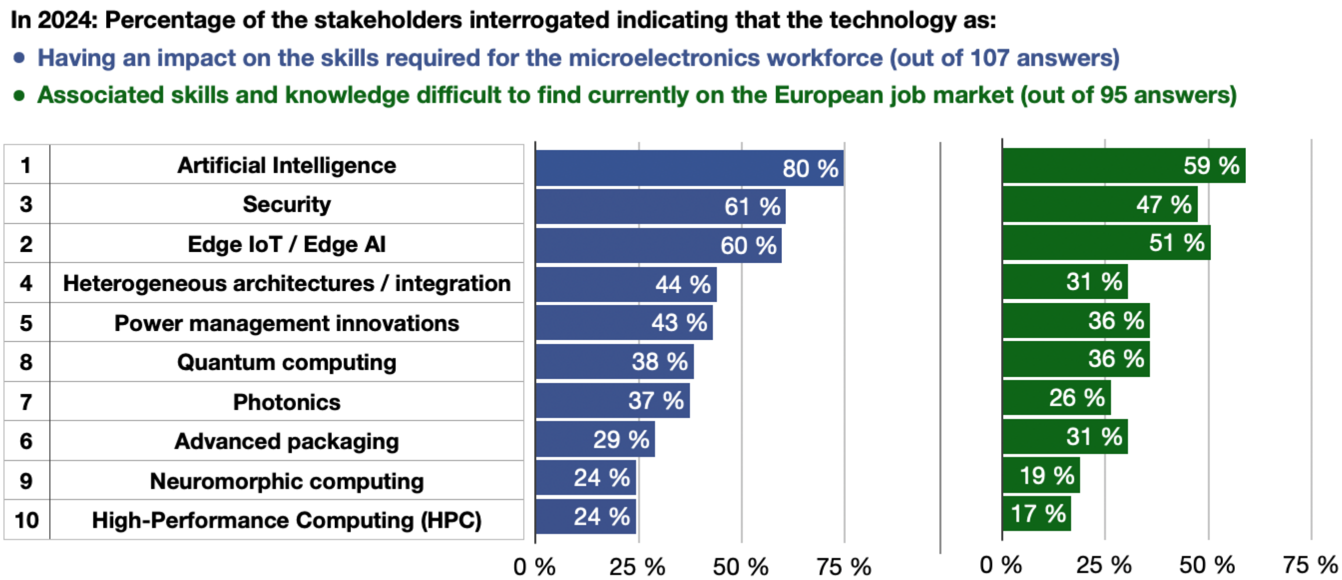
Technology	Description
Artificial Intelligence	Tiny Machine Learning (ML), Deep Learning (DNN, CNN), Low-power hardware for ML...
Edge IoT / Edge AI	Design of emerging systems (SoC, SiP, complex ASIC) and modules for Edge IoT and Edge AI
Power management innovations	Power computing, power management innovations, ultra-low power MCU
Security	Cybersecurity by design, lightweight cryptography, post-quantum cryptography, etc.
Advanced packaging	SiP, Fan-In, Fan-Out, WL CSP, Advanced IC substrates (Flip chip-based packages), Stacking technologies (2.5D & 3D), embedded die.
Heterogeneous architectures / Integration	
Photonics	Integrated photonics, photonic interconnection networks...
Quantum computing	
Neuromorphic computing	
High-Performance Computing (HPC)	

Source: 2024 ECSA Survey / METIS Yearly Monitoring Report 2023 / DECISION Etudes & Conseil

The diagram below shows the ranking of 10 technological fields by the stakeholders interrogated in 2024, answering the two following questions:

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

Figure 26: Shares of stakeholders indicating the technology as impactful or difficult to find from the results of the 2024 ECSA Survey



Source: 2024 ECSA Survey / METIS Yearly Monitoring Report 2023 / DECISION Etudes & Conseil

Overall, the trend in the impact of skills has remained consistent with previous years, except for Security, which has surpassed Edge IoT/Edge AI to become the second most impactful field affecting the microelectronics workforce in 2024. Quantum computing has also moved to the 6th position in terms of impact, whereas it previously ranked after Photonics and Advanced Packaging. This shift in quantum computing's impact aligns

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with its growing prominence and potential overall impact in every industry beyond the semiconductor industry, as well as the development of EU Chips Act initiatives in Quantum.

Neuromorphic computing and HPC continue to be regarded as the least impactful fields on the European job market, according to stakeholders' responses this year and in past surveys.

Artificial Intelligence remains the most impactful technological field in terms of skill requirements for the microelectronics workforce, and it is also identified as the most challenging skill to find in the European job market.

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EU TALENT GAP BY JOB PROFILE

This chapter presents an overview of the semiconductor industry workforce on EU soil in 2023, broken down by job profiles in figures. It includes forecasts of job openings by 2030 and concludes with predictions of talent gaps by job profile, offering guidance for EU training providers to adjust their offerings accordingly.

The data presented are based on a custom model developed by DECISION Etudes & Conseil, drawing from Eurostat, Cedefop, annual reports from key companies with facilities in the EU, in-house data from several universities (e.g., TU Graz, TU Delft), and confidential data from five major companies and Research and Technology Organizations (RTOs) within the EU.

EU WORKFORCE BREAKDOWN BY JOB PROFILE IN 2023

The 2023 semiconductor workforce distribution in the EU27, comprising 382,000 employees, reveals that engineers represent the largest portion at 49%, followed by support functions at 26%, and technicians at 25%.

Manufacturing positions represent the main category with 33% of the total workforce, encompassing process technicians and engineers (21%), maintenance technicians and engineers (5%), operators / quality inspectors (3%), quality & reliability engineers (2%), and robotic / automation technicians and engineers (2%).

Design and test positions come in second, representing 17.5% of the workforce (8% design engineers, 6% test engineers, 3% test technicians). This includes digital designers, analog designers, systems designers, test engineers and test technicians, but also layout engineers, modelling / simulation engineers, design enablement engineers, verification engineers and characterization engineers, as shown in the table below.

Application engineers, in charge of specific products serving verticals, account for 10% of the workforce.

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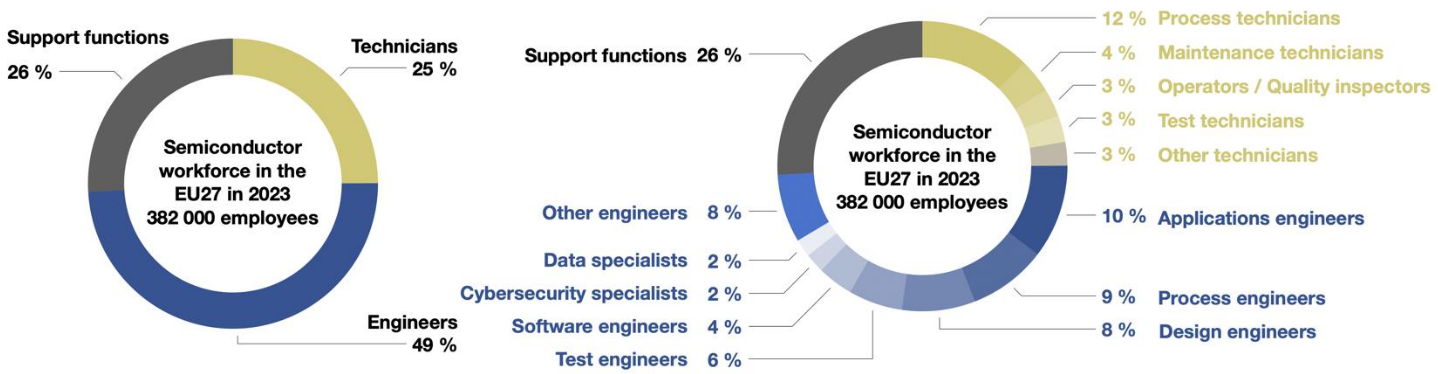
When examining the smaller shares, profiles like software engineers, data specialists and cybersecurity specialists account respectively for 4%, 2% and 2% of the workforce. These profiles do not account for a large share of the workforce in 2023 but are among the most in-demand and the fastest growing profiles by 2030.

Figure 27: Distribution of the semiconductor workforce on EU soil in 2023



(The workforce needed to build semiconductor fabs is not considered).

Source: DECISION Etudes & Conseil

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Figure 28: Distribution of job profiles in the EU semiconductor workforce in 2023

Distribution of job profiles in the EU semiconductor workforce in 2023				Number of employees in 2023	%
TOTAL				382000	100 %
Technicians	TOTAL			95532	25 %
			Process technicians / Manufacturing technicians	47 368	12 %
			Maintenance technicians	14 643	4 %
			Operator / Quality inspector technicians (quality & handling methods, plant safety, infrastructure logistics)	11 938	3 %
			Test technicians, characterization technicians	11 460	3 %
			Application technicians, working with application engineers on products development	6 303	2 %
			Robotic / Automation technicians	2 865	1 %
			Design enablement technicians	955	0,3 %
Engineers	TOTAL			188038	49 %
	Hardware engineers	TOTAL		146 744	38 %
		Application engineers	Application experts, product development engineers	39 927	10 %
		Process engineers	Manufacturing engineers, smart manufacturing engineers, additive manufacturing engineers, material engineers	33 370	9 %
		Design engineers	TOTAL	31 286	8 %
			Digital designers	10 429	3 %
			Modeling / simulation engineers	5 065	1,3 %
			System designers / architect	4 767	1,2 %
			Layout engineers	4 022	1,1 %
			Design enablement engineers	3 725	1,0 %
			Analog designers / Mixed-signal designers	3 278	0,9 %
		Test engineers	TOTAL	23 092	6 %
			Test engineers	11 174	2,9 %
			Verification engineers	6 704	1,8 %
			Characterization engineers	5 214	1,4 %
		Material engineer, expert for new materials		2 980	0,8 %
		Quality & reliability engineers	Reliability engineer / Functional safety engineers, failure analysis engineers, quality expert	7 449	2,0 %
		Robotic / Automation engineers		4 469	1,2 %
		Maintenance engineers / Field service engineers		4 171	1,1 %
	Software engineers		Software developer, embedded / firmware / cloud software engineer, software designer, compiler specialist	15 280	4 %
	Data specialists	TOTAL		7 640	2,0 %
			Data analysts		
			Data scientists		
			Data engineers		
		Machine learning engineers	AI application engineers		
			AI hardware engineers / Edge AI engineers		
	Other engineers	TOTAL		18 374	5 %
			Experts in cybersecurity	8 277	2,2 %
			Managers / Directors	7 615	2,0 %
		Sustainability and Recycling	Electronic Waste Recycling Specialists	2 483	0,7 %
			Lifecycle Analysts		
			ESG (Environmental, Social, and Governance) experts		
Support functions	Administrative, accounting, etc.			99320	26 %
			Marketing / sales engineers	11 422	3 %
			Supply chain specialists / logistics	3 311	0,9 %

(The workforce needed to build semiconductor fabs is not considered). Source: DECISION Etudes & Conseil

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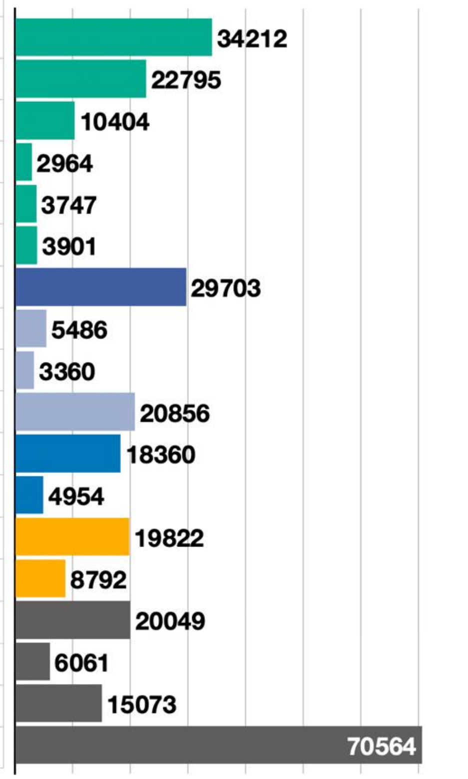
PROJECTED JOB OPENINGS BY JOB PROFILE IN THE EU (2024-2030)

The figure below provides a forecast of the job openings by job profiles from the semiconductor industry on EU soil from 2024 to 2030.

Figure 29: Number of new job openings on EU soil 2024-2030

Field	Job openings on the EU market by Job Profile from 2024 to 2030		% total	Per year
	TOTAL job openings	**271 400**	**100 %**	**45233**
Manufacturing (78 000) (29%)	**Process engineers**	34 212	13 %	5 702
	Process technicians	22 795	8 %	3 799
	Maintenance technicians	10 404	4 %	1 734
	Maintenance engineers	2 964	1 %	494
	Operator / quality inspector technicians	3 747	1 %	624
	Others (Automation, materials, quality / reliability)	3 901	1 %	650
Design (29 700) (18%)	**Design engineers and technicians**	29 703	11 %	4 950
	Of which system designers	5 486	2 %	914
	Of which analog designers	3 360	1 %	560
	Others (digital, layout, simulation, enablement)	20 856	8 %	3 476
Test (23 300)	**Test engineers** (test, verification, characterization)	18 360	7 %	3 060
	Test technicians	4 954	2 %	826
ICT (28 600)	**Software engineers**	19 822	7 %	3 304
	Data specialists	8 792	3 %	1 465
Application engineers		20 049	7 %	3 342
Experts in cybersecurity (by design, secure HW)		6 061	2 %	1 010
Other technical positions (Sustainability, management, etc.)		15 073	6 %	2 512
Support functions		70 564	26 %	11 761



(Only long-term needs, not considering the workforce needed to build the fabs). Source: DECISION Etudes & Conseil

29% of the job openings will also be related to manufacturing positions: 34 000 process engineers, 23 000 process technicians, 10 400 maintenance technicians…

Nearly 30 000 positions will also open for design-related positions (digital designers, system designers, analog designers, layout engineers, simulation / modelling, design enablement).

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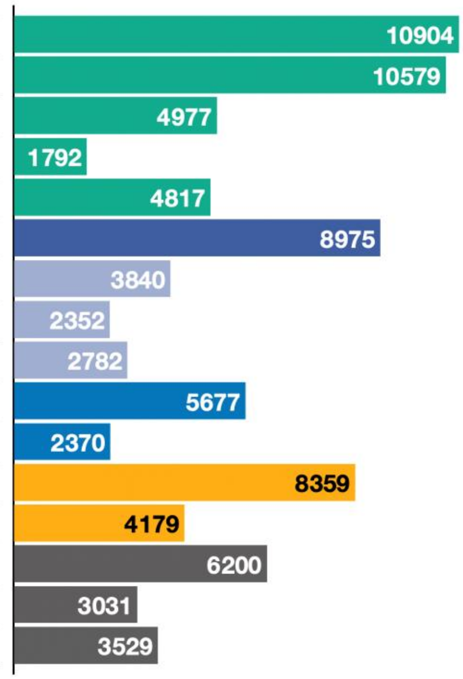
In total, design and test will represent 53 000 job openings (27% of the total).

EU TALENT GAP BY JOB PROFILE (2024-2030)

Finally, and most interestingly, the figure below presents the talent gap by job profile from 2024 to 2030. In other words, these numbers correspond to the number of job positions that will not be filled if no specific action is undertaken, or which will be filled with candidates whose education and experience do not fit the job position requirements.

Figure 30: EU Talent Gap by Job Profile (2024-2030)

Field	EU Talent Gap by Job Profile from 2024 to 2030		% total	Per year
	TOTAL workforce shortage	**75387**	**100 %**	**12565**
Manufacturing (33 000)	**Process technicians**	10 904	14 %	1 817
	Process engineers	10 579	14 %	1 763
	Maintenance technicians	4 977	7 %	829
	Operator / quality inspector technicians	1 792	2 %	299
	Others (Automation, materials, quality / reliability)	4 817	6 %	803
Design (9 000)	**Design engineers**	8 975	12 %	1 496
	Of which system designers	3 840	5 %	640
	Of which analog designers	2 352	3 %	392
	Others (digital, layout, simulation enablement)	2 782	4 %	464
Test (8 000)	**Test engineers** (test, verification, characterization)	5 677	8 %	946
	Test technicians	2 370	3 %	395
ICT (12 500)	**Software engineers**	8 359	11 %	1 393
	Data specialists	4 179	6 %	697
Application engineers		6 200	8 %	1 033
Experts in cybersecurity (by design, secure HW)		3 031	4 %	505
Other technical positions (Sustainability, etc.)		3 529	5 %	588



(Only long-term needs, not considering the workforce needed to build the fabs). Source: DECISION Etudes & Conseil

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Key messages can be derived from the above table and more generally this report's findings, to tackle the EU semiconductor talent gap:

1. **The EU ecosystem needs to establish new, specialized training curricula to equip the workforce with skills tailored to highly specific job profiles (system designers, analog designers and experts in cybersecurity).**

   By 2030, the EU semiconductor industry lacks 3 800 system designers, 2 350 analog designers, and 3 000 experts in cybersecurity.

   Each of these profiles requires very specific trainings, from Bachelor to Master, plus several months or years of work experience.

   To date, very few training programs exist in the EU to form skilled system designers, analog designer or expert in semiconductor cybersecurity. A huge gap exists with the needs from the industry, and it will not be possible to rely on foreign workforce as these profiles are also in shortage in every region of the world.

   Therefore, specialized training hubs needs to be set up in the EU, capable of producing on a yearly basis at least 600 systems designers, 400 analog designers and 500 semiconductor security specialists. Although the number of graduates needed is not that high, building such training hubs will be the only way to cope with the shortage. Action is urgent as it will take years for these training hubs to be set up and to provide skilled graduates with at least a limited first work experience.

2. **The EU semiconductor industry needs to find ways to attract existing graduates on the EU market for ICT profiles (software engineers and data specialists).**

   By 2030, the EU semiconductor industry lacks 12 500 software engineers and data specialists (machine learning engineers, data engineers, data analysts, data scientists). However, these profiles largely exist on the EU job market, and EU universities are already rising their training capacities for such profiles for years. The solution to tackle the talent gap for these profiles is not to expend training capacities, but to attract the existing workforce in the EU to work for the semiconductor industry through communication campaigns and by offering proper wages and working conditions.

   Additional on-the-job training on the specificities of the semiconductor industry might be required.

   Finally, there is room for the setting up of joint curricula in electrical engineering and data science.

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3. **Overall, the EU lacks graduates in electrical engineering to serve the EU semiconductor industry.**

Finally, by 2030, the EU semiconductor industry lacks 33 000 workers in the manufacture of semiconductors, nearly 11 000 workers in design & test (in addition to system and analog designers mentioned above), 6 200 application engineers and 3 500 other technical positions. In total, nearly 54 000 workers are missing in these positions, because of the lack of graduates in electrical engineering in the EU.

To tackle this talent gap, there is an urgent need to raise the number of graduates in electrical engineering willing to work for the semiconductor industry in the EU. To reach this goals, two main and complementary actions must be undertaken:

- Expand training capacities in electrical engineering in the EU (Bachelor and Master).
- Launch communication campaigns to attract students to pursue electrical engineering studies and work for the semiconductor industry.

The issue is indeed two folded: Expanding training capacities in electrical engineering will not be enough if students are not attracted by such studies and by working for the semiconductor industry.

Intra-EU migration could be a short-term solution, as several member states have a relatively limited semiconductor ecosystem compared to the number of their graduates in semiconductor-related fields: Spain, Romania, Greece, Bulgaria, and Croatia.

Extra-EU migration can also serve as a short-term migration, for instance with India regarding design and test needs.

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RECOMMENDATIONS

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 (see table 3). 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 3: Summary of main recommendations

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 OPTIMISING THE USE OF THE AVAILABLE LABOUR SUPPLY

UPSKILLING AND RESKILLING WITH LIFE-LONG LEARNING PROGRAMMES

This proposition was the 1st most cited in 2020. It is the 1st in 2023 and the 1st in 2024.

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 labour to be temporarily utilised 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:

Harmonise 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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FAVOR INTRA AND EXTRA-EU MOBILITY WHILE RETAINING LOCAL TALENT

This point came in 6th place of importance in 2020. In 2023 and in 2024. It is the 4th most cited policy recommendation by respondents.

Facilitating intra-EU labour 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 harmonise 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[24]. 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 uniformise 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

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

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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, 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.

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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.

LONG TERM RESPONSE: ANTICIPATE FUTURE INDUSTRY NEEDS

EXPAND AND ADAPT ACADEMIC AND IVET PROGRAMMES

This proposition was the 1st most cited in 2020, 2023 and 2024, with respondents assigning it the same level of importance as life-long learning 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.

Increase training capacities in targeted fields:

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

1. Electrical engineering. By 2030, the semiconductor industry in the EU will face a shortfall of nearly 62,000 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. Specialized Degrees for the Semiconductor Industry. Current training capacities for certain specialized roles within the semiconductor industry are significantly below the sector's needs. For these profiles,

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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:

- System designers. By 2030, the EU will face a shortage of 3,800 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.

- Analog designers. By 2030, the EU will lack 2,400 analog designers. These professionals need training in electrical engineering, RF, digital semiconductor design, and specifically, mixed 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 3,000 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 81,000 jobs in the EU semiconductor sector by 2030. In contrast, joint programs combining Electrical Engineering with fields such as Marketing/Sales/Communication (2,600 job openings) or Biology/Natural Sciences (2,000 job openings, primarily in R&D, material, or application engineering) are projected to see much lower demand by 2030.

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Table 4: 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					81 000
Artificial Intelligence / Machine Learning		V				81 000
Chemistry / Material science (Polymer etc.)			V			34 200
Marketing / Sales / Communication				V		2 600
Biology / Natural science					V	2 000

Source: METIS (MicroElectronics Training Industry and Skills) project, "Yearly Monitoring Report 2023".

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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.

FOSTER SEMICONDUCTOR ECOSYSTEMS

This proposition was the 3rd most cited in 2020, 2022 and 2024

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:

Figure 31 illustrates the main semiconductor clusters in the EU.

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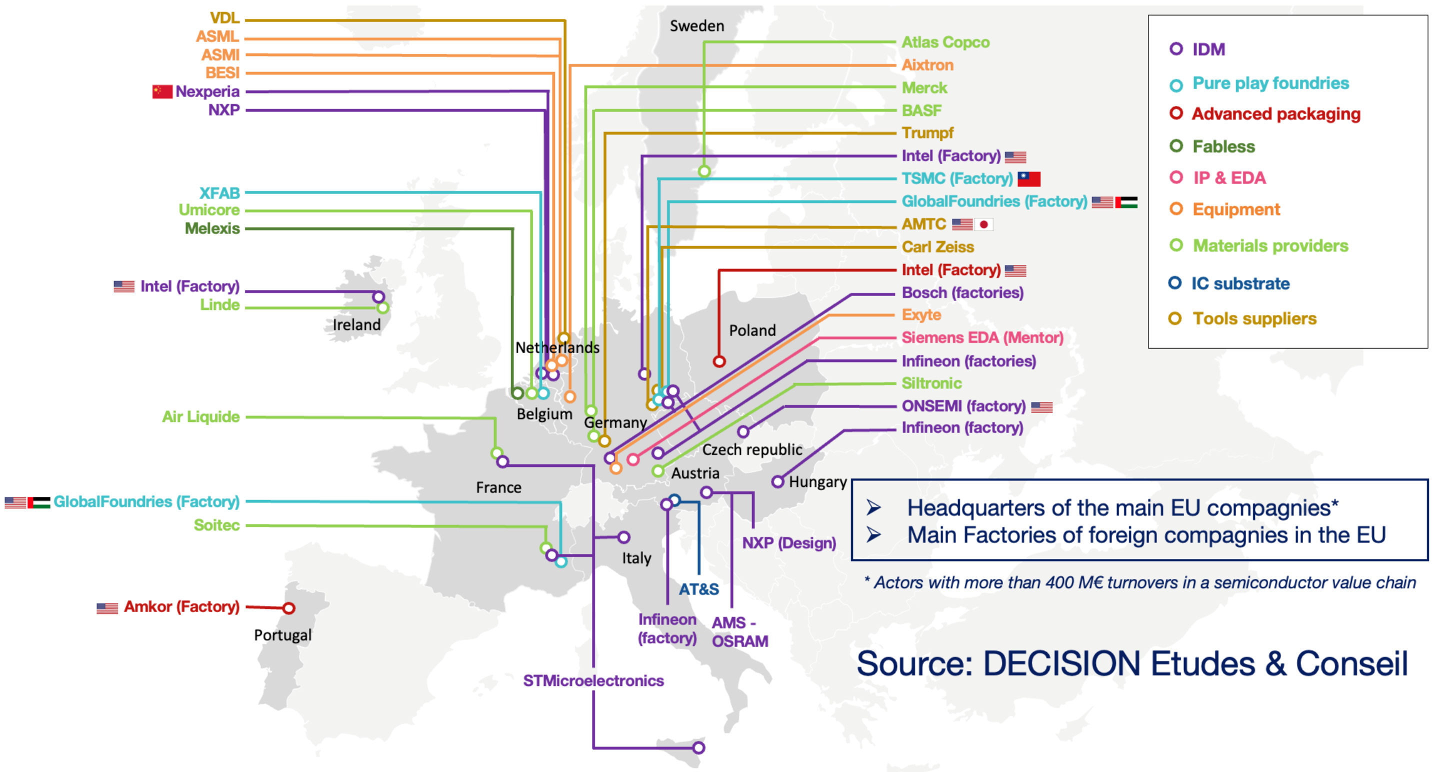
Figure 31: The main semiconductor cluster in the EU



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.

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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.

COMMUNICATION CAMPAIGN TO PROMOTE THE SEMICONDUCTOR INDUSTRY

This proposition was the 4th most cited in 2020. It is the 2nd in 2023 and 2024.

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[25] 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[26].

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

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

[26] 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 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.

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:

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Emphasizing on Work-Life Balance and Flexibility: 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.

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.

IMPROVE GRANULARITY OF EMPLOYMENT AND GRADUATES DATA

This recommendation stems from the quantitative analysis conducted to estimate the talent gap, rather than the online survey results, as the relevant question was not included in the survey.

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

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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 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[27].

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.

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

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ANNEXES

ANNEX 1 - CLASSIFICATION OF JOB PROFILES BY MAIN OCCUPATION USED FOR THE QUANTIFICATION OF THE TALENT GAP

Table: Classification of job profiles by main occupation used for the quantification of the talent gap

Main occupation	Description	Job profile
Technicians	Semiconductor technicians operate, maintain, and troubleshoot equipment used in the manufacturing of semiconductor components.	Test technician: Electrical test technician, environmental and life-time test technician, troubleshooter technician, quality technician
		Maintenance technician: Electrical technician, breakdown technician
		Process technician: Manufacturing (support) technician
		Test engineer: Product test engineer, test engineer, Design For Test (DFT) engineer, associate test engineer, senior test engineer

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		Operator / Inspector: Machine operator, inspector, repair operator, general labourer
Hardware engineers	Semiconductor engineers research, develop, and improve semiconductor devices and fabrication processes.	Design engineer: designer, Electrical design engineer, electrical project engineer, electrical product engineer, product development engineer
		System design engineer (complex ASIC, SoC, SiP, SoP)
		Analog design engineer
		Digital design engineer
		Process engineer: Manufacturing (support) engineer, quality engineer
		Robotic engineer: Electrical automation engineer, control system engineer, PLC programmer engineer
		Computer engineer
		Power electronics engineer

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		Material engineers
		Marketing engineer
		Application engineer
Software engineers	software engineers apply computational principles and algorithms to design and develop software solutions and computer systems for semiconductor-based technologies. They manage the complete software development lifecycle, including coding and testing, while ensuring adherence to product specifications, cost, quality, and timing.	Software engineer
		Embedded / Firmware / Cloud software engineer ;
		software designer
Data specialists	Data specialists are in charge of the exploitation of the data generated within the manufacturing process to improve them. They are well-versed in databases, big data technologies, and the design and implementation of Big Data architectures and software platforms	Data scientist
		Data analyst
		Data engineer
		Machine learning engineer

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Others	General services, management, administration, human resources, sales, etc.	

Source: DECISION Etudes & Conseil

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ANNEX 2 - CORRESPONDENCE TABLE BETWEEN TU GRAZ MASTER'S DEGREE PROGRAMMES RELATED TO SEMICONDUCTOR INDUSTRY AND ISCED FIELDS OF EDUCATION

Table: Correspondence table between TU Graz Master's Degree Programmes related to semiconductor industry and ISCED fields of Education

ISCED Fields of Education	TU Graz Master's Degree Programmes
0714 « Electronics and automation »	« Electrical engineering » ; « Computer science » ; "Electrical engineering and Business";
0715 « Mechanics »	« Mechanical Engineering »
0711 « Chemical and Process »	« Chemical and Process Engineering » ; "Biotechnology" ; "Technical Chemistry"
0613 "Software and applications developments"	"Software Engineering and Management"
0612 "Database and network design and administration"	"Information and Computer Engineering"

Source: DECISION Etudes & Conseil

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ANNEX 3: METHODOLOGY NOTE OF ECSA SURVEY 2024

The qualitative analysis was carried out based on the results of the ECSA Survey 2024. This year's survey follows the structure of past years surveys that have been carried out in the METIS project. 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

This year, other questions have been added to the survey to complement the analysis, especially:

- The stakeholders' hiring plans in 2024 compared to 2023
- The perception of the skills shortage in 2024 compared to 2023

This year, 130 stakeholders from 19 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 15 member-states alongside the UK, Switzerland and Turkey in Europe, and the US. Within the EU, the coverage was overall well-balanced between the member-states.

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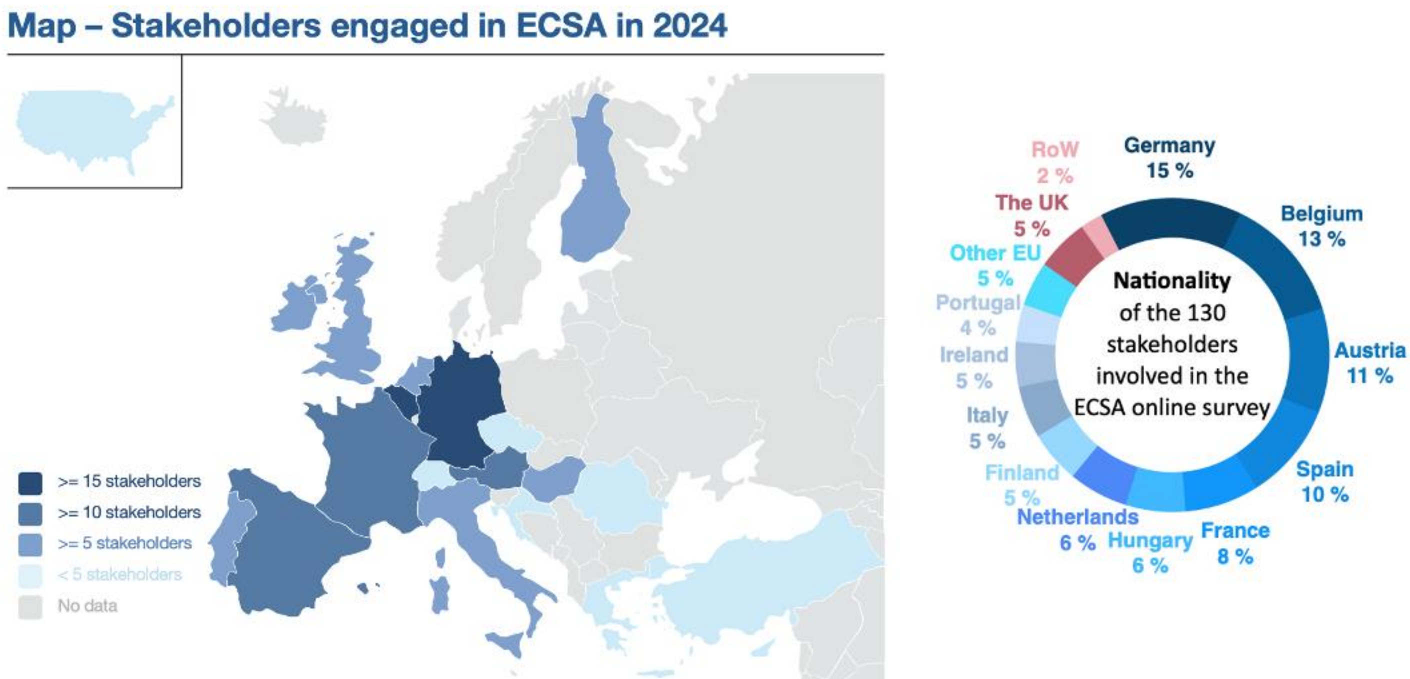
Figure: Geographic distribution of stakeholders engaged in the 2024 ECSA Survey



Source: DECISION Etudes & Conseil

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

This year’s survey gathered responses across 79 different organizations, with a balanced distribution of SMEs, large companies, universities and RTOs.

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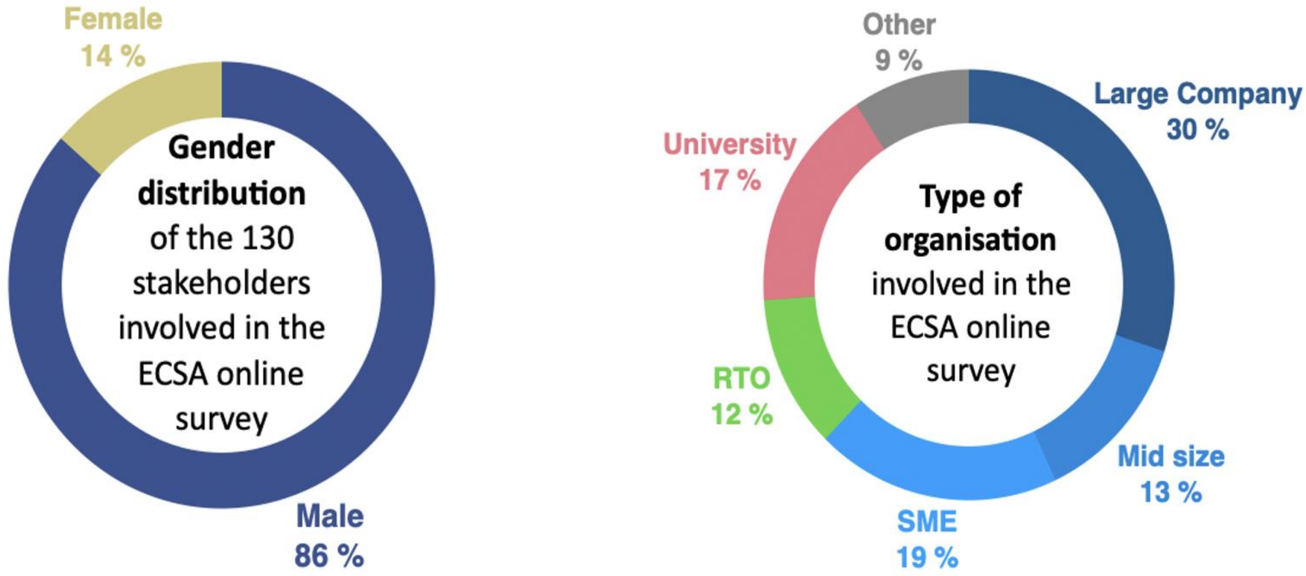
Figure: Distribution of the gender and type of organisation involved in the 2024 ECSA Survey



Source: 2024 ECSA Survey, DECISION Études & Conseil

The 2024 ECSA survey includes stakeholders from the entire semiconductor value chain: 53% semiconductor companies (IDMs, fabless & IP, equipment and tools, or materials), 8% respondents from end-user electronics systems or services, 12% semiconductor Research & Technology Organizations (RTO), and 11% other organisations.

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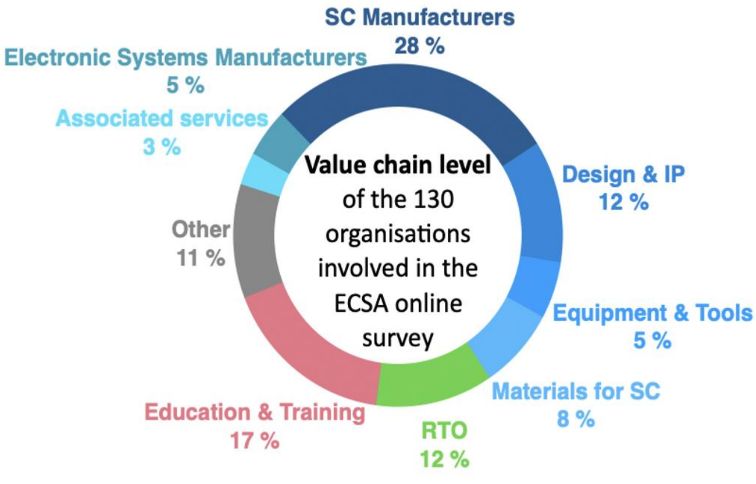
Figure: Distribution of the organization's position in the value chain and profiles of the stakeholders participating in the 2024 ECSA Survey



Source: 2024 ECSA Survey, DECISION Études & Conseil

Various types of profiles are also represented within respondents: 25% CxO, 16% Human Resources, 15% engineers, 4% public affairs / Business Development, 15% researchers, 17% professors and 8% others (consultants, project managers…).

The results show a slight bias towards engineering roles, as 15% of respondents hold engineering positions (e.g., analog designer), while none hold technician positions.

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ANNEX 4 – HOW ARE ARTIFICIAL INTELLIGENCE, PROGRAMMING AND DATA ANALYSIS

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.

ANNEX 5 – DETAILED DESCRIPTION OF CRITICAL SKILLS

1)Machine learning / Artificial Intelligence

Knowledge and skills associated to 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.

<u>Educational level (EQF):</u> Trainings to be provided from EQF 6 to EQF 7.

<u>Associated job profiles:</u>

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

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

- <u>Ability to identify/ select/ implement the machine learning toolsets</u> for manufacturing (design, automation, etc.), and/or ERP.

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- 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 of 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 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

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should be viewed as complementary to SoC. For some very high-volume applications SoC will be the preferred approach.

- System-on-Package (SoP)[28] 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.

Associated job profiles:

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

[28] "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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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.

- 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

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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:

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- 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.).
- 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

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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:

- 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).

Educational level (EQF): Trainings to be provided from EQF 7 to EQF 8.

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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).

The main skills and knowledge associated are:

- Knowledge of new materials: 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.
- Knowledge in chemical and physical sciences (e.g., nanostructures). Basic knowledge in chemistry (missing in many curricula).
- Environmental awareness associated to traditional and new materials.
- Ability to link a material with production processes, product(s) specification(s) and end-user applications.

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.

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

Associated job profile:

- 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.

Content / sub-skills and sub-knowledge:

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

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- Algorithm optimization. This skill is increasingly sought-after by industrials.

- Performance Data Analysis: Analysing performance data.

7) Quality / reliability

Knowledge associated to 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 equalling 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 defense 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

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- 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).
- 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.

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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.

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.

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- 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.

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.

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- 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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