Deliverable D2.3 - METIS Skills Strategy

Co-funded by the Erasmus+ Programme of the European Union

DELIVERABLE D2.3 METIS Skills Strategy

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Abstract

METIS (MicroElectronics Training Industry and Skills) is a Sector Skills Alliance, co-funded by Erasmus+, implementing a strategic approach to sectoral cooperation on skills aiming to bridge the microelectronics skills gap in Europe. It is a 4-year project from November 2019 to October 2023, involving 19 partners from 13 countries, coordinated by SEMI Europe: Industrials (Infineon, Bosch, X-Fab, Arcelik, Graphenea, Summa Semiconductor, Silicon Saxony), training & education organisations (TU Graz, IMEC academy, SBH Sudost, TU Sofia, USN, BME and IAL-FVG), social partners (WiTEC and EACG), a regulatory body (CIMEA), and a market research & intelligence firm (DECISION Etudes-Conseil).

The first step of the METIS project, in 2020, has consisted in building an EU sectoral skills strategy and a methodology to monitor and anticipate skills in the European microelectronics industry. A multi-stakeholder's approach has been adopted and 10 Focus Groups, 50 live interviews, an online survey and market research have been carried out during the year 2020, leading to this report entitled "METIS Skills Strategy".

This report identifies the **trends, challenges and opportunities associated to the skills needs in the European microelectronics industry**. The position of the European microelectronics industry in the global competitive landscape is assessed. The specificities of the European microelectronics workforce are described, and figures are given for the microelectronics workforce by EU country, the supply capacity of microelectronics workforce by EU country and the intensity of the demand on the European microelectronics job market. The incoming challenges for the European microelectronics workforce are identified, especially regarding the fast-changing technological landscape. The impact of COVID-19 on the European microelectronics industry, workforce and educational system is described. Finally, this report makes a state-of-play regarding diversity in electronics.

This report summarizes the **skills needs of the European microelectronics industry**. The microelectronics skills gaps in Europe are described and the main mismatches on the current European microelectronics job market are identified. The most critical microelectronics skills and knowledge from the industry are listed as well as their associated job profiles, and the impact of emerging technologies on skills is assessed.

Finally, this report presents a **strategy to face the European microelectronics skills challenge**. This report identifies a serie of best practices (HR policies, policy initiatives…), proposes new occupational profiles for microelectronics for the ESCO platform and details a strategy to face the European microelectronics skills challenge with a serie of policy recommendations.

Table of contents

I. Identify trends, challenges and opportunities in microelectronics

A. EU policy developments and contribution of the METIS Skills Strategy to relevant EU policies

METIS can contribute significantly to EU skills policy developments and provide valuable inputs to strengthen EU skills in the microelectronics sector. The METIS project fully embeds social (diversity & inclusion), environmental sustainability (circular economy) issues and EU policy goals in workforce development, and its developments resonates with EU policies, particularly on:

- Supporting **Pact for Skills**. METIS provides reskilling and upskilling opportunities in the microelectronics sector. Pact for Skills is a new EU initiative launched in July 2020, and it is a new engagement and governance model that will support upskilling and reskilling in Europe. Industry, public and private employers, social partners, chambers of commerce, education and training providers and employment agencies are invited to work together and to create a shared vision and actions. In particular, the Pact supports strategic industrial ecosystems to build large-scale partnerships, aiming to unlock public and private investments in waves until 2025. METIS can contribute to the Pact for Skills by providing the basis to develop a microelectronics ecosystem. The experience and outcomes of the project can nourish the long-term reskilling and upskilling efforts of Pact for Skills, by identifying the industry's skills priorities and needs. The METIS consortium finds the launch of Pact for Skills very timely and crucial to advance the talent pool underpinning Europe's deep digital ecosystem. The Pact will play an instrumental role in improving the scope and the quality of training partnerships at regional, national and European levels, by sharing best practices and helping the microelectronics industry and workforce adapt to the effects of COVID-19.
- Supporting the EU **Green deal**. METIS proposes new skills and corresponding trainings on sustainability and environment to ensure that the microelectronics sector will support the implementation of the EU Green Deal and prepare the workforce with skills on sustainability and climate action, as well as environmental knowledge, particularly in the field of component and system design, semiconductor materials, manufacturing and Edge AI. In the 4 new ESCO profiles proposed by METIS, such skills are considered as essential.
- Supporting the EU's **Circular Economy** strategy. The new ESCO profiles proposed by the METIS project have included skills and knowledge on circular economy. As well, METIS has identified needs for skills and corresponding training to ensure that the principle of circular economy is implemented from design and through the entire value chain of the sector.
- Supporting the EU's **AI strategy and development of digital skills**. METIS has a focus group dedicated to Edge AI to discuss what skills and knowledge are needed for the development of Edge AI and strengthen EU's competitiveness in AI.
- Supporting the EU's **Gender Equality** strategy. The METIS project has dedicated a focus group and carried out interviews with Human Resource (HR) experts on gender equality topics in order to develop comprehensive understanding of gender issues in the sector and propose strategies to attract more women to study and work in the sector. METIS is also collecting best practices from the industry to share with all stakeholders in order to promote gender equality.

During the project, 24% of stakeholders engaged (among participates of focus groups, interviews and the online survey) are women.

- Supporting the **European Digital Strategy**. The METIS project has identified skill gaps in Europe in the microelectronics sector throughout the entire supply chain and based on the identified skills gaps, the new strategy being formed ensures the EU will have appropriate skills to support implementation of the European Digital Strategy. The METIS project also identified, through focus groups, interviews and the online survey, the kind of skills and training needed for the microelectronics sector to ensure an open, democrat and sustainable digital society in Europe.
- **ESCO** is the European classification of skills, competences, qualifications and occupations. ESCO aims to provide a common reference language to mobilize workforce in the European labour market. ESCO can be used for job-searching and skill-match by both the public and private sectors. The METIS project proposed 4 new profiles based on the outcomes of the interviews and the focus group in October 2020.

METIS is also fully relevant and in line with the EU global and sectoral policies:

- EU2020 Strategy: mobilize efforts in microelectronics knowhow and contribute to uptake of high-tech economy in EU.
- 2015 Riga Conclusions: promote work-based learning and continuous industry-VET providers' feedback loops.
- ET 2020: promote mobility across EU in electronics design and manufacturing supply-chain.
- Boosting Electronics Value Chains in EU, report to Commissioner Gabriel, 2018: invest in electronics skills, in particular "design" workforce and skills shortage.
- Digitizing EU Industry Strategy, 2016: adapt workforce, including up-skilling, to align with new digital & market trends such as convergence of engineering, data and business skills.
- Renewed EU Industrial Policy Strategy, 2017: contribute to anticipating future skills needs in KETs.
- EU Pillar of Social Rights, 2017: address future of work and emerging digital labour market and their impact on microelectronics industry.
- Re-finding Industry, 2018: support work-based learning and pave the way for future-oriented and lifelong-learning training.
- Skills for KETs in EU, 2016: help replace the outgoing workforce in microelectronics and increase awareness of the sector among future workforce.
- New Skills Agenda for EU, 2016: develop a business-education-research partnership in microelectronics and support the modernization of VET with blended learning.
- Implementation Plan of the EU Industrial Strategic Roadmap, 2014: support education in cross-disciplinary microelectronics engineering.
- Digital Skills and Jobs Coalition (of which SEMI Europe has been a member): develop advanced technical skills needed for a digital economy.

B. Overview of METIS: Objectives and scope

METIS is a project carried out for the European Commission's Education, Audiovisual and Culture Executive Agency. To develop its competitiveness, the EU microelectronics sector needs to overcome severe skills shortages and to adapt to future needs in terms of skills and competences. METIS stands for **M**icro**E**lectronics **T**raining, **I**ndustry and **S**kills.

In this light, the objectives of the METIS project are to:

- Analyse key global trends affecting the sector and provide strategic insights and foresights.
- Anticipate emerging skills needs, identify jobs of the future, define related occupational profiles and monitor progress in the domain of human capital for microelectronics.
- Develop a Sector Skills Strategy to support the global leadership of the EU microelectronics industry, establishing operational linkages between skills and the future of the sector.
- Federate European synergies towards the needs of data-driven technologies such as artificial intelligence enabled by advanced microelectronics and its skills requirements.
- Establish an EU Microelectronics Observatory & Skills Council.
- Design and deliver a modular and blended curriculum, integrating work-based learning that uses OER.
- Pave the way for the pan-European recognition and certification of innovative VET.
- Use innovative tools such as industry mentoring to facilitate inter-generational transfer of knowledge in the sector.
- Embed social (diversity & inclusion) and environmental sustainability (circular economy) issues and EU policy goals into workforce development.

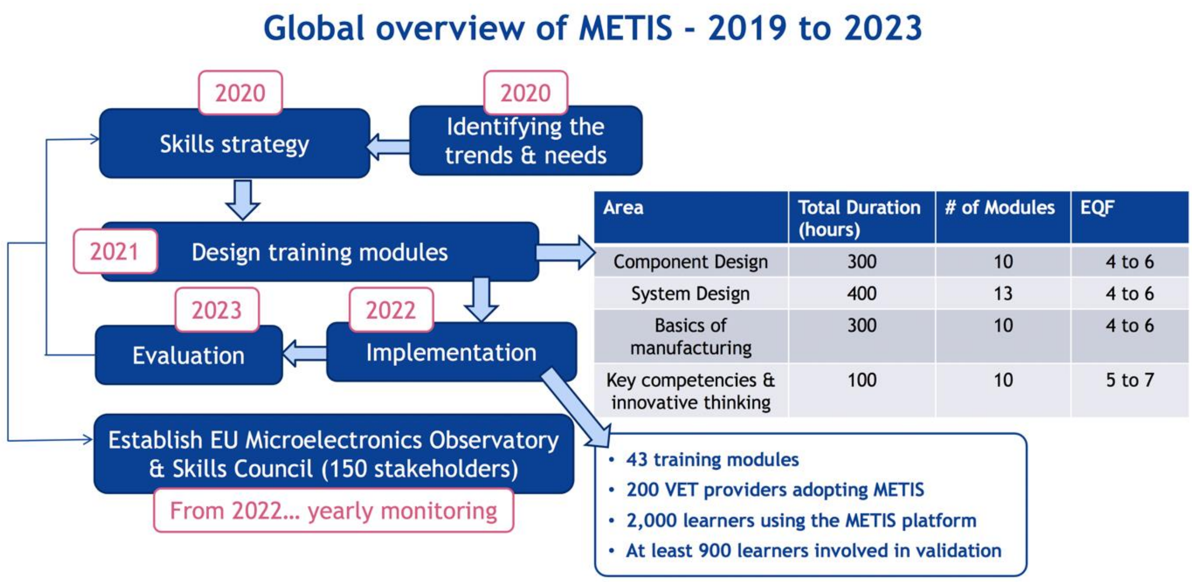
Coordinated by SEMI Europe, METIS embodies EU excellence in microelectronics, with 19 partners from 13 countries representing industry (Start-Ups, SMEs, Large Firms), national and EU industry associations, formal educational providers and regulatory bodies in the field of accreditation and certification.

One of the strategic goals of METIS is to develop the Microelectronics Sector Skills Strategy to support the objectives of the established growth strategy for the sector. To accomplish this, METIS has:

- Developed a common methodology to assess the current situation and anticipate future skills needs.
- Identified the major EU and global trends, challenges and opportunities affecting jobs, and skills needs in the sector. More specifically, METIS has analyzed the main economic and employment trends: changes in occupations, education level and demographic. METIS has pinpointed existing and emerging needs from the labour market (demand side represented by industry) and trigger the responsiveness of training systems at all levels (supply side represented by iVET and cVET).
- Proposed 4 new occupational profiles with corresponding skills and competences using the European Skills, Competences, Qualifications and Occupations classification (ESCO), and defined many more occupational profiles interesting for the European microelectronics industry.

Following the METIS Skills Strategy, METIS will set up continuous and robust monitoring that is carried out on a yearly basis. In particular, METIS will set up an Observatory and Skills Council: A permanent governance structure aiming to anticipate industry and skills development trends and to improve METIS Training and Curriculum.

The diagram below provides the high-level overview of METIS and shows the links between the METIS Skills Strategy and the other pillars of METIS.



As shown in the above diagram, the METIS Skills Strategy will nurture the METIS Work Package 3 (WP3) that will start in early 2021. The objective of WP3 is to develop the METIS curriculum and training on:

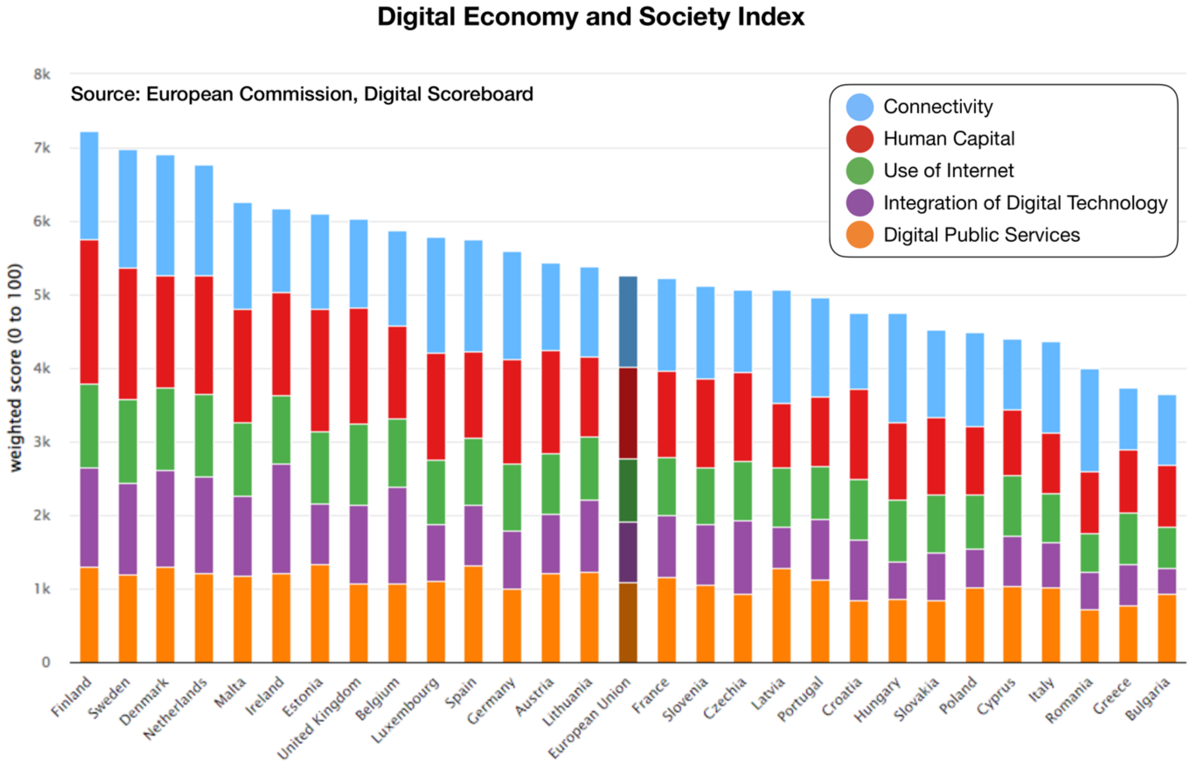
- **Electronic components design** (EQF levels 4 to 6): Provide a first specialisation in microelectronics design covering digital, analog or mixed-signal circuits, (information processing and storage, RF and microwaves, sensors and actuators).
- **Electronic systems design** (EQF levels 5 to 7): Provide a second specialisation in microelectronics design and engineering with a focus on Research & Innovation covering system-on-chip, system–in-package, hardware/software co-design.
- **Basics of electronics manufacturing** (EQF levels 4 to 5): Train the profile of "specialised technician" in microelectronics manufacturing covering topics such as: introduction to advanced materials, processing equipment, production process, testing, packaging, predictive/preventive services.
- **Key competences & innovative thinking**: Provide training on transversal skills and competences required by industry, delivered in OER environment (Open educational resources).

C. The European microelectronics industry

Today, no economy could function normally without advanced Electronic Components & Systems (ECS). From microelectronic components and the systems built around them, to the products, platforms and services they enable, ECS have become the instruments and pillars of nearly all human activities.

ECS has also lead to great societal changes, such as the way consumers and citizens use and are affected by new technologies such as IoT and AI.

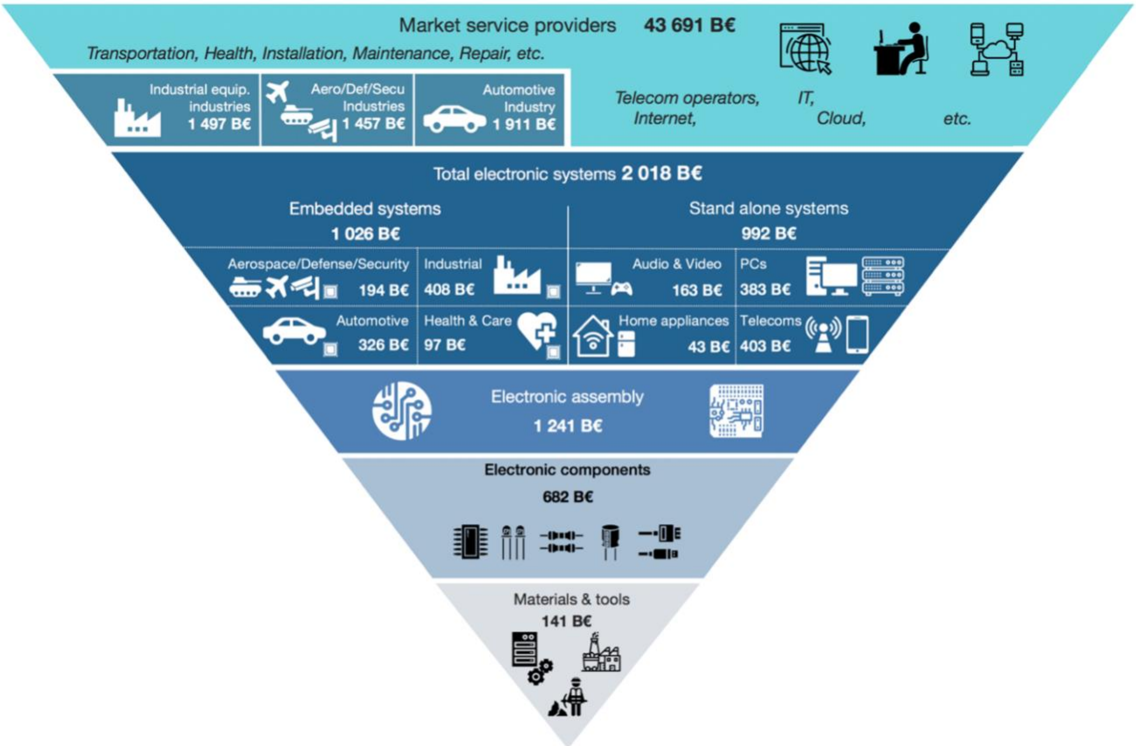
The diagram below shows the Digital Economy and Society Index score of the different EU Member States in 2020[1].



ECS have become the backbone of almost all value chains. The electronics industry relies on, and revolves around microelectronics, the smart integrated circuit chips, the processors, memories, controllers, and sensors that are the core of all electronic systems. This is what makes them all work. The very concept of the pyramid below shows how electronic components and systems diffuse all the way downstream through the global value chain.

[1] The [Digital Economy and Society Index (DESI)]() from the European Commission is a composite index based on the weighted average of the scores (0 to 100) attributed to Member States on various topics (e.g., for Connectivity: Fixed Broadband take-up, fixed broadband coverage, mobile broadband and broadband price index). Visit its website to get the detailed components of the 5 main dimensions of the index.

GLOBAL ELECTRONIC COMPONENTS AND SYSTEMS (ECS) VALUE CHAIN IN 2018



VALUE CHAIN LEVEL	PRODUCTION IN EUROPE	% EUROPE / WORLD	EUROPEAN LEADERS	WORLD LEADERS
SERVICE PROVIDERS	€ 11,054B	25%	Capgemini, SAP, Deutsche Telekom	amazon.com, Google, Microsoft
END-USER INDUSTRIES	€ 980B	20%	AIRBUS, SIEMENS, VW	BOEING, General Electric, TOYOTA
AUTOMOTIVE INDUSTRIES	€ 381B	20%		
AERO/DEF/SECU INDUSTRIES	€ 323B	22%		
INDUSTRIAL EQUIPMENT	€ 276B	19%		
ELECTRONIC SYSTEMS	€ 290B	14%	Atos, ABB, BOSCH, Continental, Schneider Electric	DELL, HUAWEI, Lenovo, SAMSUNG
STAND ALONE SYSTEMS *PC, telecoms, audio & video*	€ 60B	6%		
EMBEDDED SYSTEMS *automotive, industrial, Aerospace/Defense/ Security, medical*	€ 229B	22%		
ELECTRONIC ASSEMBLY	€ 126B	10%	ASTEELFLASH, enics, Zollner	FOXCONN, flex, PEGATRON
ELECTRONIC COMPONENTS	€ 55B	8%	Infineon, NXP, ST life.augmented	intel, tsmc, SAMSUNG
MATERIALS & EQUIPMENT	€ 24B	17%	ASML, exyte, siltronic perfect silicon solutions	TEL, APPLIED MATERIALS, Lam RESEARCH

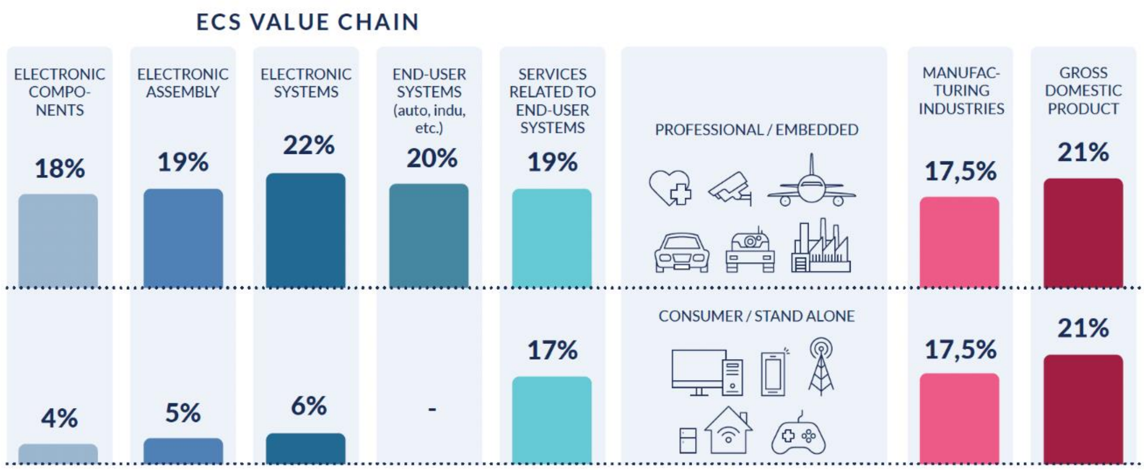
Source: DECISION Etudes & Conseil

On the supply side, electronic components - encompassing microelectronics, sensors, photonics, passive & interconnection components - with a global revenue of around €700B, gives birth to more than €2,000B of electronic products and cyber-physical systems (CPS). The electronics industry in turn generates over €5,000B revenue from cars, trains, ships, airplanes, defence & security systems, and industrial equipment. To top it off, there is currently a huge and surging digital services market that is restructuring our traditional commerce and services activities.

The European ECS industry is specialized in embedded electronics systems (in cars, trains, ships, but also in industrial and energy applications, or in aerospace, defence & security systems). The European embedded ECS value chain is very strong and Europe accounts for 22% of the global production of embedded electronic systems.

- **Automotive electronics**. The automotive industry has always been a domain of excellence for Europe, and today Europe is the first region for the manufacture of automotive ECS, ahead of China and the USA. Among the 15 top global car manufacturers, six are European (Volkswagen, Renault-Nissan, Stellantis, Daimler, BMW). This automotive electronics industry is a key driver of electronics growth and innovation within Advanced Driver Assistance Systems (ADAS), electrification of powertrains, infotainment applications, etc.
- **Industrial electronics.** The mechanical and electric engineering industries (electric equipment, machinery, robotics, rolling stock, etc.) are domains where European production remains strong, and European companies (ABB, Siemens, Schneider, Legrand) are among the world leaders. This industrial electronics industry is another key driver of electronics growth and innovation in Europe, along with the rise of Industry 4.0, Industrial IoTs, robotics, etc.
- **Aerospace/Defence/Security electronics.** The aerospace/defence/security industries have always been European strong areas, this is the result of a long history of technological advances. The USA have become market leaders in this field, but Europe remains second globally, in particular with the European conglomerate Airbus.
- **Health & Care electronics.** The healthcare industry is a crucial and promising field, where European companies Philips and Siemens are among the world leaders.

EUROPEAN ELECTRONIC COMPONENTS & SYSTEMS VALUE CHAIN (% WORLD)

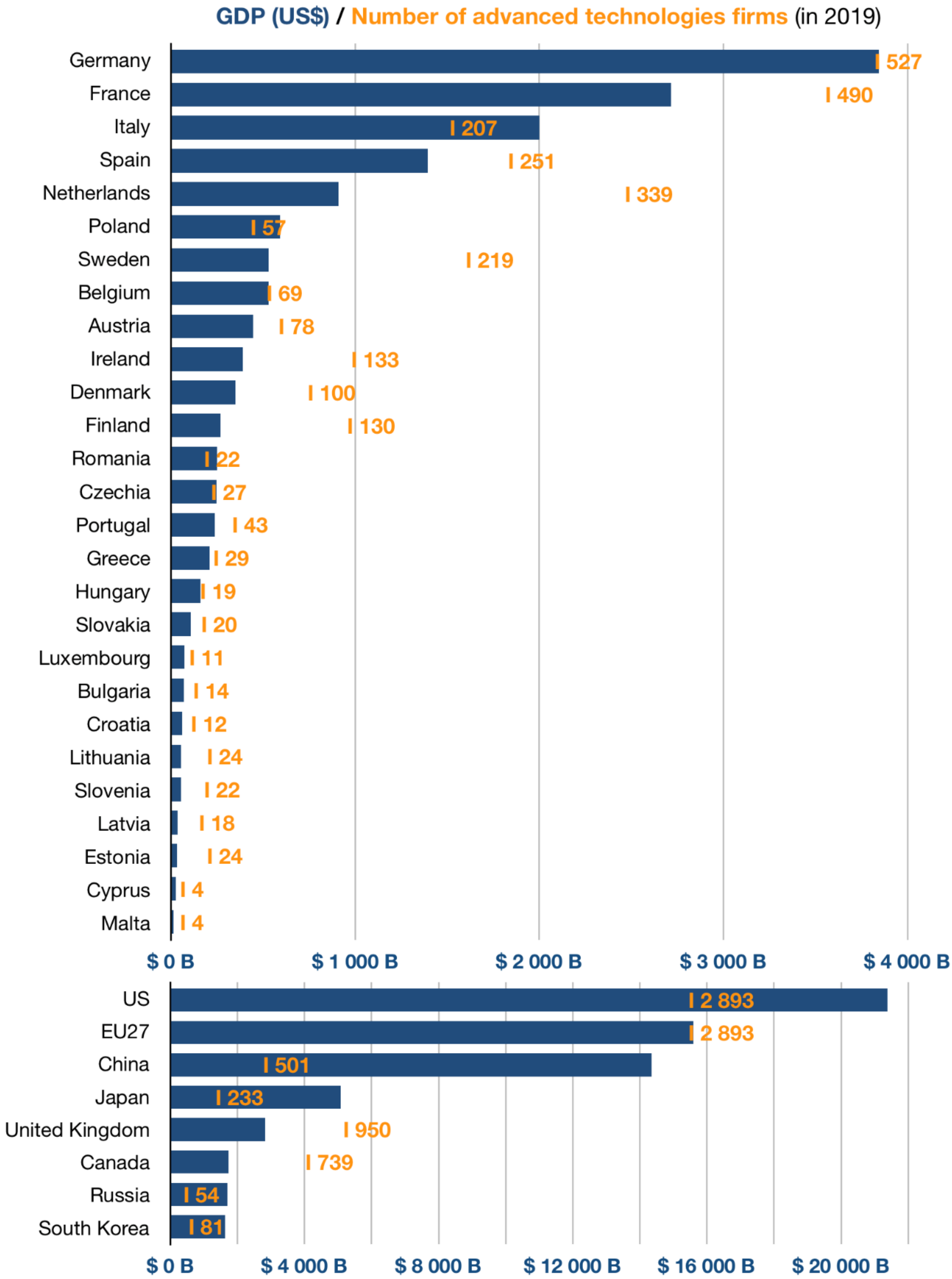


Source: Study on Emerging Technologies in Electronic Components and Systems - Opportunities Ahead / DG CONNECT, 2019-2020, (DECISION Etudes & Conseil, with data for year 2018)

Europe has strong positions and assets in:

- **The production of specific electronic components.** In terms of production of semiconductors, European leaders are world champions in certain specific segments like sensors, MEMS/NEMS, microcontrollers, smart cards, SiC and GaN for power, analog and radio frequency applications. However, European manufacturers have seen their market share decline over the years due to competition from non-European players mastering more advanced manufacturing technologies (below 20 nm). Europe has developed strong competencies in these strong native industries, in related existing or emerging technologies such as sensing & connectivity, MEMS/NEMS, cryptography, etc.
- **R&D at all the level of the ECS value chain.** Europe is a world leader in R&D thanks to its successful research schemes based on cooperation between public and private partnerships. The European Commission supports upstream and pre-competitive research necessary to remain in the technological race. IMEC, the Fraunhofer Institutes and the CEA LETI are at the cutting edge of numerous electronic components technologies, notably through numerous R&D partnerships with industry leaders (IMEC-TSMC partnership, etc.). The EU has always opted to restrict its support to industry to pre-competitive R&D. This decision has enabled highly performing R&D activity to develop in Europe, in particular for semiconductor design.
- **The development of key semiconductor production equipment (lithography).** Europe remains a world leader for some semiconductor equipment necessary to produce advanced microelectronic components. Europe has retained an important asset in the race for «More Moore» innovation with ASML. The Dutch company is one of the world's leading players in its field and has technological advantage and monopoly on certain essential machines using extreme ultraviolet lithography technologies.
- **Design (as opposed to manufacturing).** Europe remains a world leader in design especially in specific embedded segments, such as primarily automotive, industrial and aeronautics, with 30 to 40% of global design activity according to DECISION Etudes & Conseil.

The diagrams below, with data from the DG GROW ATI Data Dashboard, lists the number of advanced technologies firms by country in 2019, compared to GDP. According to these figures, the EU 27, with nearly 3 000 advanced technology companies, is well positioned compared to South Korea, Japan, China, Russia and to a lesser extent the USA. However, the UK and Canada appears to be in a better position. Within the EU 27, Germany, France and the Netherlands are the countries accounting for the greatest number of advanced technology firms. When compared to GDP, the countries in the best position appears to be Estonia, Finland, Sweden, Ireland and the Netherlands.



Number of active venture capital backed firms developing advanced technologies as captured by the merged dataset of Crunchbase and Dealroom according to related categories and search in the description of firms.

Advanced technologies considered: Micro-Nano-electronics, Nanotechnology, Photonics, Robotics, Industrial Biotechnology, Advanced Manufacturing Technology, Advanced Materials, Artificial Intelligence, Augmented-Virtual Reality, Big Data, Blockchain, Cloud computing, Connectivity, Internet of Things, Mobility, Security.

Source: Dealroom and Crunchbase, Advanced Technologies for Industry (ATI) Data Dashboard, DG GROW, DECISION Etudes & Conseil

D. Position of Europe in terms of employment in microelectronics

As shown in the table below, the microelectronics sector in Europe is directly responsible for 455,000 high-skilled jobs[2] and is an enabling sector for the entire electronics value chain, from materials to systems, which accounts for 2.6 million jobs and the demand for new skills is increasing.

Table: The European electronics value chain in 2018

Electronics value chain	European production (B€)	Employment in Europe
TOTAL	487	2 570 000
Electronic systems	290	1 350 000
Electronic assembly	126	765 000
Electronic components	47	290 000
Materials & equipment	24	165 000

Source: DECISION Etudes & Conseil

The European workforce in microelectronics is characterized by the specificities of the microelectronics industry in Europe:

- Mainly dedicated to specific end-user segments: automotive, industrial (electric equipment, machinery robotics, rolling stock, Industry 4.0, etc.), aerospace-defense-security and health & care.
- Specialized in the production of certain types of products: sensors, MEMS/NEMS, microcontrollers, smart cards but also, SiC and GaN for power, analog and radio frequency applications.
- A large part of the activity on the European soil is dedicated to design activities or Research & Development activities (R&D).
- The absence of advanced semiconductor manufacturing in Europe. Except one factory in Ireland owned by a non-European company (14 nanometers by Intel), there are no foundries in Europe producing semiconductors under 22 nanometers. European companies are now more specialized in the integration of complex innovative systems rather than on advanced manufacturing.

The European education & training ecosystem adapts to these specificities and focuses the trainings on topics such as CAD, test, packaging, materials, new physical principles... For instance, 75% of the companies in the microelectronics sector in Bulgaria are for automotive electronics. They need knowledgeable and skilled engineers in semiconductor design and manufacturing, embedded systems, microsystems, assembling and packaging.

[2] Including jobs associated to the production of passive components.

Methodological note: Statistics on the microelectronics workforce at European level

European statistics provide figures on employment related to the manufacture of electronic components (NACE rev 2 code C.26.11 "Manufacture of electronic components", which covers active components, passive components and PCB manufacturing). However, they do not provide any figure on electronic component manufacturing in terms of graduates each year or the intensity of demand in the labor market. Therefore, in the following sections, the numbers shown often correspond to broader categories than electronic component manufacturing, depending on the availability of data. These categories are presented below, classified from the broadest to the closest to the field of microelectronics as such:

- **STEM graduates**. STEM stands for Science, Technology, Engineering and Mathematics. This category encompasses students graduated from EQF 5 to 8 (from short-cycle tertiary education to doctoral or equivalent level). STEM graduates include graduates in microelectronics but largely exceeds the direct field of microelectronics.

- **ICT specialists / graduates**. The definition of ICT from the OECD based on NACE rev 2 largely exceeds the direct field of microelectronics. It encompasses:

    - **ICT manufacturing industries:** Manufacture of electronic components and boards (261), Manufacture of computers and peripheral equipment (262), Manufacture of communication equipment (263), Manufacture of consumer electronics (264), and Manufacture of magnetic and optical media (268).

    - **ICT trade industries:** Wholesale of computers, computer peripheral equipment and software (4651), and Wholesale of electronic and telecommunications equipment and parts (4652).

    - **ICT services industries:** Software publishing (582), Wired telecommunications activities (611), Wireless telecommunications activities (612), Satellite telecommunications activities (613), Other telecommunications activities (619), Computer programming activities (6201), Computer consultancy and computer facilities management activities (6202), Other information technology and computer service activities (6209), Data processing, hosting and related activities (6311), Web portals (6312), Repair of computers and personal and household goods (95), Repair of computers and peripheral equipment (9511), and Repair of communication equipment (9512).

- **Micro and Nano Technologies, as defined by the DG GROW ATI Dashboard**. This category includes two sub-categories. Micro and Nanoelectronics (1) corresponding to semiconductor components (fabrication, design, packaging and testing from nano-scale transistors to micro-scale systems integrating multiple functions on a chip). It also includes Nanotechnologies (2) defined as the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale.

To obtain more precise statistics actually corresponding to the field of microelectronics, a dedicated study would be necessary, in the continuity of the "Study on the Electronics Ecosystem: Overview, Developments and Europe's Position in the World (Smart 2016-0007)" conducted by DECISION for the DG CONNECT in 2018-2019, centered on employment.

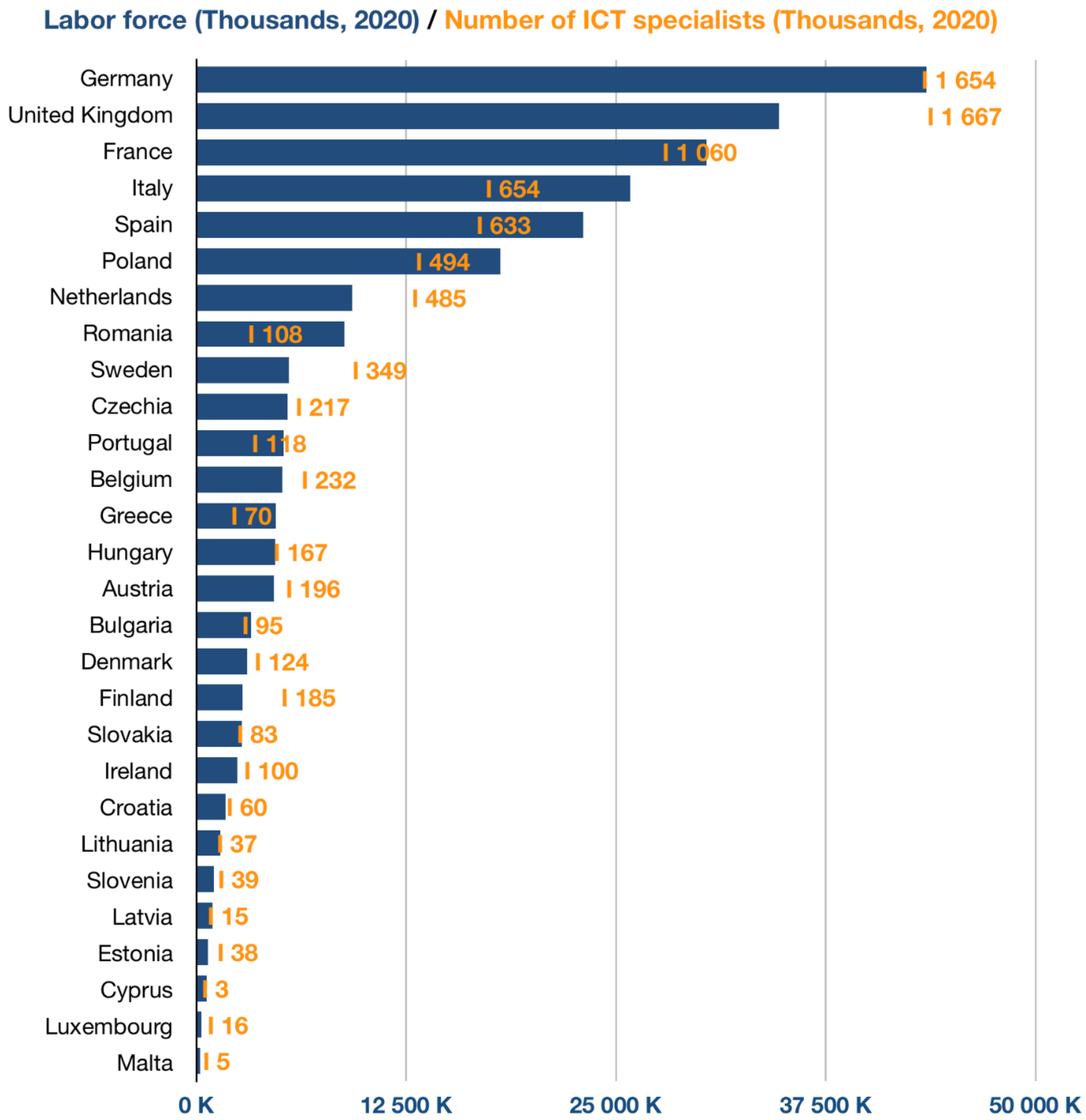
1) Microelectronics workforce by EU country

The EU 27 accounts for nearly 8 millions **ICT[3] specialists** in 2020, with an annual growth rate of the number of ICT specialists in the EU of 4% over the 2015-2020 period, according to the European Digital Economy and Society Index.

According to the ATI Data Dashboard (DG GROW), Germany, France, Italy, Spain, Poland and the Netherlands are the five countries accounting the greatest number of advanced technology firms in 2019 within the EU 27. These 6 EU members are also accounting for the largest number of ICT specialists according to the EU Digital Economy and Society Index (see the bar chart below).

When considering the number of ICT specialists in percentage of the total labor force, the twelve EU members in the best position appears to be Finland (6.7%), Sweden (6.3%), Estonia (5.5%), the Netherlands (5.2), Luxembourg (5.1%), Belgium (4.5%), Austria (4.2%), Denmark (4.1%), Ireland (4.1%), Czechia (4.0%), Germany (3.8%) and Slovenia (3.8%).

[3] Information and communication technology abbreviated as ICT.



Broad definition of ICT specialists based on the ISCO-08 classification and including jobs like ICT service managers, ICT professionals, ICT technicians, ICT installers and services.

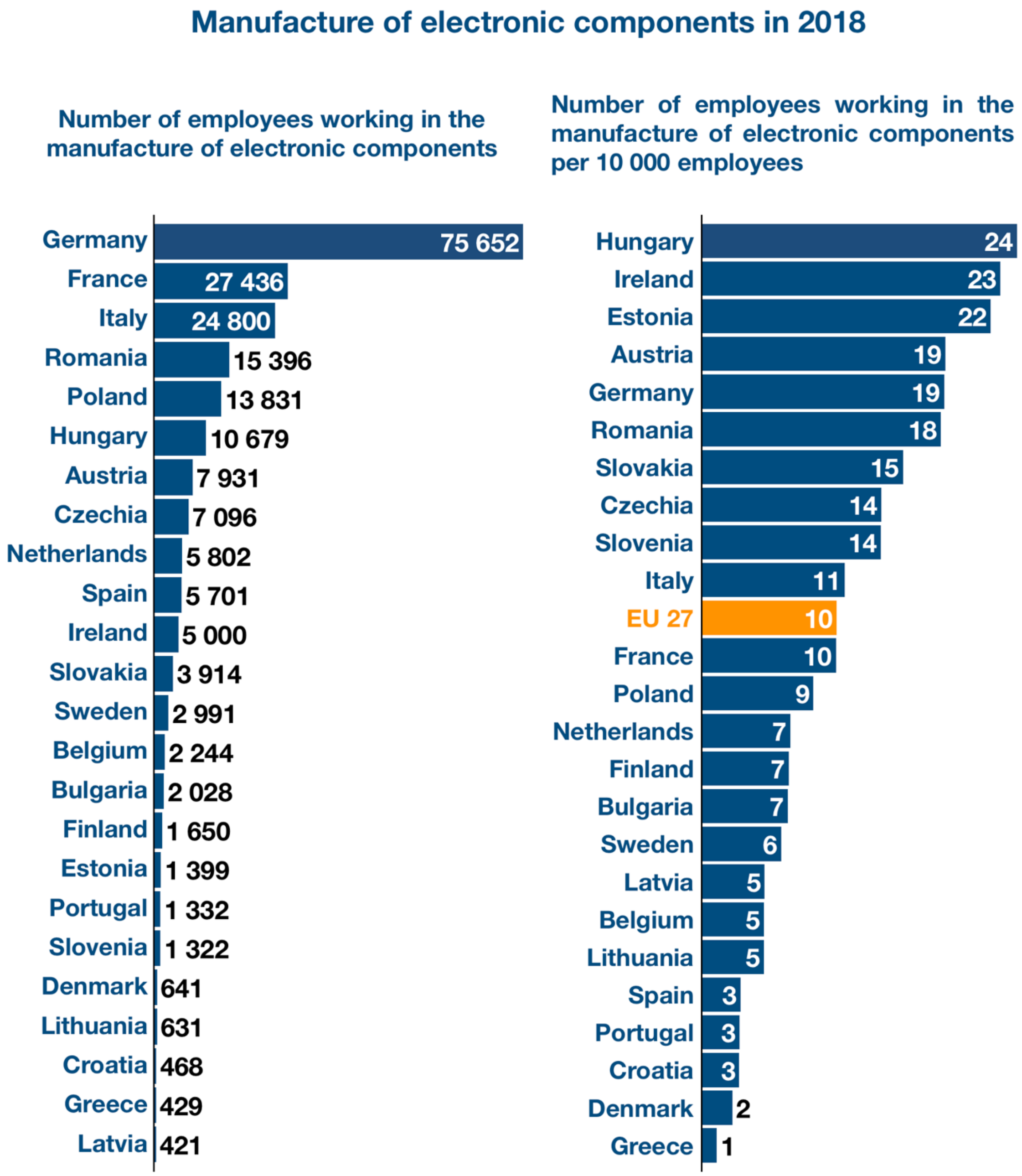
Labor force comprises people ages 15 and older who supply labor for the production of goods and services during a specified period. It includes people who are currently employed and people who are unemployed but seeking work as well as first-time jobseekers. Not everyone who works is included, however. Unpaid workers, family workers, and students are often omitted, and some countries do not count members of the armed forces. Labor force size tends to vary during the year as seasonal workers enter and leave.

Source: Eurostat, European Commission, Digital Scoreboard, Digital Economy and Society Index, DECISION Études & Conseil

Considering **employees in the manufacture of electronic components**, another trend appears. According to Eurostat, the EU 27 accounts for 219 000 employees in 2018 with an annual growth rate of 3% over the 2012-2018 period.

As shown in the diagram below, Germany appears by far as the first European country in terms of employees. France and Italy are in second and third position, as for ICT specialists, but Spain appears only in tenth position and Netherlands only in ninth position.

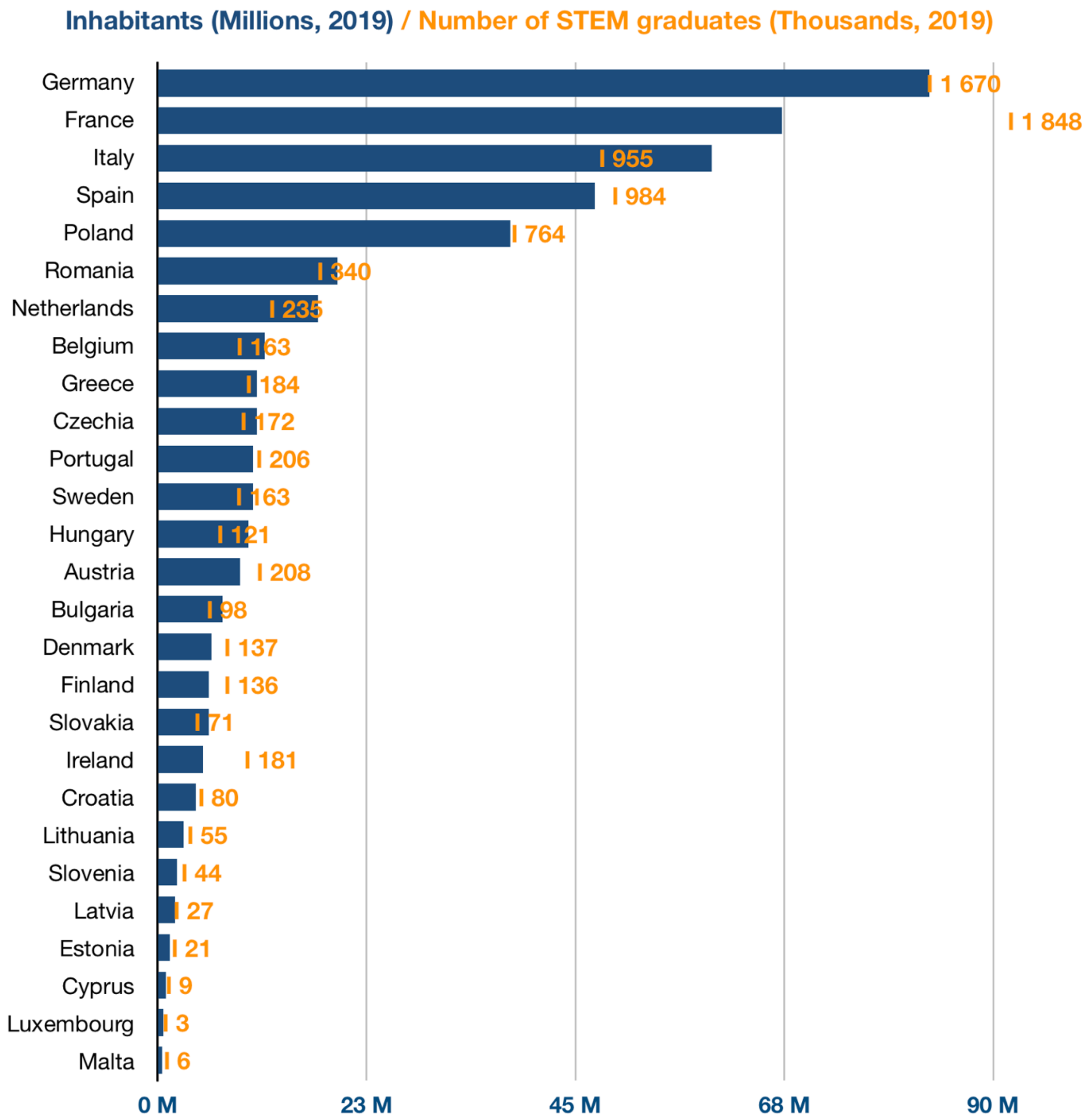
When considering the number of employees in the manufacture of electronic components per 10 000 employees, the six EU members that clearly appears in the best position are Hungary (24), Ireland (23), Estonia (22), Austria (19), Germany (19), and Romania (18).



Source: Eurostat, European Commission, DECISION Études & Conseil

2) Supply of microelectronics workforce by EU country

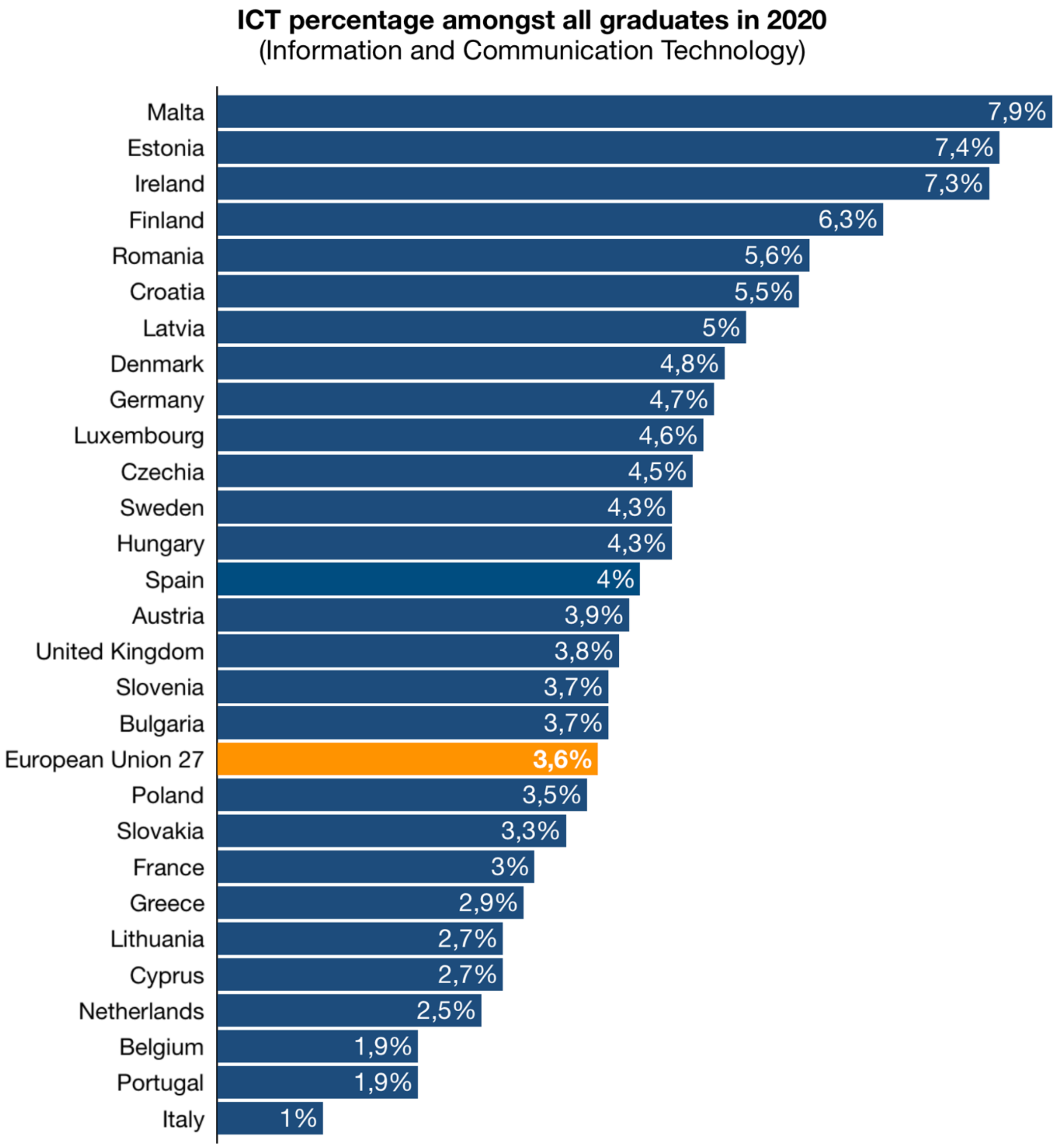
The bar chart below, with data from Eurostat, shows the number of STEM[4] graduates in 2019 compared to the number of inhabitants by EU country. The country with the largest number of STEM graduates in 2017 are Germany, France, Italy, Spain and Poland. With regards to the number of inhabitants, the ten countries that produce the largest number of STEM graduates are Ireland (3.3%), France (2.6%), Poland (2.4%), Denmark (2.3%), Finland (2.2%), Austria (2.2%), Spain (2.2%), Portugal (2.1%), Germany (2.0%), and Slovenia (1.9%).



Source: Eurostat, DECISION Etudes & Conseil

[4] Science, Technology, Engineering and Mathematics, abbreviated as STEM.

Regarding the **specialisation of the education system in ICT**, the bar chart below, with data from the EU DESI, shows the number of graduates with a degree in ICT in percentage of the total graduates by EU country in 2017. The six countries that appear to be significantly above the EU average regarding the specialisation of their education system in ICT are Malta, Estonia, Ireland, Finland, Romania and Croatia.

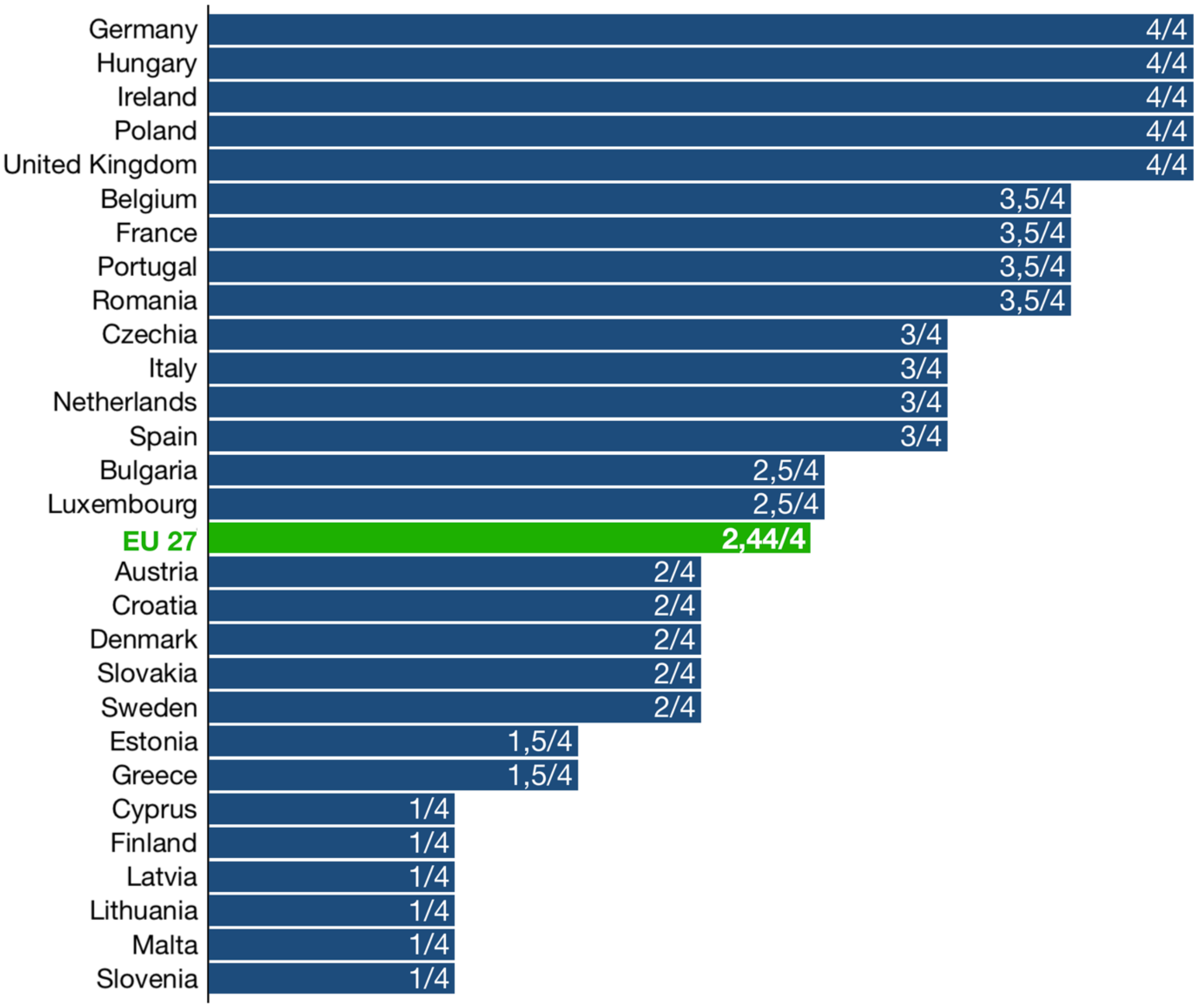


Source: Eurostat, European Commission, Digital Scoreboard, Digital Economy and Society Index, DECISION Etudes & Conseil

3) Demand for microelectronics workforce by EU country

The bar chart below, with data from the DG GROW ATI Dashboard, shows the intensity of the demand for online vacancies in Micro and Nano Technologies in the EU countries in 2019. The average EU intensity of demand is moderate to high (2.4/4). The countries with the greatest intensity of demand are Germany, Hungary, Ireland and Poland. This analysis using the LinkedIn social network is likely to have influenced the results as the other channels that exist for job search are more or less socially accepted in the different European countries.

Intensity of demand of online vacancies in Micro and Nano Technologies in 2019



The indicator captures the intensity of hiring demand for the specific technological skills as published on LinkedIn using the classification developed by LinkedIn directly:

- *Low (1)*
- *Moderate (2)*
- *High (3)*
- *Very high (4)*

Source: LinkedIn, Advanced Technologies for Industry (ATI) Data Dashboard, DG GROW

METIS
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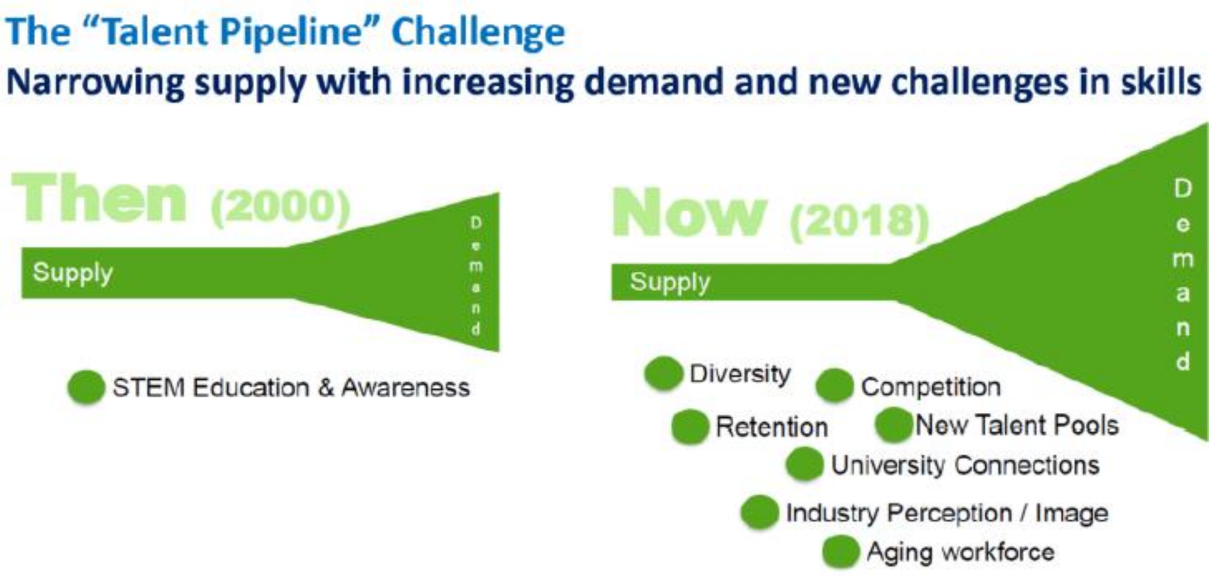
E. Challenges for the European microelectronics workforce

Overall, the EU benefits from an excellent education and R&D ecosystem leading to a great ability to train high-skilled employees in many areas (machine learning, cybersecurity, cryptography, blockchain, photonics, etc.) Several companies interviewed by METIS noticed the great ability of European universities to understand and teach new technologies compared to other regions. However, five main challenges need to be addressed in order for Europe to remain competitive in the fast-changing innovative landscape.



1) A rising technical complexity: A difficulty to combine the good skills

Historically, engineers in the electronics industry needed formal training in engineering methods and analog electronics design and production. In addition, the main technological development trend was the miniaturization of components and products through the Moore's law. Nowadays, this environment has drastically changed for two reasons.

Digitization. First, a worldwide digitization wave has started. This is leading to the integration of new products of electronic hardware & software components being able to communicate with each other, generating data that can be exploited, and needing to be secured through cybersecurity tools (the so-called Cyber-Physical Systems). Microelectronics workers of today therefore must be able to combine the associated skills and knowledge.

Secondly, **the technology innovation landscape is much less clear** with the progressive end of the miniaturization process (Moore's Law) and the emergence of numerous new technologies at every step of the value chain. The Moore's law is expected to end by the end of the 2040s and it is already being outpaced, in terms of total R&D investments worldwide, by other technology developments (mainly artificial intelligence applications for now). Consequently, engineers, especially in R&D centers, need to be trained on numerous new technologies: AI algorithms, photonics, neuromorphic computing, etc.

2) A lack of skilled workforce in the EU

Since the early 2000s, the demand for talents in electronics in the EU has constantly increased while the corresponding supply as significantly decreased to the extent that the current number of open vacancies for electronics engineers in Europe has reached 64 000 according to the European Commission ICT Monitor.

During this period, China has impressively raised its number of trained engineers in electronics. According to the report “Education Indicators in Focus N°31” by the OECD published in 2015 on STEM graduates (Science, Technology, Engineering and Mathematics), should the proportions of STEM graduates continue at the current levels, China and India will account for nearly 2/3 of the OECD and G20 STEM graduates in 2030 (respectively 37% and 27%). Furthermore, it is estimated that the BRIICS countries (including Indonesia) will produce three-quarters of the global STEM graduates by 2030. Europe and the United States will be lagging well behind with 8% and 4% of STEM graduates by 2030 respectively.

One consequence of this lack of skilled workforce is European companies look to hire more and more non-EU workers, especially from Asia. For example, a large company which has 550 employees at a site in Austria lists 29 different nationalities on that site. Another large company among the European leaders in the microelectronics industry reports 80-90% of its applicants coming from non-EU countries.

Foreign employees are described by several companies interviewed by METIS as on average more difficult to adapt to the company: it takes more time for them to become productive as they also need to adapt to local specificities. This is a result of “national character,” where a country’s specificity influences how people work, communicate, what they expect. In this regard, there is a difference between Asians and Europeans, and even within Europe there are big differences between colleagues from different countries. This is why companies develop specific company cultures aimed at enabling employees to go beyond these different ways of working.

3) An aging workforce: A risk to lose key skills & knowledge

The EU electronics industry suffers from a hole in the middle of the age pyramid (employees from 30-50 years old), combined with an ever-decreasing interest from the younger generation in manual and engineering jobs. According to the SEMI Workforce Development Council Europe (1st Meeting, 2018), the current average age of the workforce is 45-50+ in many segments, causing problems of trans-generational knowledge flow.

The image of manufacturing jobs needs to be improved in this regard, as there is the threat of losing key skills and knowledge if this hole is not filled soon enough.

4) A brain drain in several sectors

Foreign companies benefit from the excellent EU education and R&D ecosystem through the installation of subsidiaries in EU member states with low taxation. It has the positive effect of creating a few high-skilled jobs in the EU, but it also leads to a brain drain as European students who are trained by the EU R&D ecosystem are in the end employed by these foreign companies. European companies (especially SMEs) often find it difficult to compete with wages (and benefits) offered by large foreign players, who generally offer wages 10% to 30% higher for equal skills, which leads to this type of brain drain, according to DECISION Etudes & Conseil. This type of brain drain is particularly apparent in some sectors, such as machine learning.

5) Intra-European regional disparities

Finally, in Europe, as many regions in the world, faces regional disparities. Industrial sites are often installed in isolated regions far from megacities. It is the case for many microelectronics manufacturing sites across Europe, as reported by many companies interviewed by METIS, for instance in Austria and Germany.

The best solution is often to create initial training centers (like universities), near industrial sites to attract students that will stay after their studies. The creation of clusters to regroup several industrial sites from different levels of the value chain as well as universities and VET providers is therefore identified as crucial in this regard.

For job profiles that do not require employees to be physically on-site (non-manufacturing profiles), this problem is less apparent as companies have the opportunity to hire people from different countries without relocation. Companies are increasingly using this practice since the beginning of the COVID-19 crisis.

F. A new technological landscape, driving the demand for new skills in the microelectronics industry

For the past ten years, the technology landscape impacting microelectronics has become increasingly complex, involving more and more fields of study.

First, “More Moore” and “More than Moore” have become increasingly apparent as diverging technology paths in terms of circuits emerge. This resulted in two development orientations:

- The “More Moore” approach characterized by following the Moore’s law (speed and transistor density doubling every 18 months) is dedicated to speed and computation power. It represents the greater part of the production (about three quarters).
- The “More than Moore” approach is characterized by diversification of the applications (analog, RF, Passives, HV/Power, sensor/actuators, Biochips and so on). This constitutes about 25% of the market.

Second, according to Gartner, the cost of manufacturing equipment for leading-edge semiconductor manufacturing is rising at 7% to 10% per year.

Third, a great number of new technologies are emerging from downstream in the electronics value chain, especially among smart systems and Cyber-Physical Systems (CPS) markets:

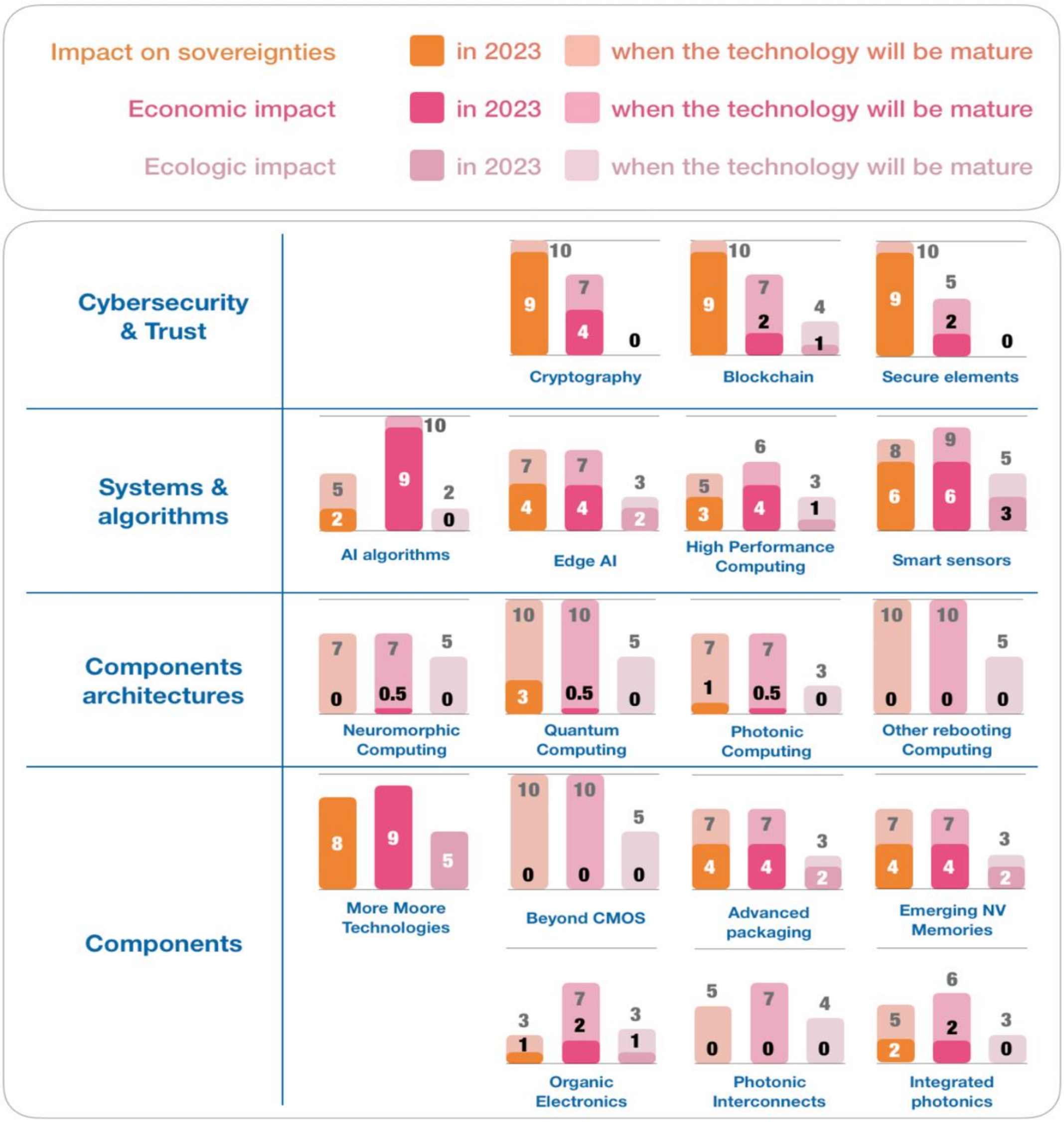
- Emerging technologies and applications associated to software and data analysis: Artificial Intelligence (AI), big data, data handling and data analytics, etc.
- Increasing combinations of several key enabling technologies such as industrial biotechnology, photonics, spintronics, etc.
- Many other innovations in different fields: cybersecurity, connectivity, etc.

These emerging computing technologies in smart systems and CPS markets require specific modules and components, and the electronic components industry needs to develop this hardware. New skills for microelectronics employees from different field of study (data science, materials science, chemistry, physics, etc.) are becoming crucial to understand these emerging computing technologies.

In the study "Emerging technologies in electronic components and systems (ECS) – Opportunities ahead", prepared for DG CONNECT in 2019, DECISION Etudes & Conseil provided a complete roadmap of the technologies impacting the Electronic Components and Systems (ECS) value chain: 18 key technologies were identified, and their multidimensional impact assessed. The results are summarized in the figures below.

In this context, the purpose of METIS is to contribute to the competitiveness of EU microelectronics industry by addressing the shortcomings in education & training, skills and employability with a focus on paving the way for EU leadership in data driven technologies such as AI, which generates unprecedented opportunities that go beyond market dynamics and job creation, and encompass issues related to security and digital sovereignty. Without an up-to-date microelectronics skills-base, Europe will not be able to take a leading position in the digital economy nor face critical challenges.

Worldwide technological impact by 2023 vs. long run



Impact on sovereignties	0 if no impact, 10 for the technologies with the highest impacts
Economic impact	0 if no impact, 10 for the technologies with the highest impacts
Ecologic impact	0 if no possible impact foreseen, 10 if the technology as an intrinsic very positive impact. Detailed explanations depending on every technology. The two factors are: improved energy yield compared to previous technologies and the existence of specific eco-friendly applications (in smart grids, etc.)

(The detailed explanations of the grades can be found technology by technology in their related chapters)

Example for Blockchain: Blockchain will very significantly impact on sovereignties through its impacts on multiple sovereign fields: monetary transactions, cybersecurity, identification & authentication and secure communications. The Blockchain market (outside cryptocurrencies), cannot be considered as an established market and the usability and mass deployment of the technology stays at the prototype or concept level for a lot of domains, due to government regulation or legal issues. The blockchain market will remain rather small by 2023 (€ 19 B), with a medium impact on the majority of the electronic end-user segments and small impacts on the video game / game console markets and the (very large) finance sector. Blockchain is very energy consuming and therefore as no great potential ecologic impact. Yet, two main specific eco-friendly applications of Blockchain are envisaged: easing smart-energy development (smart grids), e.g. through peer-to-peer localized energy with blockchain managed networks; and tracking products from origin to source, hence reducing carbon footprints & unsustainable practices, and incentivizing recycling schemes.

Source: Study “Emerging technologies in electronic components and systems (ECS) – Opportunities ahead”, carried out by DECISION Etudes & Conseil for the DG CONNECT, 2019

G. The impact of COVID-19

Impact of the COVID-19 pandemic on the European electronics industry

The negative impact of COVID-19 on the global and European microelectronics industries has been lower than one could have expected in early 2020. The European microelectronics industry had benefited from a strong annual growth in 2019 (6.2% on average), and this trend should continue in 2020 (3.5% annual growth foreseen) and even improve in 2021 unless US embargos hamper this potential growth, according to DECISION Etudes & Conseil.

Indeed, electronics dedicated to personal computing, communications, as well as logistics (warehouse related to e-business) is experiencing a very good year, precisely because of teleworking induced by the COVID-19. This same can be seen for contactless payment, encouraged for hygiene reasons during the COVID-19 pandemic. After experiencing an initial sharp decline, industry (the first end-user sector for microelectronics) rebounded sharply in Asia around June, and encouraging signs are being observed in Europe and America. Automotive electronics is the segment that suffered, but this is mainly because of the closure of factories during Q2 of 2020. However, factories quickly reopened, and the automotive market has restarted in China (the world's largest market). This is in part because end users want to avoid public transportation. The electrification of vehicles also remains a driving force for growth.

The global growth prospects for the European microelectronics industry are good for 2021 and the main threat is the trade war between the USA and China rather than the COVID-19[5] pandemic.

Impact of the COVID-19 pandemic on the European microelectronics workforce

Stakeholders interviewed by METIS provided an overview of the impact of the COVID-19 pandemic on the European microelectronics workforce: evolution of job positions, skills need, daily work, recruitment processes, etc.

- **Impact on universities activities**

  Most of the universities' activities continued to operate remotely thanks to digital media: online lectures, online examinations, virtual laboratories… Generally, this format received positive feedbacks from both students and teachers.

  The two main negative impacts reported are the increased difficulty to exchange with students (interact, collect their feedback, assess their understanding, understand their needs for additional explanations, etc.), and the difficulty to pursue laboratory courses and carry out laboratory works. These are fundamental parts of the trainings in microelectronics that cannot take place online.

  Some universities plans foresee that in the future there will be mixed teaching (face-to-face and remote), leaving the student the possibility to attend lectures in both ways, through the positioning of a camera in all the classrooms.

- **Impact on business activities**

  Most of the companies' activities continued to operate remotely thanks to digital media and tools for remote work that had been put in place. It is also true for the recruitment processes: job

[5] At the moment of writing this document.

interviews through video conferences, companies onboarding videos, etc. overall, the activity is therefore not significantly impacted by the COVID.

However, some recruitment projects that could not happen remotely have been cancelled, such as MicroElectronics Camp for pupils organized by companies, on-site events, etc.

The main negative impact reported is the increased difficulty to exchange / communicate between workers because of the COVID-19 pandemic. The lack of in-person meeting makes teamwork, collaboration, understanding and networking more difficult than before the COVID-19 pandemic.

In addition, the lack of general knowledge of the entire microelectronic systems manufacturing processes, already identified before the COVID-19 pandemic, became more problematic because of the COVID-19 pandemic and the reduced communication between workers. The numerous engineers who have been trained in a specific domain and lack general knowledge face difficulties in their work because they need this general knowledge, and it became more difficult to acquire it through teamwork because of social distancing measures. The need for knowledge of modern engineering flows / general knowledge of microelectronic systems is being increased by the COVID-19 crisis.

Finally, some companies have taken initiatives associated to COVID-19. For instance, Axcelis works with local community colleges on provision of virtual training on soft skills related to COVID-19 such as resilience, stress management, showing great benefits to its employees.

- **Impact on recruitment trends**

  The impact of the COVID-19 pandemic on recruitment trends is mitigated. Half of the companies interviewed report that it had no impact on their hiring. The other half reported a significant slowdown of their hiring.

  Some companies focused their recruitments on critical job profiles and skills. Therefore, recruitment of supporting functions are slowed down in priority.

Impact of the COVID-19 pandemic on higher education and recognition

However, the COVID-19 pandemic had a large impact on higher education and recognition.

CIMEA produced a report in April 2020 focused on the monitoring of the effects of the COVID-19 pandemic on higher education and recognition. Approach and contents of the report issued by CIMEA have been included in the document "Recognition of foreign qualifications in times of COVID-19 - A reflection document for the ENIC-NARIC Network and their stakeholders".

The main challenges caused byCOVID-19 for recognition were identified as:

a) Disrupted learning (breakdown of the continuity of learning & teaching, shift from in-class to on-line learning environments).

b) Mobility (virtual vs physical mobility).

c) Qualifications (changes in learning outcomes, impact on VET, on professional qualifications and on learning pathways where massive practical activity is required).

d) Digitalisation (acceleration of online learning, teaching and research).

The good practice is linking the identification of key aspects of post-COVID-19 VET and HE, and recommendations to education & training providers and to recognition practitioners. Recommendations focus on:

a) Flexibility in the design and development of the METIS curriculum and training, and work-based learning approach (D3.1), as well as in the METIS training delivery (WP4).

b) Awareness of how contents of the learning outcomes certified by a qualification may change according to models of provision of training (physical vs virtual learning environments) and to the amount of practical training.

c) Transparency of information on the qualifications awarded (D3.3).

d) Micro-credentials: possible adoption of the approach (Common Micro credentials Framework) for training delivering and awarding procedures (D4.3, D4.4).

e) Monitoring of medium- to- long term impacts of COVID-19 on Education & Training systems, industry sectors and labour markets (WP2).

The COVID-19 emergency opened new scenarios in the ways of teaching and, generally, in the field of education. The pandemic has underlined the need to deploy digital solutions that can guarantee the right to the recognition of qualifications at any time and at greater flexibility in the procedures for issuing and sharing academic documents, as well as the possibility of the verification of national qualifications abroad.

In this context, quality assurance, digitalisation and blended education are key words that the METIS Project has to take into account. Furthermore, the assessment of micro-credential plays a crucial role to facilitate the portability of competences.

H. Diversity in electronics

METIS has set up a Focus group dedicated to the analysis of diversity in the electronics and microelectronics industry. This chapter presents the results of this focus group. The development of the Focus Group Diversity in Electronics, in the framework of the project METIS 4 Skills, is the asset to the whole project that brings into play the perceptions that are in the industry towards the levels of inclusion of diverse groups: how has this evolved throughout the last 10 years and how do they see an increase in that representation on the future. The participants' background was diverse and contained areas from theoretical knowledge to practice in the industry, universities, NGO's, workers, students and HR members.

Table: Participants to the Focus group

Organisation	Field
Infineon	Large company - Semiconductors
Edwards	Large company - Semiconductors equipment
Guidewire Software	Mid-size company - Software
LAAS-CNRS	Research & Development
Lund University	University
WiTEC	NGO
ENHI: European Network for Holistic Integration	NGO

1) Minorities: What are we talking about?

The fieldwork is developed from a perspective of *grounded theory*, which means that the participants can shape the concepts from their understanding of them. Thus, when the word minority was mentioned during a focus group or the concept of underrepresented groups was used, the main thinking went to the participation of women in education and the working market involved with the microelectronics industry.

This shows that even after going through years of work to diversify the composition of the groups that are involved with this industry, there is still a large path to follow. Many suggestions were made, pointing to environmental and educational issues rather than the working space itself.

At the same time, women are seen as a minority immediately when talking about high-level positions, with an inverse relationship between women and power, increasing the numbers on their participation as the position level decreases.

But the minority is not the smallest group in a population, instead, it is the concept that has been used to refer to these clusters that are not at the high level of power, and that, when escalating down in power and influence, the changes do not seem to be significant until the lowest salaries, responsibilities and that is if they are included on the public sphere (Acker[6], 2006).

It is not only women, even if, when talking about the minority, that is the group that is most thought off, but minority includes those that are not neurotypical, and these that have some sort of different mobility capacity than the average. When talking about minority it is absolutely necessary to talk about intersectionality, and with that, we have to include race, gender identity, sexuality, language, religion, body and brain.

The success of the institutions of power in the closest history are reflected straight on these, anything that deviates from the original normative will be seen as ab-normal, thus, not allowed on the public sphere, reclused either on prisons, hospitals or at home (Foucault[7], 1975). As a result, the highest positions were held by, mostly, white male in Europe and all the colonial territories, this continues until now 200 years after the independence movements, or by the traditional male figure in the Social Structures of the territories such as China.

Thus, when we refer to minorities, we refer to the large groups of the population that have been receiving differential treatment, lower participation and presence on media and have encountered a lack of role models (Wirth[8], 1941). The work done in the last 30 years, approximately, has been focused on erasing these gaps and bringing into the public sphere, power positions and role models to those that are least represented and that can have as much or more talent than others.

Some countries have increased the inclusion from early stages. Reflected in the creation of plans for education with norms that do not differentiate by gender, that gives the pedagogic support for children with neurological different needs, and that creates an environment where all can learn at the same time and get the same chances. These efforts are great but cannot be local since the market is global, for this the European Union has financed a diverse range of projects and programs, through

[6] Acker, J. (2006). Class Questions, Feminist Answers; Rowman and Littlefield Publishers; USA, Maryland.

[7] Foucault, M. (1975). Vigilar y Castigar; Siglo XXI; Madrid, España.

[8] Wirth, L. (1941). Morale and Minority Groups. American Journal of Sociology, 47(3), 415-433. Retrieved November 12, 2020, from http://www.jstor.org/stable/2769291.

their Erasmus+ program, AMIF program, and others, all pointing to invest in people and bring to the market all the talent that can be brought and cover all the needs that the future might bring.

2) How are minorities situated on the World?

Whereas you see minorities as a subject it directs you to ethnic minorities, sexual orientation minorities or others. Surprisingly, these are the least affected groups as interpreted by the participants on the fieldwork for METIS. The reason is that the market is global and the participation in it comes from diverse groups, if something, some of the groups that are ethnic minorities in Europe were mentioned as some of the represented groups in this mark, such as people from India, Persian speaker countries, China, South Korea and middle east. All of these groups have different levels of influence in the world's political climate and economic fluctuation, even when seen as minorities from a European perspective, there are many strong economies involved in the industry.

The visualization of the power that the ethnic minorities can have has been an effort since the early 2000s and had the most effect on the first decade of this millennia, with diverse initiatives that pointed to increase the numbers in public spheres through quotas of power or secured seats on the different international organisations and local national political structures (Ghai[9], 2003).

The perception is that the second decennia of the 2000s have been marked by resistance while the advance of the effective inclusion of minorities, either ethnical or gender based. Also, during the last 20 years, minority groups have had more visibility and lift up a precepted slow shift in the public perception of them. An example is the broad knowledge of the changes in the diagnosis for all the neurodiversity that exists. This is thanks to the biggest exposition and representation in the media of all the issues related to minorities.

In the last 5 years, the women's movements have achieved a level of influence higher than ever before and their representation in the public sphere is not unseeable, but still, the participation in STEM (Science, Technology, Engineering and Mathematics) is marked by different areas of specialization and lower long-term carriers in the specific areas related to microelectronics.

3) Minorities in the STEM industry

In the industry, we can find different STEM (Science, Technology, Engineering and Mathematics), occupations that have a higher representation of women and group of minorities than others. Those groups are usually connected to other areas of STEM that are not directly related to microelectronics such as chemistry or biology. The following data has been gathered by the International Labour Organisation (ILO) and it shows the representation of female groups in percentages throughout the world.

The numbers that are represented in the table are part of the global effort to collect the data but are also showing as mentioned before all the STEM professions. When talking about microelectronics, the participation is much lower than 40%.

[9] Ghai, Y. (2003). Public Participation and Minorities, Minority Rights Group International, the UK.

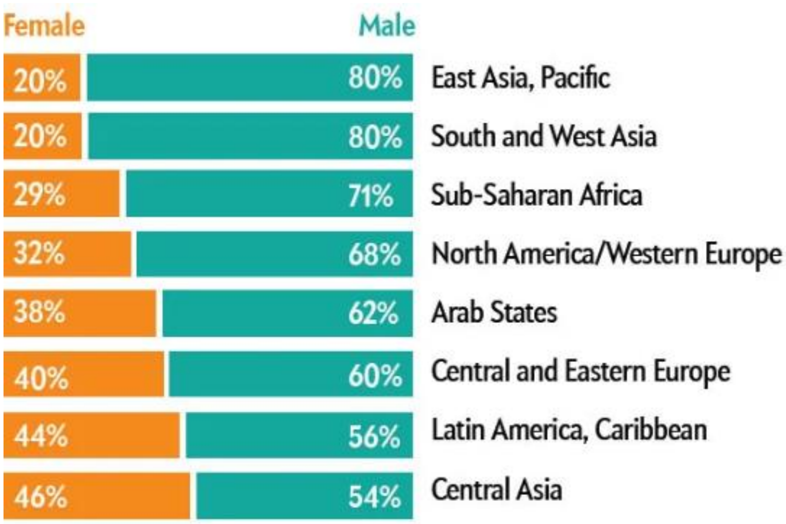
Science, Technology, Engineering and Mathematics (STEM) occupations

Country	STEM occupations (thousands)	STEM occupations (% of employment)	Female share of STEM occupations	STEM tertiary graduates (thousands)	Female share of STEM tertiary graduates
Austria	725	17%	35%	253	26%
Czechia	820	16%	36%	208	36%
The USA	24,001	15%	48%		
The UK	4966	15%	40%		
Israel	518	14%	42%		
Slovakia	302	14%	39%	107	35%
Portugal	557	12%	44%	224	38%

The experimental series on STEM occupations are tabulated from national household survey microdata. Data on tertiary graduates in STEM subjects are ILO calculations based on UIS figures.

Source: ILOSTAT Get the data Created with Datawrapper

STEM Research Workforce, by Region (2010, or latest data)



Regarding the high achieving, the table at the left created by Guterl, Fred for Scientific American shows the numbers of PhD graduates by demographic areas in STEM fields[10].

The difference between the least and the most is of a very significant 26%, Europe being situated in the middle numbers.

In the same article, the situation of people with disabilities is not better, showing that only 6% of the science and engineering occupations have some condition of disability. Contrasting to the 10% that they represent on the society.

So even if better than in the past, the future needs to be more inclusive in order to grasp the capacity to bring in the industry all the talent that might be out there.

[10] Read the article here: https://www.scientificamerican.com/article/diversity-in-science-where-are-the-data/

4) Minorities in electronics

a. State of play in 2020

State of play by minority

The subject of minorities is directly translated as women's participation, even after a couple of intents to diversify the topic, the north kept on women's participation and quotas. As it seems, despite different efforts in the industry to give more chances for women, there are more women in the race to make a career than the opportunities to achieve one.

Throughout the development of this focus group, the different definitions that could be related to other definitions of a minority were not taken into account by the participants, this means that the utterly important subject for them to treat is the participation of women in their own areas of expertise.

This not only means that inclusion of other groups that could be defined as a minority do not even get to the discussion, but the one group that has been actively trying to integrate is still failing to fill up the quotas and with that giving the people interested in the matter new ideas on ways to discuss how to achieve the highest level of integration for women in STEM and in microelectronics more specifically. At the same time, this puts into doubt the efforts that they, themselves, have been witnessing failing for different reasons.

Women are still seen as a group that has not achieved full integration in the labour market neither has it manages to equal the participation of males in the education field or in the academic world.

Another group that was considered by the participants in this focus group is the LGBTQ being this one of the minorities that have more representation in power positions but at the same time a group that has been focused by the industry to have the support necessary and to create policies for them to be in a safe place when at work.

The place of women in electronics

The difference that could be found in the educational field were always pointing to the drop of women during their educational years. Many of the participants expressed their worry because, on the run, women were leaving their careers due to different reasons.

- 1st is the drop-off of women in the first years of university education, this drop off is caused due by the lack of identity and group feeling, in which the young students have to prove to their peers that they belong to the place they are and have to deal with constant discrimination and lack of integration with their own peers. Even if the professors tried to help this group, the feeling of non-belonging will affect their decisions in the long run.

  From this many of the participants expressed their worry for the young students not only because the environment can be hostile but also because they feel they are failing, somehow, to support their own students.

  Examples of these came to the discussion from different countries in Europe and a male professor was expressing his frustration about how low was the active participation and interest that women were showing in his class when he has to fill a quota of women; at the same time, a female professor was sharing her own techniques that she has developed throughout the career to increase the participation of her female students giving them extra

Co-funded by the Erasmus+ Programme of the European Union

space to speak and extra amount of assurance, being clear with the fact that they did deserve to be in that classroom because, as she expressed, there are many studies that show how the perception female have of their own abilities affects the way they dare to participate in a class, in contradiction to the feeling of abilities their male classmates tend to have, or the space they tend to occupy not only on physical space and voice but also on over talking when the female classmates are speaking. The sustained continuing of these situations affects the belonging feeling of women and the professor express it as one of the main reasons for women to drop their studies within the field of mathematics for electronics.

And, if these problems that female student have to develop were not enough, it was also expressed that since professors single out students to offer positions as assistant researchers or possible candidates to PhD, most females do not get this chance because the professors do not see the same driven interest and curiosity that their male students are showing during seminars and workshops. This is frustrating not only for the industry but also for the professors themselves because they do not manage to keep the students in a balanced level of integration in the first years of the career which means that in the oncoming years this situation will still sustain as the same or get worse.

- 2nd the participants expressed a worry about the development of the career after graduation: Not only it is difficult for the employers to find applicants and fill the quotas of women in their companies, but also motherhood is constantly intervening in their investment on women. Once women become mothers, they feel the pressure to reduce the working hour's or simply stop working because they cannot keep the rhythm of their male co-workers. This problem is increased by the fact that many women are subjected to contracts per project, which do not protect them from employers' abuse in case of pregnancy. It reduces the chances for younger female to have strong role models and admire women that allowed them to dream of a career in the field.

  It was expressed by one of the participants that they have been taking steps forward hiring the most capable candidates through, for example, written interviews that will allow one to know their ability to code without getting a name or a last name, much less a gender, but that the candidates were still mostly male. Furthermore, in the last year, not even one female had applied to the positions they have open.

  The position that Europe has in the world regarding electronics and microelectronics is shaped by the European culture itself.

  As many of the participants expressed, the market is international, so they do not see a big difference between Europe and the rest of the world, but at the same time they express their worries about the number of women participating in the market and the different strategies that their companies or institutions have developed to increase integration

  One of the participants in this focus group was from Tunisia. This participant is a female student at the PhD level who explained how it works in her home country on how the situation is for many of her colleagues, which shows to not have enough job opportunities for females. The market is not in consonance with the rate of women graduating and pursuing a high level of education, pointing towards a high level of salaries and power positions in the market.

  After graduation, the problem arises because they have to migrate to other countries in order to get a job in their field. After migration they become a new minority and have to confront new challenges related to that, finding a safe space within their class comrades.

  From another perspective, different countries have developed their own policies to assure the participation of diverse groups while trying to keep up with the growing needs of the market.

Countries as Sweden and Ireland have developed sophisticated systems of quotas and culture of expected gender balance in their teams. These policies find different levels of acceptance throughout the market in these countries, but one of the biggest fears expressed by participants are the low expectations towards females related to their position as a result of quotas.

b. Rising diversity in electronics

The advantages of increasing diversity in electronics

From the participants perspective, the better diverse groups are successfully integrated, the more chances of achieving high-quality work they have. None of the participants expressed a negative impact of diversity. If something comments in that direction were expressed, it was regarding the doubts of how effective the tools are to measure the achievements. But for all the participants it seemed to be an active question how to rise the diversity in their workplaces and of how to avoid the leakage of talent.

This means, for the participants, that they would like to see greater diversity, and they would like to open the chances for future generations to not even have to think about this as a variable but to see it as the standard.

Policy recommendations

All the participants presented different perspectives on how to advance with the issues that were treated during this session.

One of the first suggestions that came up was the fact that it is necessary to address the public at younger levels to start creating an interest in STEM, microelectronics, programming, etc. For instance, when the children are in kindergarten. this is a way to assure that they will grow up thinking that they can dream with a career in whatever dream they want.

Another recommendation that came up during this session was the fact that it is necessary to give more exposure to the industry and to put the market in the news and on the media with more human role models (e.g., examples of successful women in the industry), that can have a real effect in the identity of the youngers.

The role model is one of the ways that most participants thought could be possible to reach out. Role model is essential for the groups that are not represented in this moment because they do not know, subconsciously, that they can also dream of a job in these areas, and that it is not solely reserved for one specific group of people.

These role models can come from all the different areas we had in the focus group. It could be from academia, it could be from NGOs, or from the industry, as long as they increase representation and allow children to identify with someone who looks or moves like they do.

Even though it is understood that the role models will not have a direct effect on representativity, they will have a direct effect in the mindset that reflects on behaviours of the people who dream. This leads to a change in the initial behaviour when they enter the studies, the sensation of not belonging that is leaving people outside of the market by making them feel they have to stop their studies or that they should not apply to a certain career.

It will be expected that hand in hand with the feeling of belonging, the less represented groups will also participate more in lectures and get more job opportunities in places where trust is required, such as research assistance.

This will increase the number of people belonging to minorities that have high achieving careers.

Some of the policies that have been taken by different countries are already being seen as successful, while a higher percentage of women are applying to start their studies in the Bachelor degree within traditionally male-dominated careers such as computer science, electronics, physics, and mathematics.

The next challenge will be to assure that woman do not have to quit their careers when becoming mothers. This requires measures such as:

1) Assuring contracts and regulations to protect the mothers.
2) Creating a system of care that share not only the economy in the household but also the weight of the caring job that has been traditionally made by women. Examples of specific measures would consist in allowing free kindergarten from the moment the parental leave is finished or setting up parental leaves that allow women to nurture their children in order for them to decrease the possibilities of health-related issues in the future. This brings, also, savings to the country economics, due to a higher rate of women paying their taxes and lowering the long-term effects on inhabitants' health care.

As long as women are being left outside the market because they become mothers, diversity could not be achieved even if efforts are made towards the LGBTQ community to integrate with the market, or other efforts are made to support students that are not neurotypical.

To assure the integration of different ethnicities, it is also necessary to take into account the differences in language. English is dominant in the international job market, but in the working environment, the local language is the one that dominates, which leaves outside of decision making and social gatherings the groups that are not fully integrated into the local society. This leaves migrant communities at a high disadvantage even when they are better educated than the locals because they could never speak as a native of the country. This variable requires further development in hiring policies and cultural sensitivity and is not exclusive to the microelectronics industry.

Integration and representation of diverse groups include the levels of management and this is one of the harder groups to change in their composition, and the higher they are, the harder it is to see diversity.

II) Strategy to face the European microelectronics skills challenge

A. Examples of best practices: Initiatives to be benchmarked

METIS

BEST PRACTICE #1

TITLE

STUDY

COUNTRY / REGION(S) INVOLVED

AUSTRIA / CARINTHIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PUBLIC

TIME OF LAUNCH

ACADEMIC YEAR 2019/2020

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

As it is becoming increasingly difficult for industry to find highly qualified specialists the initiative "Study & Work" offers the possibility of early contact between selected students and recruitment industry representatives. In addition, it creates the opportunity for companies to confront students and the Carinthia University of Applied Sciences with questions from practice that can be worked out in the theoretical framework. An intensive exchange on subject-specific problems not only promotes the bond between university and business, but also offers both sides considerable added value.

This program supports studies in following areas: Civil Engineering & Architecture, Engineering & IT and Management

ORGANISATIONS INVOLVED

INDUSTRY

Infineon Technologies Austria, PMS, Stadtwerke Klagenfurt AG, Flextronics International GmbH, ROBOOPTIC Systems GmbH (for Systems Engineering studies)

EDUCATION

University of Applied Sciences - Carinthia

LEASSONS LEARNT / CONDITIONS FOR SUCCESS

The main condition for success is to have dedication of industry partners to provide internships/part-time jobs to students and devote to on the job learning of the students

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

Students have the opportunity to get in touch with potential employers at the start of their studies. Depending on the company and area of study, students can in parallel work (part-time) and study and this allows an optimal combination between theory and practice and at the same time offer the opportunity to study in a goal-oriented manner and earn money at the same time.

The objective is to create a solid basis for further professional development. The Carinthia University of Applied Sciences supports students with a professional-friendly schedule for each semester. In Engineering and IT areas of studies, this program supports bachelor and master studies candidates.

EVALUATION AND OUTCOMES

Expected outcome is to have fresh graduates who already have practical experience and knowledge from the industry and can be fully operational after they complete studies.

BEST PRACTICE #2

TITLE

INFINEON ENDOWED PROFESSORSHIPS

COUNTRY / REGION(S) INVOLVED

AUSTRIA / CARINTHIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE

TIME OF LAUNCH

2016 - ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

In view of the accelerated digital transformation, the promotion and exchange of knowledge and know-how are crucial factors. In order to provide the best possible conditions for the education and further training of young talents in scientific and technical disciplines in Austria, Infineon Austria maintains close partnerships with universities.

SIZE OF THE FUNDING

N/A - A few of this endowed professorship are part of initiatives of the federal ministry and some of them are 100% sponsored by IFAT.

ORGANISATIONS INVOLVED

INDUSTRY

Infineon Technologies Austria AG

EDUCATION

- University of Innsbruck – Power Electronics
- Technical University of Graz – Data Science
- Technical University of Graz – Autonomous driving
- Technical University of Vienna – Human-Centered Cyber-Physical Production and Assembly Systems
- University of Klagenfurt & Technical University of Graz: Industry 4.0 – Adaptive and connected production systems
- University of Klagenfurt – Sustainable Energy Management

GOVERNMENT

Federal Ministry Austria

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

The Infineon endowed professorships support the university education of much needed graduates in specific MINT fields. In addition, the collaboration between basic and applied research will be intensified through this initiative.

EVALUATION AND OUTCOMES

6 successful endowed professorships (including Theses, Journals and specific researches in the targeted areas of interest for the industry)

METIS

BEST PRACTICE #3

TITLE

SMART LEARNING CLASSES (PART OF "CARINTHIA COALITION" INITIATIVE)

COUNTRY / REGION(S) INVOLVED

AUSTRIA / CARINTHIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE

TIME OF LAUNCH

START OF CLASSES 9TH SEPT. 2019 TILL JULY 2020

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Goal:
Creating a common standard for new digitally supported forms of teaching to make pupils fit for their future work life

The aim of the "Carinthia Coalition" is to counteract the brain drain and take measures to ensure that there are modern training provisions available for young people in Carinthia to find good career prospects there. This will also raise the level of education in Carinthia in the long term. The aim is to create an educational offer that lives up to the expectations and requirements of the labor market and is appropriate for a modern business location and an industrialized country.

Scope:

- Closer connection between academia and industry trough smart technology and didactics as well as a common standard for innovative teaching methods supported by digitization
- Expanding the Infineon talent network and early positioning as an employer of choice for technical college students

ORGANISATIONS INVOLVED

INDUSTRY

Infineon Technologies Austria AG

EDUCATION

5 higher technical colleges (HTLs):

- HTL Wolfsberg
- HTL Villach
- HTL Klagenfurt Mössingerstraße
- HTL Klagenfurt Lastenstraße
- HTBLA Ferlach (Since Sept 2020)

GOVERNMENT

Carinthian Education Department

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

The Smart Learning classes are designed as pilot classes and were launched at the secondary technical colleges in Carinthia. Smart Learning means using digital technologies for teaching and studying technical subjects and linking them with analog learning experience, such as working in teams, social exchange and close connection to industry practice.

There are 7 classes involving approx. 210 students. The

pilot project is meant to last 5 years.
The technical colleges benefit from knowledge exchange, product & material support as well as financial support every academic year.

EVALUATION AND OUTCOMES

Cooperation with 5 technical colleges in Carinthia:

- Common Smart Learning Framework & Standards
- Closer connection and mutual support between Smart Learning Schools and Infineon
  - o Use of provided teaching material and links, request for individual topics
  - o Close cooperation between departments and schools
- Notable increase in interest in summer internships, diploma thesis and Study & Work Program amongst students from these schools
- Events: Participation of Teachers & Students in the UniDay, Summer School and Infineon formats like webinars & lectures, site visits, school visits, other events
- Infineon branded classrooms/labs (ongoing)

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Conditions for success

- Close cooperation between technical colleges and Infineon and regular exchange within the project team.

Interaction with students via site visits, virtual events for them to experience the benefits of this cooperation and to create additional motivation amongst students

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

AVERAGE

(due to possible legal restrictions on other countries in terms of industry-school-relations)

BEST PRACTICE #4

TITLE

INFINEON STIPENDIUM (INFINEON SCHOLARSHIP FOR MINT STUDENTS FOR A SEMESTER ABROAD)

COUNTRY / REGION(S) INVOLVED

AUSTRIA / CARINTHIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE

TIME OF LAUNCH

EVERY ACADEMIC YEAR

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

TU Graz offers companies the opportunity to support excellent students going abroad. Infineon supports this program with certain amount per academic year supporting 1-2 MINT students in their semester abroad. [*MINT-Mathematics/Informatics/Natural Sciences/ Technical Sciences]

ORGANISATIONS INVOLVED

INDUSTRY

Infineon Technologies Austria AG

EDUCATION

Technical University of Graz

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

Students of TU Graz can apply for specific company scholarships and Infineon can choose amongst their scholarship applicants. The applicants learn about Infineon and the microelectronics industry.
There is also an official ceremony, where Infineon gets to meet the chosen students and symbolically hands over the scholarship.

EVALUATION AND OUTCOMES

Excellent MINT students are given the opportunity to gather experience at a different university abroad and expand their horizon.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Conditions for success

- Close cooperation between technical colleges and Infineon and regular exchange within the project team.

Interaction with students via site visits, virtual events for them to experience the benefits of this cooperation and to create additional motivation amongst students

METIS

BEST PRACTICE #5

TITLE
BM = X^3 INNOVATIVE CONCEPTS FOR VOCATIONAL TRAINING IN THE HIGH-TECH SECTOR

COUNTRY / REGION(S) INVOLVED
GERMANY / BADEN-WÜRTTEMBERG, SCHLESWIG-HOLSTEIN, BERLIN, OTHER REGIONS

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PUBLIC

TIME OF LAUNCH
BY 2024, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Comprehensive vocational training academy as an open, decentralized structure for the high-tech sector with a digital learning platform.
Increasing the attractiveness of dual training.
Creation of flexible training modules to increase the quality of education, training, and further education.
Advanced training in the micro and nanotechnologies.
Paths of advancement and new additional concepts and degrees. Consistency and equivalence of occupational & academic education.

SIZE OF THE FUNDING

Federal Ministry of Education and Research (BMBF) Competition InnoVET: Approx. 4,8 Million Euros (total 82 Million Euros for 17 different projects)

ORGANISATIONS INVOLVED

INDUSTRY

Robert Bosch GmbH, Bosch Sensortech GmbH, other companies

EDUCATION

- Ferdinand Braun Institute, Leibniz Institute for High Frequency Technology Berlin e.V. (FBH) - network coordination;
- Lise-Meitner-Schule Berlin (LMS) , Berlin University of Technology and Economics - DE: HIVE (HTW); Regional vocational training center of the Steinburg district, (department of micro and nanotechnologies, Itzehoe) (RBZ);
- Technical University of Braunschweig - Institute for Microtechnology (IMT);
- University of Kaiserslautern, training and further education network pro-mst; microTEC Südwest e.V., Freiburg;
- University of Rostock - Institute for Vocational Education (IBP)

GOVERNMENT

Federal Ministry of Education and Research (BMBF)

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

The transformation or digitalization creates the opportunity for employees / specialists or academics to further their education in the field of semiconductor technology. The aim is to develop the talented employees in the direction of semiconductor experts and to create new prospects for the future.

EVALUATION AND OUTCOMES

Through internal / external training courses and also cooperation with other companies / educational institutions / universities, we secure the shortage of skilled workers on the competitive job market and we strengthen the cooperation between high-tech companies.

LESSONS LEARNT/CONDITIONS FOR SUCCESS

The motivation of the employee and the commitment of the cooperation partners offer employees new perspectives and career opportunities to prepare for the future.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

BEST PRACTICE #6

TITLE
APPRENTICESHIP

COUNTRY / REGION(S) INVOLVED
FRANCE

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PUBLIC

TIME OF LAUNCH
MORE THAN 10 YEARS, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

PART OF THE EDUCATIONAL FRENCH STRATEGY TO MIX WORK AND EDUCATION
As it is becoming increasingly difficult for industry to find highly qualified young specialists the initiative offers the possibility of early contact between selected students and industry. It creates the opportunity for students to work on specific topics during a period of time (from 1 to 5 years).
This program supports studies in all areas and most of the educational level (EQF : 5,6,7)

SIZE OF THE FUNDING

In average (depends on the student profile) 8000€/ Apprentice/Year + 9 000€ to cover training fees

ORGANISATIONS INVOLVED

INDUSTRY
Yes

EDUCATION
Yes

GOVERNMENT
Yes

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

Students manage in parallel work (part-time) and study and this allows an optimal combination between theory and practice and at the same time offer the opportunity to study in a goal-oriented manner and earn money at the same time.

EVALUATION AND OUTCOMES

Expected outcome is to have fresh graduates who already have practical experience and knowledge from the industry and can be fully operational after they complete studies.

LESSONS LEARNT/CONDITIONS FOR SUCCESS

To make sure that apprentice work on real projects or tasks and can count on a dedicated company tutor. If we want to hire them at the end of the apprenticeship period, we need to make them a job offer before they are graduate (lot of competition between industry to hire the good student)

METIS

BEST PRACTICE #7

TITLE

EMPLOYEE LENDING

COUNTRY / REGION(S) INVOLVED

FRANCE

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE SUPPORTED BY PUBLIC LEGAL FRAME

TIME OF LAUNCH

2020, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Business crises and use of short time work in company when the activity strongly decrease or there is no activity

ORGANISATIONS INVOLVED

INDUSTRY

Yes

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

On voluntary bases, employees who are working within a company with no or low activities du to Covid Crises, might work for an external company during a negotiated period of time – his/her salary and wages are paid per the host company . In this case the employee is not in short time work

EVALUATION AND OUTCOMES

For the host company: expected outcome is to have expert from other company that could bring new expertise, new vision or process solving methodologies. For the Home company: it decrease the labor cost during the crisis but it's also a way to train the employee –he/she is back having seen other way of working and other competencies

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

MEDIUM

(need to be legally supported by labor law)

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Legal frame is a key success factor to ensure trust between the 2 companies – partnership

METIS

BEST PRACTICE #8

TITLE
WORK & TEACH

COUNTRY / REGION(S) INVOLVED
FRANCE

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PRIVATE AND PUBLIC DEPEND ON THE SCHOOL STATUS

TIME OF LAUNCH
ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Employee working in companies might also teach at university or business/Engineering School for few hours on a specific topics or on a long run

ORGANISATIONS INVOLVED

INDUSTRY
Agreed that the employee is off and have 2 activities

EDUCATION
They hire the employee

GOVERNMENT
They pay teaching hours

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

Some employee, expert in 1 or several topics might on top of their normal working activities, deliver some training within university or schools

EVALUATION AND OUTCOMES

Allow the students to have feedback and training from expert with working life experience

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Lot of work for the employee who will cumulate work and teaching activities – need to be on voluntary bases

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

MEDIUM

(need to be legally supported by education and government)

METIS

BEST PRACTICE #9

TITLE
EUROPRACTICE

COUNTRY / REGION(S) INVOLVED
BELGIUM, UK, GERMANY, FRANCE, IRELAND

TIME OF LAUNCH
1995, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

EUROPRACTICE was launched by the European Commission in 1995 as a successor of EUROCHIP [1989-1995] to enhance European industrial competitiveness in the global market. Over the past 25 years, EUROPRACTICE has provided the industry and academia with a platform to develop smart integrated systems, ranging from advanced prototype design to volume production.

ORGANISATIONS INVOLVED

INDUSTRY
End users

EDUCATION
5 research organisations involved IMEC, STFC, Fraunhofer, CMP, Tyndall National Institute [providing the service], universities and research centres can be end users too

GOVERNMENT
Funding came from the European Commission

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES
EUROPRACTICE is a consortium of five renowned European research organisations, who support academic institutions and medium-sized companies with IC prototyping services, system integration solutions, training activities and possibilities for small volume production. In addition, they provide universities and research institutes with access to CAD tools.

EVALUATION AND OUTCOMES

Early prototyping capabilities, access to large infrastructures [IMEC, Fraunhofer, etc.], staff/student training

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Great example of industry-academia collaboration

METIS

BEST PRACTICE #10

TITLE

PAY SUBSIDY

COUNTRY / REGION(S) INVOLVED

FINLAND

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PUBLIC

TIME OF LAUNCH

N/A – ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Ministry of Economic Affairs and Employment of Finland managed TE-office offers pay subsidy. A pay subsidy is an economic benefit that a TE Office may grant an employer to cover pay costs of an unemployed jobseeker. The purpose of work supported by pay subsidy is to enhance the professional competence of prospective employees to be hired with pay subsidy, and to help them find work in the open labour market. Link

SIZE OF THE FUNDING

~10 k€ per employee eligible for subsidy

ORGANISATIONS INVOLVED

INDUSTRY

All eligible companies

GOVERNMENT

Ministry of Economic Affairs and Employment of Finland / TE-office

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Lack of specific experience may hinder the employment of persons with otherwise suitable skills and mind-set for microelectronics manufacturing. Pay subsidy provides an employer a risk-reduced method to employ and enhance the competence of such persons.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

Depending on similar programs existing in other countries.

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

The granting of pay subsidy is subject to an estimation made by the Employment and Economic Development Office (TE Office) that the jobseeker's unemployment is caused by the lack of professional competence, and work supported by pay subsidy will enhance the jobseeker's professional competence and opportunities to find work in the open labor market. If the person to be hired with pay subsidy is aged 60 or over, the granting of pay subsidy primarily requires that the person has been unemployed for an uninterrupted period of 12 months immediately preceding the granting of pay subsidy.

Although a pay subsidy is granted and paid to the employer, the granting of the subsidy is always based on the unemployed jobseeker's need for the service.

EVALUATION AND OUTCOMES

Summa Semiconductor has found two excellent and skilled cleanroom engineers with the help of this program. One person had a long academic career but no industrial experience. Other person had lacking language skills but extensive education. Decision to employ these persons was facilitated by the availability of pay subsidy.

METIS

BEST PRACTICE #11

TITLE
"INTEGRATED, SCALABLE, FUNCTIONAL NANOSTRUCTURES AND SYSTEMS" (NANOSIS)

COUNTRY / REGION(S) INVOLVED
TURKEY, SOUTH KOREA, ITALY, RUSSIA, U.K., GREECE

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PUBLIC

TIME OF LAUNCH
Q1 FROM 2021, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Part of a publicly funded program

SIZE OF THE FUNDING

5.55 M€ [5.77 k€ for Arçelik]

ORGANISATIONS INVOLVED

INDUSTRY

12 private companies

EDUCATION

9 Universities

GOVERNMENT

3 Research centres

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

NANOSIS will conduct research with a vision focused on detecting and preventing health-threatening and contaminating factors

- Under the leadership of the infrastructure, experience and human resources of its stakeholders
- With materials, structures and systems functionalized using nano-based technologies
- Reducing foreign dependency with the goal of localization
- For the development of integrated and scalable products and technologies
- As a pivot technology platform for different sectors, primarily healthcare
- Creating outputs that create socio-economic added value and creating social awareness

The technological targets for the NANOSIS are:

- Synthesizing and / or controlling the properties of nanomaterials that stand out with their physico-bio-chemical properties, with engineering approaches,
- Development of nanotechnological devices that gain superior performance and functionality with the use of these materials, and realization of integrated systems that can reach the end user in target applications with material-device integration.

METIS

BEST PRACTICE #12

TITLE
WORKING GROUP: STEM (EDUCATION)

COUNTRY / REGION(S) INVOLVED
GERMANY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PRIVATE

TIME OF LAUNCH
Q4 — 2019, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Part of corporate objectives /collaborative initiative -> informal working group between HR people from big companies within Silicon Saxony and similar/same needs/challenges -> pre HR process, targeting mostly pupils, partly also students

SIZE OF THE FUNDING

Appr. 25k EUR + internal staff costs at involved companies
- ->Estimation: at least 10k (internal costs) for each participating institution

Implemented without external funding

ORGANISATIONS INVOLVED

INDUSTRY
Infineon, Global Foundries, X-Fab, SiSax

EDUCATION
DCA

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

Quarterly Meetings with practical developments for corporate branding activities

EVALUATION AND OUTCOMES

Group based Student internship program (1-2 weeks per year) for microelectronics (internship is mandatory for every pupil in Germany), group of appr. 15-20 pupils

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Internship in Microelectronics can't be virtual, suspended for the time being due to COVID19

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

VERY HIGH

Best practice example available within Silicon Saxony from Software players (e.g. SAP et al.)

METIS

BEST PRACTICE #13

TITLE
DRESDEN MICROELECTRONIC ACADEMY

COUNTRY / REGION(S) INVOLVED
EUROPEAN RESP. WORLD-WIDE ACTIVITY, BUT TAKING PLACE IN DRESDEN

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PUBLIC (DRESDEN UNIVERSITY)

TIME OF LAUNCH
FROM 1999 ONWARDS

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

(Yearly Summer School, driven by various funded projects within the University + ecosystem in the framework of different projects) – at the moment connected to a so called "excellence cluster" for electronics within the university https://cfaed.tu-dresden.de/dma-welcome

SIZE OF THE FUNDING

App. 30k EUR

ORGANISATIONS INVOLVED

INDUSTRY

- TU Dresden with its Research Cluster cfaed
- Globalfoundries
- X-Fab
- Bosch
- Infineon

City of Dresden and Silicon Saxony as promotion partners

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

https://cfaed.tu-dresden.de/dma-welcome

EVALUATION AND OUTCOMES

2 weeks summer school programme with visibility for regional ecosystem players

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Mobility, visibility, relatively generic title allows flexibility with regard to (value chain) content

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

BEST PRACTICE #14

TITLE

INFORMATION EVENT: SILICON VALLEY OF AUSTRIA

COUNTRY / REGION(S) INVOLVED

AUSTRIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PUBLIC

TIME OF LAUNCH

YEARLY, FROM 2014

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

The industry should actively go to the University and offer that their experts are included into the lectures to give the students a better insight into the needed skills for working in a microelectronics industry.

SIZE OF THE FUNDING

External lecturers mainly funded by industry

ORGANISATIONS INVOLVED

INDUSTRY

Infineon, ams, NXP

EDUCATION

TU Graz, mostly master students

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

Industry experts should give talks on different aspects on microelectronics.

EVALUATION AND OUTCOMES

Industry was wishing for students to be educated in the topics, they provide external lecturers for.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

Easy to transfer, organizational requirements similar to other lectures, easier if similar courses are already held

METIS

BEST PRACTICE #15

TITLE
EXTERNAL LECTURERS

COUNTRY / REGION(S) INVOLVED
AUSTRIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PUBLIC

TIME OF LAUNCH
2014, ONGOING EVERY SEMESTER

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

The aim of this event, is to give our students a chance to listen to the microelectronics industry introducing themselves (typically representatives of 10-12 integrated circuits design and manufacturing companies), to give a possibility to network and chance to exchange information: with a formal podium as well as in a foyer meeting.

ORGANISATIONS INVOLVED

INDUSTRY

Infineon, Intel, NXP, ams, Panthronics, Usound, dialog, IDT, ST microelectronics, SteadySense, CISC

EDUCATION

TU Graz, sometimes also students from other schools (EQF 5)

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

The main goal is to motivate students to study microelectronics and IC design in their master's program.

EVALUATION AND OUTCOMES

Since this event, we definitely have more students interested in electronics and IC design.

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Motivated students and company representatives

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

Easy to transfer, medium organizational requirements

METIS

BEST PRACTICE #16

TITLE
SPECIALIST IN SEMICONDUCTOR TECHNOLOGY, SPECIALIST IN MICROSYSTEM TECHNOLOGY

COUNTRY / REGION(S) INVOLVED
GERMANY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PRIVATE (COMPANIES) AND PUBLIC

TIME OF LAUNCH
2010, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Demographic change and the shortage of skilled workers brought companies, educational institutions and the public sector together to set up a program to remain competitive. The target group are lateral entrants who want to switch to a completely new professional field. Funded by the employment agencies and support from companies in the semiconductor industry and their suppliers.

SIZE OF THE FUNDING

about 9.200 € /person

ORGANISATIONS INVOLVED

INDUSTRY
Different companies in the semiconductor industry and their suppliers

EDUCATION
SBH Südost GmbH, dresden chip academy

PUBLIC
Federal Employment Agency

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

SBH Südost GmbH developed a training program for career changers in the fields of semiconductor technology and microsystem technology.
The practice-oriented training lasts 6-8 months. The program then includes a 6-8 month internship in a company in the semiconductor industry.
content:
- Electrical engineering
- Electronics
- Pneumatics
- semiconductor processes
- semiconductor technology
- clean room technology
- clean room behavior
- microsystem technology
- structure and connection technology
- English
- measurement and control technology

[for example: RHe Microsystems GmbH
, X-Fab GmbH Dresden, First Sensor Microelectronic Packaging GmbH]

EVALUATION AND OUTCOMES

About 500 trained participants who were able to take a job in the semiconductor industry

LESSONS LEARNT/CONDITIONS FOR SUCCESS

High quality and practice-oriented training that is tailored to the needs of industry and can be adapted at short time

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

BEST PRACTICE #17

TITLE

BACHELOR OF ENGINEERING (B.ENG.) / + VOCATIONAL EDUCATION MICROTECHNOLOGY

COUNTRY / REGION(S) INVOLVED

GERMANY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE (COMPANIES) AND **PUBLIC**

TIME OF LAUNCH

FROM 1999 ONWARDS

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Bachelor's degree in microtechnology with professional training in microtechnology
9 Semester / 210 ECTS

SIZE OF THE FUNDING

about 6.200 € / person (SBH)
Study is free
+ The students receive a salary from the company providing the training during the entire training period.

ORGANISATIONS INVOLVED

INDUSTRY

Different companies in the semiconductor industry and their suppliers

EDUCATION

SBH Südost GmbH, dresden chip academy

PUBLIC

Westsächsische Hochschule Zwickau
(University of Applied Sciences)

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

This form of study leads in nine semesters to both the professional qualification as a micro technologist and a Bachelor of Engineering degree. In order to achieve both degrees, practical professional training takes place parallel to the course, alternating with periods of study.

EVALUATION AND OUTCOMES

About 100 trained participants (semiconductor industry)

LESSONS LEARNT/CONDITIONS FOR SUCCESS

The cooperative study is significantly shorter than training and study together.

A very practice-oriented degree due to the close interlinking of theory and practice.

During their studies, the student gets to know his future field of activity in the company and is gradually prepared for his future work as a bachelor's degree.

METIS

BEST PRACTICE #18

TITLE
INDUSTRIAL EXPERT ROBOTICS

COUNTRY / REGION(S) INVOLVED
GERMANY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)
PRIVATE (COMPANIES) AND PUBLIC

TIME OF LAUNCH
SINCE OCTOBER 2020, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

National strategy to prepare and train employees in companies for new technologies and to make them fit for the digitalized world of work.

ORGANISATIONS INVOLVED

INDUSTRY
Different companies in the semiconductor industry and other

EDUCATION
SBH Südost GmbH, dresden chip academy

PUBLIC
Federal Employment Agency, further education
BiBB [Federal Institut for Vocational Education and Training] for vocational Education

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES
Offer that combines the basics of Industry 4.0, robot technology and the related specialist areas.
content:
- Industry 4.0
- Electrical engineering
- Electronics
- Automation technology
- Sensors
- Electro pneumatics
- Robotics
- Programmable logic controller

EVALUATION AND OUTCOMES

Courses are still running

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

METIS

BEST PRACTICE #19

TITLE

LINE EXPERT

COUNTRY / REGION(S) INVOLVED

GERMANY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE (COMPANIES) AND **PUBLIC**

TIME OF LAUNCH

2020, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Part of the corporate goals

ORGANISATIONS INVOLVED

INDUSTRY

Infineon Technologies Dresden GmbH

EDUCATION

SBH Südost GmbH, dresden chip academy

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

IFD - HR development strategy.

Content:
- Semiconductor theory (dca)
- Semiconductor processes (dca)
- Quality management (IFD)
- FMEA, SPC, (IFD)

EVALUATION AND OUTCOMES

First group is ready, group 2 started May 2021

LESSONS LEARNT/CONDITIONS FOR SUCCESS

Practice-oriented, special training for employees of Infineon Technologies Dresden GmbH.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

METIS

BEST PRACTICE #20

TITLE

SPECIALIST MICROTECHNOLOGY (IHK)

COUNTRY / REGION(S) INVOLVED

GERMANY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE (COMPANIES) AND **PUBLIC**

TIME OF LAUNCH

SINCE 2012, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Create offers, advanced training below the engineering level in microtechnology. Up until that point there was nothing more than training for skilled workers in Germany.

SIZE OF THE FUNDING

about 9.200 € /person

ORGANISATIONS INVOLVED

INDUSTRY

Different companies in the semiconductor industry and their suppliers

EDUCATION

SBH Südost GmbH, dresden chip academy

PUBLIC

Chamber of industry and commerce

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

A part-time training model based on the work-process-oriented training model with decisive advantages:

- Part-time, oriented towards the work process
- Individual training agreement, takes into account specialist knowledge already acquired in the work process
- Use of the most varied forms of education possible

Content:

- Quality management
- semiconductor technology
- semiconductor processes
- operational project work

Examination in front of the chamber of industry and commerce.

EVALUATION AND OUTCOMES

About 100 trained participants (semiconductor industry)

LESSONS LEARNT/CONDITIONS FOR SUCCESS

High quality and practice-oriented training with an examination in front of the chamber of industry and commerce.

METIS

BEST PRACTICE #21

TITLE

THE NORWEGIAN INFRASTRUCTURE FOR MICRO- AND NANOFABRICATION (NORFAB)

COUNTRY / REGION(S) INVOLVED

NORWAY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PUBLIC

TIME OF LAUNCH

2011, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

The vision of NorFab is to be a robust and competent backbone consortium supporting and enabling research and innovation within micro-and nanotechnology (MNT) in Norway. NorFab will be an enabling resource for both academic and industrial R&D Funded by research council of Norway.

SIZE OF THE FUNDING

5 million Euros for USN and total 32 million Euros

ORGANISATIONS INVOLVED

INDUSTRY

SINTEF

EDUCATION

University of Oslo, University of South Eastern Norway and Norwegian University of Science and Technology (NTNU)

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

The European countries (France, Norway, The Netherlands, Spain, Sweden, Portugal, Italy and the Czech Republic) have established a consortium, EuroNanoLab, with the aim to make better use of existing investments and reduce the time of process development by sharing process know-how, similar model as Norfab.

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

NorFab provides access to state-of-the-art laboratories for Norwegian researchers, independent of their academic, institute or company affiliation. The laboratories include the three nodes NTNU NanoLab in Trondheim, SINTEF MiNaLab and UiO MiNaLab in Oslo, and the University of South-Eastern Norway´s MST-Lab in Horten.

Norfab offers more than 2000 m^2 of cleanroom laboratories with advanced synthesis and analytical equipment.

EVALUATION AND OUTCOMES

This cooperation has gives us access to many more processing equipment that we would have if we would stand alone.

LESSONS LEARNT/CONDITIONS FOR SUCCESS

This cooperation has given access to lab and knowledge across universities

METIS

BEST PRACTICE #22

TITLE

COMPANY SPONSORING OF LABORATORIES AT TUS

COUNTRY / REGION(S) INVOLVED

BULGARIA

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE

TIME OF LAUNCH

ONGOING SINCE 2012

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

Part of corporate objectives and of the goals of the university to collaborate with the industry

SIZE OF THE FUNDING

More than EUR 500 000

ORGANISATIONS INVOLVED

INDUSTRY

COSTAL, AREXIM Engineering, VISTEON, CEZ

EDUCATION

University of Oslo, University of South Eastern Norway and Norwegian University of Science and Technology (NTNU)

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

The companies sponsored the creation of laboratories at TUS with expensive and modern equipment to train students specific skills for the needs of the companies, i.e. to prepare their future employees.

The experts form the companies participate in the training process.

A new practice is the contract of TUS with a company that pays the education fees of some students from one speciality to stimulate them to study it and to be prepared for further job at the company. These are the big companies, as in nuclear energy for example.

Other practice is the grant paid by a company for the 5 years of education of a student who should work at the company after graduation.

EVALUATION AND OUTCOMES

Quantitative	Qualitative
100s of graduates ready for a job at big companies without need of in-company training during the first 6 months or one year The enterprises in electronics, mechatronics and energetics (COSTAL, AREXIM Engineering, VISTEON, CEZ) rely on trained new employees.	VET responsive to the needs of the industry University equipped with innovative professional laboratories Students have work-oriented education

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

HIGH

LESSONS LEARNT/CONDITIONS FOR SUCCESS

These practices exist in most if not all polytechnics in Europe. It would be good to transfer them to the VET schools providing training at lower levels of EQF.

BEST PRACTICE #23

TITLE

AEIT ASSOCIAZIONE ITALIANA DI ELETTROTECNICA, ELETTRONICA, AUTOMAZIONE, INFORMATICA E TELECOMUNICAZIONI (Italian Association of Electrotechics, Electronics, Automation, Information and Communication Technologies)

COUNTRY / REGION(S) INVOLVED

ITALY WITH CONNECTION WITH THE EUROPEAN ASSOCIATION FITCE (FEDERATION OF TELECOMMUNICATION ENGINEERS OF THE EUROPEAN COMMUNITY).

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE (No-profit)

TIME OF LAUNCH

1897, ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

AEIT is a private initiative which received a public recognition of organisation with a cultural mission.

ORGANISATIONS INVOLVED

INDUSTRY

ABB, e-distribuzione, Edison EDF Group, GEWISS, Prysmian Group, Terna

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

AEIT promotes and support:
- the study of science, electronic, automation, information technologies and telecommunications;
- the development of related technologies and applications;
- cultural growth and professional development of its members in the mentioned areas.

AEIT also supports young researchers and students, active in the related fields or joining them, and contributes to:
- address technical training towards employment proposals and expectations in the industrial segments of interest of AEIT;
- support professional development.

EVALUATION AND OUTCOMES

1. R&D support, know-how dissemination and application of innovation
   - Collaboration with universities, schools, industries, institutions, research centres, national and international associations (AICA, EUREL, INFORAV etc.) to Increase members' knowledge and skills;
   - Promotion of links with universities, schools, institutions and industries to support young people training and career development, targeting their employment;
   - Establishment of awards, and awarding of scholarships;
   - Surveys on new technologies and new technical regulations, and on the quality of young students/researchers' technical training.
   - VET courses in: Electrotechnics, Energy, Maintenance, Electrical Systems, Measurements, Regulations, Security.

2. Institutional Relations and External Communication
   - interaction with Ministries and Authorities, mostly on innovation, law evolution and regulations in the reference sectors.

LESSONS LEARNT/CONDITIONS FOR SUCCESS

VET courses and other initiatives are performed on a peer-to-peer basis by company staff and experts . There is a shared interest to train people with skills and competences which are demanded by the industry sector.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

AIET is in connection with the European Association FITCE (Federation of Telecommunication Engineers of the European Community).
Similar initiatives may be found elsewhere in Europe and there is a full transferability of the practice.

METIS

BEST PRACTICE #24

TITLE

THE ITALIAN SOCIETY OF ELECTRONICS - SIE (SOCIETÀ ITALIANA DI ELETTRONICA)

COUNTRY / REGION(S) INVOLVED

ITALY

TYPE OF INITIATIVE (PUBLIC, PRIVATE)

PRIVATE

TIME OF LAUNCH

(PRIOR TO 2015), ONGOING

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

This is an association of individuals (no organizations are admitted as members), mainly from HEIs.

ORGANISATIONS INVOLVED

EDUCATION

Professors, researchers and students

SUMMARY OF THE INITIATIVE AND ITS OBJECTIVES

It is a non-profit association established with the aim to promote and develop education, training, research and technology transfer activities in the Electronics sector. SIE members are full professors, associated professors and students from Italian Universities, and researchers from Italian public Research institutions.

Its main aim is to pursue the research through the cooperation among individuals.

Activities include, among others:

- promotion of research, development and advanced training initiatives and projects in the field of Electronics, its applications and technologies;
- active support for the participation of its members in projects financed by public and private bodies;
- dissemination of papers and publications;
- organisation and management of courses, seminars, conferences, and any other event aimed at promoting and disseminating the results of research and innovation in Electronics;
- enhancement of scholars' and researchers' skills with the support of scholarships or training awards.

EVALUATION AND OUTCOMES

Among the other activities, the following worth a mention:

- the Annual Doctoral School with the participation of outstanding experts from the academia and doctoral students from Italy and abroad.
- SIE issued a brochure for Secondary Education students, in order to give essential information on this branch of science and technology, on its role in today's society, and on what it will inevitably have in outlining the future of humanity (*"L'elettronica inventa il tuo futuro (Electronics create your future)*
- YouTube Channel https://www.youtube.com/channel/UCQqw7T-ac8TLUdhqX1u587A/featured
  The SIE YouTube Channel allows to a) support guidance activities targeted at students accessing to higher education and b) disseminate topics related to higher education, training, research and technology transfer in the Electronics sector. Editorial and scientific contents are visualised via videos, using appropriate testimonials (e.g., Youtubers, science communicators). Using social media that are popular among young people, as well as adopting a friendly and informal communication allow to better target messages to a young audience, and make scientific topics understandable, more appealing and easier to disseminate than traditional publications. In addition, the practice allows fast publishing, updating and creating links among contents

LESSONS LEARNT/CONDITIONS FOR SUCCESS

- Information is a key factor to find the best resources to place in the labour market of Electronics and Microelectronics
- A friendly language is the best way to address young people
- Practical examples and concrete numbers are key factors to approach students and stimulate their interest
- The use of videos increases potential of dissemination and accessibility of information
- The use of familiar testimonials increases potential of dissemination among young people

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

- *The brochure can be easily translated in national contexts, adding country-specific information.*
- *The brochure can also be used in a EU context, giving an overview of the existing opportunities in Electronics and/or Microelectronics.*
- *The idea of the Youtube Channel can be promoted in other countries in order to support the development of virtual networks and a wider database of resources.*

METIS

BEST PRACTICE #25

TITLE

ICT KENNEDY FOUNDATION

PLACE & DATE OF IMPLEMENTATION

FRIULI VENEZIA GIULIA AND VENETO REGIONS, ITALY, FROM 2010 ONWARDS

(BASED ON NATIONAL REGULATIONS – SEE THE PRIME MINISTER'S DECREE OF 25 JANUARY 2008)

INVOLVED PARTIES FROM PARTNERS

The coordinating body of the ITS courses is a Foundation which includes schools, training institutions, companies, universities and research centres thus creating an authentic integration between teaching and work. The Foundation involves 19 business partners, 12 education partners, 3 science partners and a public administration.

FUNDING OF THE PRACTICE

Public Funding: FSE and Ministry of Education, University and Research

Private Funding: The support of partner is also economic, as in the case of Friuli Foundation, an organization with the purpose of promoting economic development and social utility, based on the principle of subsidiarity.

CONTEXT BEHIND THE INITIATIVE (E.G. LAUNCHED IN THE FRAMEWORK OF A NATIONAL OR REGIONAL STRATEGY/ PART OF CORPORATE OBJECTIVES/ PART OF A PUBLICLY FUNDED PROGRAMME)

There are about 200 companies and organizations that collaborate with ITS Kennedy: they ensure ample opportunities for internships, teaching, planning, updating on specific ICT topics, sharing of projects and networking.

The ITS were the first experience in Italy of a professionalizing post-secondary non-university training offer similar to some European realities, such as the German Fachhochschule or the Brevet Technicien Supérieur of French superior technician, united by the characteristic of: favoring direct insertion into the world of work; responding to companies' s request for personnel with non-university tertiary training, with practical experience; continuing from a previous training course carried out in alternation between school and work; allowing the continuing education of adults.

ITS courses have a duration of at least 4 semesters, about 1800/2000 hours, but courses of 6 semesters can be set up in agreement with universities. The ITS trainings meet the demand of companies for figures with technical and practical skills that can be directly spent and provides for: laboratory activities; compulsory internships (including abroad) for at least 30% of the total number of hours; at least 50% of the teaching staff comes from the world of work and professions.

The degree has European significance as it is associated with a EUROPASS diploma supplement. To those who have attended at least 80% of the course and passed the final examination, the ITS body issues a "higher technical diploma", which is placed at the 5th level of the European Qualifications Framework (EQF).

According to art. 7 of the Prime Ministerial Decree of 25 January 2008, 6 technological areas are envisaged: sustainable mobility, new technologies for life, new technologies for Made in Italy, innovative technologies for cultural-tourism assets and activities, information and communication technologies, energy efficiency.

To access this type of training, candidates must have an upper secondary education diploma or a four-year diploma of vocational education and training supplemented by an annual course of higher technical education and training (IFTS). The courses allow those wishing to continue with university studies later on to acquire university credits for the purpose of obtaining a degree. The Kennedy Foundation offers curricular paths in the area of "Information and Communication Technologies"

ACHIEVED BENEFITS

QUALITATIVE

- Connecting students at the beginning of their professional careers with leading industries
- Highlighting the importance of networking with industry

QUANTITATIVE

- 83% of graduates find work one year after graduation
- 11.4% become "off-site" nationally but also internationally
- 5% of ITS members have already graduated but are looking for a more sectoral and practical experience.
- compulsory internships (including abroad) for at least 30% of the total number of hours;
- that at least 50% of the teaching staff comes from the world of work and professions;

LESSONS LEARNED AND SUCCESS FACTORS

Schools, training institutions, companies, universities and research centres, other bodies and institutions can give life to a reality with stable legal personality. Companies, training organizations of all levels, research centres and public bodies can work together to detect employment needs (knowledge and skills), provide for their training, with the support of policy makers.

LEVEL OF TRANSFERABILITY (IN OTHER COUNTRIES / OTHER FACETS OF THE VALUE CHAIN)

YES

B. Policy recommendations

The policy recommendations formulated by the 251 stakeholders from 159 organisations of the microelectronics industry interrogated by METIS in 2020 are summarized below.

1) Involve the microelectronics industry in the education process

In microelectronics, cross-border cooperation between education & training providers and industry is weak. Closer collaboration between industrials and education providers is very important and requires openness and understanding from both sides, industry and education institutions. Companies can be involved in education processes starting at the high school level.

The insufficient cooperation between industrials and education providers is prejudicial for the following reasons:

- The companies adapt very fast because of the market pressure. The microelectronics sector's innovation pace is so fast that limits education providers to catch up. Education providers are therefore not always aware of new skills needs, resulting in outdated curriculum and rigid transition to the world of work.
- Universities are involved in R&D projects but not indirectly in manufacturing processes. Therefore, the curriculum made by universities can put a too great emphasis on R&D topics and not enough on basic manufacturing processes or engineering technics made for large-scale manufacturing (e.g., design for manufacturing).

The following recommendations are made to increase the industry-education cooperation:

1 - Develop internships, apprenticeships, PhDs and graduate training programs co-organized (and co-funded?) by universities and industrials.

For instance, students working in the industry during internships and apprenticeships could be managed by companies but be under the monitoring of the university to benefit from the theoretical knowledge associated with their tasks during their working time and receive support in case of lacking the knowledge to be productive.

Three to six months of internships at the early stages of studies should also be generalized.

Public bodies have the opportunity to sponsor internships, apprenticeships, PhD and/or graduate programs co-organized by universities and industrials.

2 - Generalize the use of experts from the industry as teachers at the university.

Industrials should provide experts to give lectures at universities to give the students a better insight into the needed skills for working in microelectronics industry.

3 - Generalize the organisation of regular presentations of companies at universities.

In order to:

- Have company representatives meet with students to present their activities and products.
- Inform the students about the typical job positions in the microelectronics industries.

4 - Blur the lines between universities and companies.

In order to go even further in the cooperation between industrials and education providers, initiatives to develop life-long training and to combine study and training in a single workplace should be developed:

- Generalize the involvement of companies in the design of universities and VET training programs.
- Generalize the involvement of universities and VET providers in career-long/life-long training within companies, to design life-long training programs, blurring the lines between initial and vocational training. Companies should provide enabling framework to motivate continuing learning through HR management (e.g., raising awareness, training, etc.), involving VETs and universities. Currently, except a few countries in the EU, work-based learning is not integrated into the overall education-industry partnership.
- Develop universities' applied courses directly in companies' factories and involve university teachers in companies' facilities (to present them the last manufacturing processes, etc.).
- Generalize co-funded and co-organized projects between universities and companies. Universities and industrials should cooperate more intensive on enabling innovative (arise from research) applications.

2) Improve the image of the microelectronics through communication campaigns

The microelectronics industry suffers from a poor image as a field to work in. People should also associate the microelectronics sector with Europe and not only with Silicon Valley and Taiwan or Asia. A set of initiatives should be organized to promote KETs and microelectronics to the public and attract young students.

Raise the importance of semiconductors in society through communication campaigns. The key messages of such communication campaigns would be:

- Presenting microelectronics as the enabling industry for the digital world and the digital and green transitions.
- Presenting microelectronics as a crucial industry for the sustainability of almost all the other industries, consumers of microelectronics products. Learners and the future workforce do not sufficiently connect microelectronics (hardware) with its contribution to societal and environmental issues.
- Presenting microelectronics as an essential industry for everyone's better life as digital innovations and services (smartphones, software applications for infotainment/mobility/retail/food delivery, IoTs, etc.) are enabled by the microelectronics

industry. Learners and the future workforce do not sufficiently connect microelectronics (hardware) with data technologies (AI & software).

- Presenting microelectronics as an industry at the heart of today's innovation: concentrating most of electronics innovations and enabling software and digital innovations. Promote the technological innovations enabled by microelectronics.
- Presenting microelectronics as a significant industry in Europe, providing jobs and growth.
- Provide a basic understanding of what is microelectronics, the microelectronics value chain and of Cyber-Physical Systems (requiring microelectronics).

Teach microelectronics-related topics at an early stage of the education system.

- Train energy efficiency and semiconductor to high school students.
- Train more software skills in lower education.
- Push Digitalization in schools.

Conduct actions to raise the interest of young people in STEM educations for technical jobs, electrical engineering and microelectronics.

- Promote the typical job positions STEM students could pretend to in the microelectronics industry and the associated career evolutions.
- A more intense lobbying on the microelectronics industry's career opportunities is needed.

Finally, some stakeholders are not convinced by the need for such communication efforts. According to them, students are not sufficiently attracted by the microelectronics industry in Europe because of the relatively small size of the industry compared to other regions. Therefore, according to them, **initiatives to build a stronger microelectronics value chain in Europe are the best way to attract students to microelectronics.** Especially, supports to invest in state-of-the-art large scale manufacturing capacities of processors in Europe.

3) Develop clusters and networks favouring dialog between industry and education representatives

Such clusters and networks are required to enable universities to be in close contact with local companies to understand their needs.

More precisely, several stakeholders pledge for the organisation of forums of discussions between the microelectronics industry and universities & VET representatives to identify synergies and actions at the European level. Such a forum would be in charge of:

- **Setting up dedicated groups defining and updating roadmap of skillset needed.**
- **Mapping training and course from European education providers**, especially to enable SMEs to know where to recruit students for certain profiles. Indeed, large companies have the

capacity to actively be informed about course provided by universities across Europe, but it is harder for SMEs.

These will be some of the roles of the Observatory and Skills Council, organized by METIS and co-led by SEMI Europe and Silicon Saxony.

4) Sponsor state-of-the-art manufacturing infrastructures to be shared by large companies, education players and SMEs

State-of-the-art large scale semiconductor production capacities are increasingly costly (up to several billion euros), leading to three challenges for the European microelectronics ecosystem:

- The European microelectronics industry lacks state-of-the-art manufacturing capacities to compete with other regions of the World in both memories and processors.
- SMEs have a particular difficulty accessing factory facilities able to produce large volumes and state-of-the-art semiconductors. In the current situation, SMEs' possibilities to scale up production volumes in Europe are therefore very limited as there is a big gap between R&D facility processes and large foundries in terms of technology maturity and manufacturing volumes (except for a few large research and technology organisations such as IMEC and CEA LETI).
- European laboratories and R&D activities face difficulties to maintain R&D projects applied to state-of-the-art manufacturing processes.

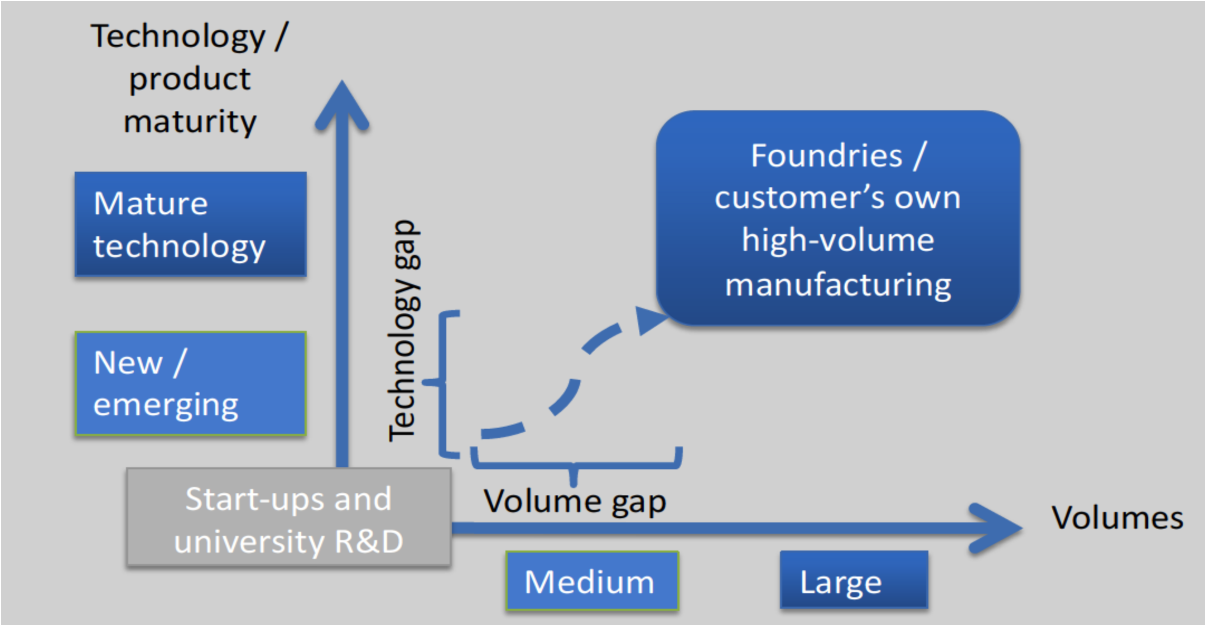
In order to respond to these difficulties, **public bodies at the EU level could:**

- **Sponsor investments in state-of-the-art manufacturing capabilities in Europe, requiring highly concentrated investments.**
- **Ensure the access to such manufacturing capabilities for both large companies, SMEs and universities to support R&D applied to state-of-the-art semiconductor manufacturing processes.**

Sponsor investments in shared cleanrooms in the More than Moore area of special manufacturing processes is another option as investments in cleanrooms are less expensive than in the Moore area for state-of-the-art semiconductor production facilities (e.g., below 20 nm).

Sharing facilities (even laboratories), between industrials and universities, are in general a good practice.

Difficulty to invest in large scale state-of-the-art manufacturing capabilities, especially for start-ups and universities R&D



Source: Summa Semiconductor

5) Develop Joint degrees in microelectronics

Due to the recent innovations impacting the microelectronics industry, there is a growing need for a joint curriculum. The table below summarizes the four types of joint degrees that are the most required by the microelectronics industry: Electronics & Software, Electronic & Chemistry, Electronics & Marketing and Electronics & Biology.

Proposals for joint degrees / curricula for microelectronics

Fields of study	Proposals for joint degrees			
	1	2	3	4
Microelectronics / Electro-engineering / Mechanics / Mechatronics	V	V	V	V
Software / Data science / Informatics	V			
Chemistry / Material science (Polymers, etc.)		V		
Marketing, Sales and Communication			V	
Biology / Natural Science				V

In the same vein, more curricula dedicated to microelectronics should be set up in Europe.

METIS
Co-funded by the Erasmus+ Programme of the European Union
Microelectronics Training, Industry and Skills (METIS) project number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B under the action Sector Skills Alliances in vocational educational education and training Grant Agreement number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B

6) Favor intra- and extra-EU mobility

Several measures are needed to facilitate the mobility of workers within and outside the EU. The mobility of workers is particularly important for the microelectronics industry as it is difficult to hire in microelectronics producing regions often far from large cities. Extending the search for talent across borders is often necessary to find qualified and willing candidates.

Ease administrative processes

- **To hire employees from abroad the EU.**
- **To facilitate intra-EU workers' mobility.**

Currently, companies in some EU countries have to wait several months for authorization from the administration to employ foreign workers.

Enhance the uniformization of degrees and curriculum across the EU.

It is still currently easier to hire locally because of the remaining differences between what universities offer in Europe, and it is difficult for companies (especially SMEs) to understand these differences between EU educational systems.

7) Other policy recommendations

Below is the list of other recommendations made by the stakeholders interviewed by METIS:

- **Impose targets linked to sustainability for the industry with deadlines (e.g., 2030, 2050)**, such as Co2 free activities by 2050.
- **Build/develop gateways for newcomers in the microelectronics industry.**
    - Facilitate student sponsorship programs so that the microelectronics industry can support scholarship (fees) of future entrants (Tax rebate, etc.).
    - Develop dedicated "gateway" programs to "fast train" non-STEM graduates.

C. Recommendations for training modules

This chapter describes the main skills and knowledge needed by the European microelectronics industry that must serve as a basis for the design of training modules to upskill and reskill the workforce. To get the detailed results that have served as a basis to build these results, please read the report "**Skills and Occupational Profiles for Microelectronics**" and its annexes, from METIS, released in 2021.

1) Basics of manufacturing

To be taught on a common basis to all workers in the microelectronics industry.

Skills/knowledge	Required at EQF level n°
• Knowledge of standardized testing techniques. • Introduction to standardized maintenance techniques. • Knowledge of standardized production processes, processes flows and manufacturing lines. • Knowledge of standardized processing equipment: standardized machines used to manufacture semiconductors (lithographic, deposition, etching and cleaning, process control), and electronics products.	4 & 5 for technicians 6 for engineers

2) Fundamental knowledge in microelectronics

To be taught on a common basis to all engineers in the microelectronics industry.

Skills/knowledge	Required at EQF level n°
• Basics of electrical engineering. • Ability to set up hardware, applied electronics. • Basics of analogue and digital electronics design: including analogue circuit design, digital circuit design, RF design and power supply design. Knowledge in analytical tools such as ETAP, schematic and spice simulation. Understanding in hardware description languages (e.g., VHDL). CMOS, Bipolar, Diodes, etc. • Ability to analyse transistor-level circuits. • Good fundamental knowledge in chemistry, physics, mathematics, mechanics and material science. • Introduction to semiconductor materials (traditional materials and emerging ones). Silicon, Silicon Carbide, Gallium Arsenide, Gallium Nitride, Germanium… • Basic knowledge of quality engineering. • Basic knowledge in failure analyses, physics of failure.	6

Microelectronics Training, Industry and Skills (METIS) project number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B under the action Sector Skills Alliances in vocational educational education and training Grant Agreement number 612339-EPP-1-2019-1-DE-EPPKA2-SSA-B

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Co-funded by the Erasmus+ Programme of the European Union

3) Design

Basics of design

To be taught on a common basis to all engineers in the microelectronics industry.

Skills/knowledge	Required at EQF level n°
• Design for manufacturing: Knowledge of the techniques to build robust, reliable and high-performance circuits or layout (as opposed to techniques to achieve the best specifications without looking at reliability, corners, etc.). Knowledge of design techniques to take into account temperature variation, technology variations and environmental effects. • Ability to use industry-standard tools for design and layout (Cadence, Synopsys, VHDL, etc.). • Proficient with statistical signal analysis, signal detection and estimation. • Virtual prototyping. • Ability to carry out layout and back annotation.	6

Advanced design / System Design

Definition of system design: Design of microelectronics systems: System-on-Chip (SoC), System-in-Package (SiP) and System-on-Package (SoP).

Skills/knowledge	Required at EQF level n°
• Knowledge of microelectronic systems architectures: System-on-Chip (SoC) and System-in-Package (SiP). • Ability to design system architectures: complex ASICs, Systems-on-Chips, and System-in-Package. • System design thinking / System-Level modelling and validation. Ability to design ICs, ASICs, FPGAs, PCBs, Systems-on-Chips and System-in-Package. • Knowledge, ability to design and fabricate the different types of microsystems (MEMS, MOEMS, etc.). • Proficient with statistical signal analysis, signal detection and estimation. • Mixed-Signal Design: Proficient with analogue and digital electronic design, noise, signal integrity, etc. • Hardware-software integration (Required at EQF 6). Hardware-software co-design. • Advanced design for manufacturing: Ability to optimize system architectures and component integration against production constraints. • Top-Level Simulation: Ability to create testbenches needed for chip and full system validation. • Understanding of the whole design and product life cycle.	7

4) Manufacturing

Manufacturing engineers (EQF level 6–7)

65% of process engineers are hired at the entry level with an EQF level of 7 or more. The other 35% are hired with an EQF level of 6.

Skill/knowledge type	Skill/knowledge
Mandatory	• Deep knowledge in semiconductor - and electronics assembly technologies, competence in related quality standards (e.g., IPC). • Familiar with the concepts of design for manufacturing, design for assembly, design for test, design for inspection. • Knowledge of FMEA – failure mode and effect analyses – procedures, and RCA – root cause analyses techniques. • Assure the operation of automatic manufacturing lines, preventing and troubleshooting of machine failures, manufacturing equipment downtime reducing. • Analysis of process outputs, improvements of processes. • Can use complex data analysis tools, understanding of applied statistics. • Design inspections and tests for addressing end-product quality. • Keep and enforce health and safety regulations of the manufacturing environment. • Basic multidisciplinary knowledge covering chemistry, material science, and physics.
Soft	• Critical thinking, innovative thinking, problem-solving mindset.
Emerging/advanced	• Knowledge, analysis and use of innovative production materials and production processes. • Knowledge and application of standards about functional safety, like ISO-26262. • General knowledge and application of I4.0 concept. • Basic knowledge of Quality 4.0 concept. • Ability to establish a digital model of manufacturing equipment.

Manufacturing technicians (EQF level 4–5)

60% of process technicians are hired at the entry level with an EQF level of 4-5. The other 40% are hired with an EQF level of 6.

Skill/knowledge type	Skill/knowledge
Mandatory	• Able to understand and perform task following the work instruction. • Knowledge of production/assembly processes (especially semiconductors and PCB manufacturing). • Act on failures of machines, assist in repair and documentation. • Learn and install new manufacturing lines, support pilot manufacturing. • Assist in root cause analyses of manufacturing defects and failures. • Carry out preventive maintenance of manufacturing equipment. • Support TPM procedures – total productive maintenance, cooperate with maintenance technician. • Execute product changeover and manufacturing start-up. • Monitoring the output of the manufacturing line. • Gather data from manufacturing and report it to senior staff members; basic knowledge in Word, Excel, Outlook, SAP, QDAS. • Prepare, read, document engineering drawings and drafting.

	• Keep health and safety regulations of the manufacturing environment. • Ability to limit the impact of process hazards on the workshop and the work in progress.
Soft	• Cooperate with the process- and manufacturing engineers. • Basic understanding of the I4.0 concept.
Emerging/advanced	• Basic understanding of standards about functional safety, like ISO-26262. • Use AR and VR tools for digital instructions in microelectronics manufacturing. • Understand new safety standards introduced by cyber-security production systems. • Media skills for understanding virtual prototyping. • Understand the concept of MaaS (manufacturing-as-a-service). • Introductory knowledge of materials (traditional materials and emerging ones).

Maintenance technicians (EQF 4-5)

45% of process technicians are hired at the entry level with an EQF level of 4-5. The other 45% are hired with an EQF level of 6, and 10% with an EQF level of 7.

Skill/knowledge type	Skills/knowledge
Mandatory	• Knowledge of processing equipment. Able to analyse equipment signals (alarms, SPC/FDC). • Basic knowledge of production processes (especially semiconductors). • Knowledge of standardized testing techniques. • Knowledge of predictive/preventive maintenance services. • Able to assure the uninterrupted, safe operation of manufacturing lines and availability of production machines, operating equipment. • Ability to maintain (daily, weekly, yearly), calibrate and troubleshoot manufacturing lines, machines, equipment. • Analyse and repair machine failures. • Ability to inspect and prevent failures of technological procedures; reduce downtime. • Read maintenance instructions and plans; TPM – total productive maintenance. • Knowledge in health and safety regulations.
Soft	• Report and document maintenance and repair work. • Cooperate with the stock department and engineering departments. • Coordinate the operators in the shift. • Innovation: Partner in support of innovative Equipment Engineering Methods.
Emerging/advanced	• Introduction to materials (traditional materials and emerging ones). • Suggest development to prevent recurring problems in manufacturing. • Basic skills in ERP (enterprise resource planning) systems to record performed repairs and maintenances.

5) Test and quality

Test engineers (EQF level 6)

62% of test engineers are hired at the entry level with an EQF level of 6. 31% are hired with an EQF level of 7 and 7% are hired with an EQF level of 4-5.

Therefore, the following list of skills and knowledge must be mastered ideally at EQF 6 and at EQF 7 otherwise.

Skill/knowledge type	Skills/knowledge
Mandatory	• Programming Automatic Test Equipment (ATE) - using C, C++, Java, Python, MatLab, C#, LabVIEW or Smalltalk. • Test Station Setup: troubleshooting, maintenance & calibration. • Ability to lead Test Development Process. • Design for test (DFT) techniques. • Competencies in Analog electronics. • Design of software modules for test equipment in C, C# and Visual Basic. • Define Test Competencies & Practice - cooperation with concept, design and lab verification engineers. • CRM - developing / maintaining internal & external customers' needs. • Performance Data Analysis - analyzing performance data - leveraging databases (SQL) and visualization tools (Tableau).
Soft	• Analytic & Problem-Solving Skills. • Technical Presentation & Report Writing. • Communication: Ability to negotiate and communicate on business and technical topics.
Emerging/advanced	• Lead Test Development Process. • Security issues in product level: Security / Cybersecurity / Security-by-design / Reverse engineering. • Proficient with RF Test Equipment - Network Analyzers, Spectrum Analyzers and Signal generators. • Artificial Intelligence. • Transfer knowledge: Ability to apply theoretical knowledge into manufacturing context (DOE, FMEA, SPC, etc.). • Virtual prototyping. • System simulation.

Test technicians (EQF level 4-5)

60% of test technicians are hired at the entry level with an EQF level of 4-5. 40% are hired with an EQF level of 6.

Therefore, the following list of skills and knowledge must be mastered ideally at EQF4-5 and at EQF 6 otherwise.

Skill/knowledge type	Skills/knowledge
Mandatory	• Affinity with hardware electronics. • Knowledge in programmable power supplies, function generators, multimeters. • Assistance in planning Q-tests (product validation) and performing the tests. • Keep and enforce health and safety regulations at the test area. • Setup and operate back-end test equipment and bench-test equipment. • Conduct product quality tests, in-circuit-tests, functional tests, burn-in tests. • Update and maintain product reliability testing data. • Health-check and calibrate test and inspection equipment. • Documentation, basic knowledge in Word, Excel, Outlook, SAP, QDAS, compile product reports.
Soft	• Support and cooperate with test engineers, support product development. • Communication: Able to communicate work in progress to next shift; Able to write reports.
Emerging/advanced	• Supervision of test equipment maintenance: prevent and repair test machines. • Reveal recurring process-material-machine problems – assist in developing corrective actions.

6) Other advanced skills in microelectronics

Sub-areas	Skills/knowledge	Required at EQF level n°
Transversal skills	• Quality / reliability. Knowledge associated with reliability issues, functional safety and robustness of microelectronics (EMC, EMI, ESD, ageing, radiation hardness…). Knowledge of quality standards (e.g., IPC). Ability to assess the quality and perform reliability analyses. Knowledge of the methodology of quality (Quality 3.0 and 4.0), and ability to use Quality tools (including quality tools associated with I4.0). • Knowledge of applications. Ability to link and adjust semiconductor materials, design specifications and production processes to end-user applications.	6 & 7
Process engineering / Material engineering	• Deep knowledge of materials in microelectronics. Knowledge of traditional and new materials: polymers, shape-memory materials, composites, materials for additive manufacturing, gallium nitride, etc. Understanding of material properties, and the need to modify the integration flow. • Ability to link a semiconductor material with production processes, product(s) specification(s) and end-user applications. • Environmental awareness associated with traditional and new materials and with traditional and new production processes.	6 & 7
Power electronics engineering	• Power management innovations: Conversion, power harvesting solutions… • Packaging for power applications (IGBT, etc.). • Power supply design. • Smart power electronics	7

7) Key competencies & innovative thinking

<table>
<tr><th>Sub-areas</th><th>Skills/knowledge</th><th>Required at EQF level n°</th></tr>
<tr><td>Digital skills

Skills associated to the digital transition</td><td>• Machine learning / Artificial Intelligence.
o Fundamental knowledge and understanding of AI tools.
o Ability to select and use the machine learning toolsets for manufacturing (design, automation, etc.), and/or ERP.
o Ability to replace basic skills in production with machine learning algorithms to increase competitiveness and to facilitate innovation.
o Understanding of the environmental, social and ethical impact of AI applications
• Data analysis skills.
o Ability to interpret and make sense of a large volume of data. Knowledge of potentially biased conclusion led by biased data.
o Data management: SQL, etc.
o Data visualization: Tableau, etc.
o Data integrity: Ability to ensure the integrity of data, particularly when using a large volume of data. Knowledge of the techniques to assess the quality of data.
• Security / Cybersecurity by design.
o Data Security & Privacy by design: Ability to ensure the security of data & data privacy. Including IP protection.
o Security by design (Especially important for IoT and I4.0.): Know-how and applicability of secure protocols necessary.
o Skills used for cyber-physical (production) systems like diagram a network for security.
o Reverse engineering for the prevention of industrial spying (especially for test engineers).
o Cybersecurity: forensic, etc.
• Ability to develop software code in C, Visual C, C++, C#, .NET, Java, JavaScript, Python, Matlab (for software engineers). Required at EQF 6.
• Embedded software: Embedded Linux, RTOS (Real-time Operating System).</td><td>6 & 7</td></tr>
</table>

<table>
<tr><th>Sub-areas</th><th>Skills/knowledge</th><th>Required at EQF level n°</th></tr>
<tr><td>Environmental & social skills

Associated to Green Deal and circular economy.

To be taught on a common basis to all</td><td>• Circular economy: Circular economy in the design process to include already at design level the principle of green economy and green growth, as an industrial product’s environmental performance, is fixed up to 80% at the design stage.
o Sustainability, recyclability and reusability of production: How to “green microelectronics production” for instance dealing with issues that relate to the processing of raw materials and disposal of industrial waste.
o Ability to assess the environmental impact of a design.
• Energy efficiency of the manufacturing processes: How to minimize energy consumption and protect the environment through manufacturing processes.
• Environmental aspects associated with traditional and new materials.</td><td>All EQF levels</td></tr>
</table>

engineers in the microelectronics industry.	• Artificial intelligence & sustainability: Specific course is given to students aiming to work on cloud/edge computing and/or and artificial intelligence. The goal is to sensitize them to the energy consumption generated by AI applications at the macro level and present good practices and alternative solutions (example: social utility of advanced driving assistance systems using AI vs energy consumption and emissions associated with their integration into cars). • Sustainable development goals (SDG): (Maximum EQF 6) All engineers should be aware of challenges and understand that their work should contribute to SDGs. • Introduction to climate change. • Resource management. • Social inclusion and digitization: Sensitization to the potential social exclusion caused by digitization and especially AI. All engineers should be aware that not everyone has the same digital skills. Systems and applications developed should serve all groups of people, not only for certain groups. Regarding artificial intelligence, developers should be aware of the potential direct or indirect bias caused by AI that can discriminate against certain minorities (such as ethnic groups). AI may also result in job losses, and developers should be aware of that. • Diversity in electronics. Sensitization to the importance of diversity for teamwork: in terms of gender, but also of educational background and other criteria. A team should consist of people with diverse backgrounds as people with different backgrounds will see things differently.	
Soft skills	• Teamwork: Collaboration, cooperation, ability to be supportive, helpful, agreeable. Can be taught through collaborative projects. • Communication: o Ability to communicate, to present oneself, self-marketing. o Technical presentation skills: Ability to explain complex topics to non-experts in a few words, cross-discipline communication. o Oral and written communication skills. • Creativity: Innovation capacity, design thinking. Ability to come up with new ideas, new designs, new technologies, new applications.	All EQF levels