Boosting the potential of Key Enabling Technologies

Addressing Skills Needs in Europe

Acknowledgements

The results produced by the "Vision and Sectoral Pilot on Skills for Key Enabling Technologies" are the fruits of sustained collaborative efforts with a wide range of experts and organisations.

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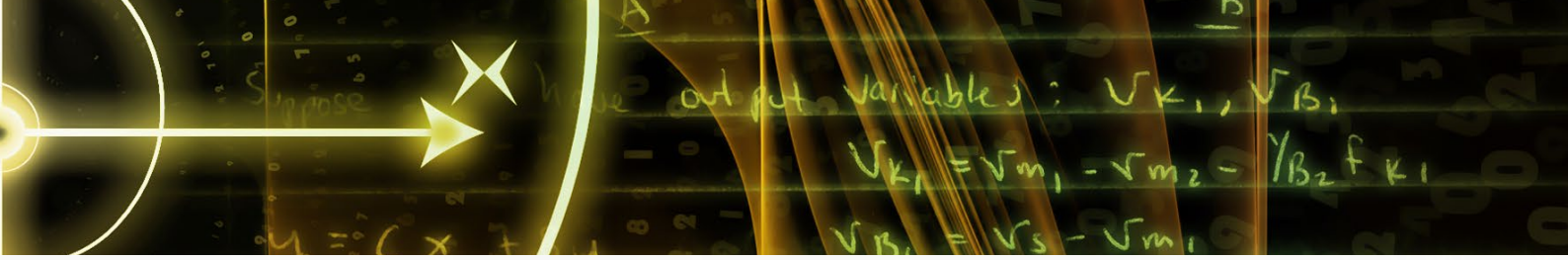


Foreword

Smart phones, electric vehicles, 3D printing, bioplastics and connected machines - for all of this, we need key enabling technologies (KETs). Advanced manufacturing and materials, industrial biotechnology, semiconductors and photonics are crucial for Europe and for triggering innovation in processes, products and services. They are key drivers for growth, jobs and societal benefits.

Products strongly dependent on these technologies represent a production volume of almost 1 trillion EUR, or 19% of the total production of all EU countries. Altogether they enable 3.3 million European jobs or 11% of all EU employment related to manufacturing. KETs are crucial to secure a robust industrial base for Europe. Their growth potential offers huge opportunities for businesses and new services to consumers. If our companies can seize them, this will mean more jobs for our citizens.

However, still too few European companies are embracing new opportunities offered by KETs. Europe is not investing enough in these technologies. Competition is fierce and Asia is moving into markets for products and services with high value-added where traditionally Europe has been dominant.

Photo© European Union/Gino De Laurenzo

That is why the Commission is working together with the Member States and industry to create better framework conditions for investment in KETs. We are also working to facilitate access to technology centres for companies in order to help them to speed up the commercialisation of their ideas and research.

For European industry to compete and flourish, we must also ensure that we have a workforce with the right skills. This document provides a summary of the state of play of KETs in Europe and their skills requirements as well as concrete examples of best practices and recommendations. Estimates show that between 2013 and 2025, Europe will need between 1 million and 3 million new highly skilled professionals to satisfy new demand stemming from KETs deployment. It is a huge opportunity we cannot miss.

Enjoy the reading!

Lowri Evans
Director General
DG Internal Market, Industry, Entrepreneurship and SMEs
European Commission

Key Enabling Technologies – the engine of a sustainable knowledge-based economy

Key Enabling Technologies (hereafter "KETs") are the technologies that enable process, goods and service innovation throughout the economy. KETs currently include Micro-/Nanoelectronics, Nanotechnology, Photonics, Advanced Materials, Industrial Biotechnology and Advanced Manufacturing Technologies. These technologies are knowledge-intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly skilled employment.

KETs have the potential for application in virtually all sectors and industries, including aeronautics, automotive, engineering, chemicals, textiles, space, construction, healthcare and agriculture. KETs are the 'technology building blocks' behind a wide range of innovations, such as 3D printers, LED lighting, advanced robotics, bio-based products, smart phones, nanodrugs, smart textiles and many more. Products strongly dependent on KETs-components represent 19% of all EU 28 production, and KETs account for 3.3 million jobs in 2013[1].

KETs drive both the development of entirely new industries and the transformation of the existing industrial base in Europe. KETs have the potential to modernise manufacturing processes by reducing production costs, raw materials and energy consumption as well as tackling waste and pollution. The nations and regions mastering KETs will be at the forefront of managing the shift to a sustainable knowledge-based economy. To this end, in 2012, the European Commission adopted a strategy to boost the industrial uptake of KETs in Europe.

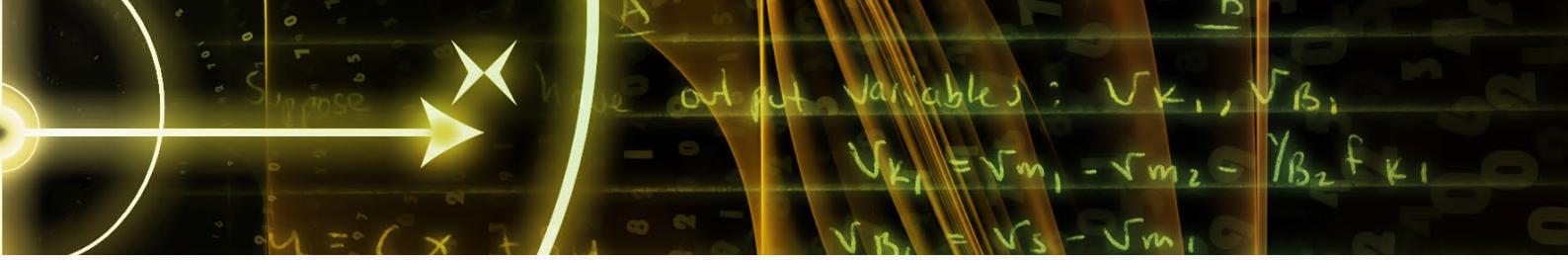
6 KETs identified by the European Commission[2]

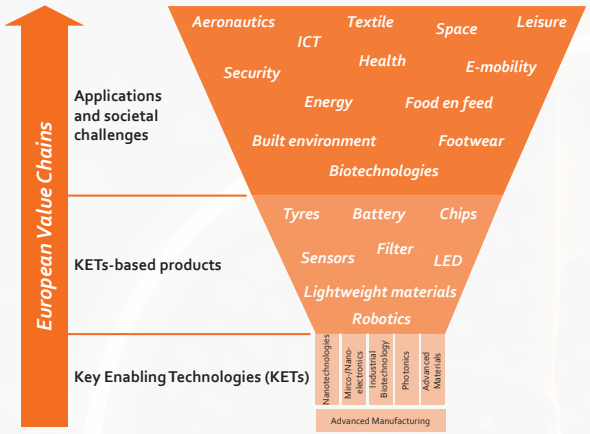
- **Advanced Manufacturing Technologies:** including innovative technologies, such as 3D printing, robotics, automation, modern machine tools, measuring/control/testing devices for machines, automated and IT-based manufacturing, aiming to advance products or processes[3], for example, by improving material and energy efficiency.
- **Industrial Biotechnology:** including enzymes, micro-organisms, amino acids and fermentation processes; excluding biotechnology for healthcare and agriculture. Industrial biotechnology is used for products such as bio-fuels, detergents, materials including plastics, rubber tyres, and chemical building blocks.
- **Nanotechnology:** dealing with methods to manufacture structures on a molecular or atomic scale. Examples of applications include nanomedicine for improved healthcare, as well as carbon nanotubes for lighter materials and for higher conductivity and improved energy management.
- **Advanced Materials:** covering a broad area of innovation in materials such as lightweight materials, low-carbon material energy solutions and other, including polymers, macromolecular compounds, rubber, metals, glass, ceramics, other non-metallic materials and fibers, as well as the whole field of nanomaterials and specialty materials for electric or magnetic applications.
- **Micro-/Nanoelectronics:** related to smallest and smartest of electronic components and systems that interact with each other. Examples include semiconductors, advanced sensors, power components, piezo-electrics and electronic chips.
- **Photonics:** related to optical technology applications in the areas of lasers, optical fibers, lithography, optical measurement systems, microscopes, lenses, optical communication, digital photography, LED and OLED lighting, cameras in phones, displays and solar cells.

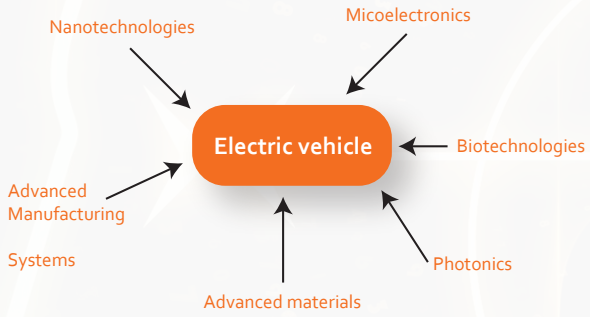
[1] KETs Observatory Second Report, November 2015. More information at https://ec.europa.eu/growth/tools-databases/kets-tools/library

[2] Communication of the European Commission "Preparing for our future: Developing a common strategy for key enabling technologies in the EU", COM(2009) 512 final, Brussels, 30.09.2009.

[3] Advanced digital technologies (such as Internet of Things, Big Data analytics, cloud and high performance computing) are often also considered as advanced manufacturing technologies but are not included in the current KETs definition.







(Source: High-Level Expert Group on Key Enabling Technologies)

By combining various KETs, competitive and innovative solutions such as the electric vehicle, can be produced, to address various societal challenges including clean transport[4].

European strategy for KETs

With its 27% share in worldwide patenting of KETs technologies[5], Europe is still leading in the development of KETs. However, one of the major weaknesses of Europe lies in its ability to translate the knowledge base into specific goods and services. This innovation gap has been labelled as the European 'Valley of Death'. KETs-related manufacturing is decreasing in the EU, and patents are increasingly being exploited outside the EU.

The European Strategy for KETs has an objective to accelerate the rate of exploitation of KETs in the EU and to boost the development of innovative products, processes and services. By doing so, the KETs strategy aims to keep pace with the main international competitors of the EU, thereby restoring growth in Europe and creating jobs in industry, while at the same time addressing today's major societal challenges[6].

The implementation of the European KETs strategy in order to close the innovation gap in KETs is on-going, and progress has been made. Additional initiatives are needed to help bringing industry back to Europe and to maintain global leadership in strategic sectors.

Some initiatives have already been launched, including actions with the following objectives:

- Further implementation and consolidation of the KETs strategy, in particular through Horizon 2020 and Smart Specialisation;
- Facilitating public-private cooperation for ambitious investments in innovative projects that can enhance the EU competitiveness vis-à-vis the international competitors (so called 'Important Projects of Common European Interest');
- Facilitating the access of SMEs to KETs technology infrastructures to speed up the uptake of KETs by SMEs and the commercialisation of new ideas;
- Ensuring the right framework to speed up the market uptake of KETs solutions.

[4] High-Level Expert Group on Key Enabling Technologies
[5] KETs Observatory, First Annual Report, May 2015
[6] See also Key Enabling Technologies web page of DG GROW at: http://ec.europa.eu/growth/industry/key-enabling-technologies/index_en.htm

Main achievements of the EU strategy for KETs

Progress has been made in adapting and aligning European instruments and policies in support of KETs deployment. The list below highlights the key achievements so far.

- KETs are now a priority under Horizon 2020 with a dedicated budget of almost 6 billion EUR, including 30% for activities combining different KETs (so called 'cross-cutting KETs'), and rebalanced support for close-to-market activities (such as pilot lines, prototypes and demonstrators), with a bigger focus on impact and manufacturing.
- KETs are now a priority for the European Structural and Investment Funds (ESIF). A broad range of innovation actions are eligible, including first production activities. 65% of the European Member States and regions indicate a KETs-related priority in their smart specialisation strategies, and KETs represent 22% of all regional research & innovation priorities.
- Synergies between Horizon 2020 and ESIF are encouraged.
- KETs have been identified as a priority by the European Investment Bank; following the Memorandum of Understanding between the European Commission and the EIB signed in February 2013, the EIB lending to KETs projects has increased by 10% per year on average (up to 9 billion EUR in 2013-2015).
- The new State Aid rules give more flexibility to Member States to support KETs-investments. A Communication on Important Projects of Common European Interest has been adopted highlighting its importance for the KETs Strategy.
- A KETs Observatory has been established providing the EU and national policymakers and business stakeholders with quantitative and qualitative information on the performance of the EU Member States and other competing economies regarding the deployment of KETs.
- In terms of governance, the High Level Group on KETs advised the Commission on the implementation of the KETs Strategy and delivered specific Recommendations in its Final Report in June 2015. A KETs Member States Group has been established to enable synergies and ensure coordination at EU, national and regional level in line with the European Strategy for KETs.

Luigi Ambrosio
Director National Research Council of Italy (CNR), Department Chemical Science and Materials Technology, Italy

"To face present and future challenges, a continuous investment in research and innovation is needed at European level, ensuring support for frontier research and breakthrough ideas in view of their industrial exploitation. Innovative small and medium-sized enterprises will play a major role in fostering Key Enabling Technology development and job creation in Europe, thus paving the way for the new European Industrial Renaissance."

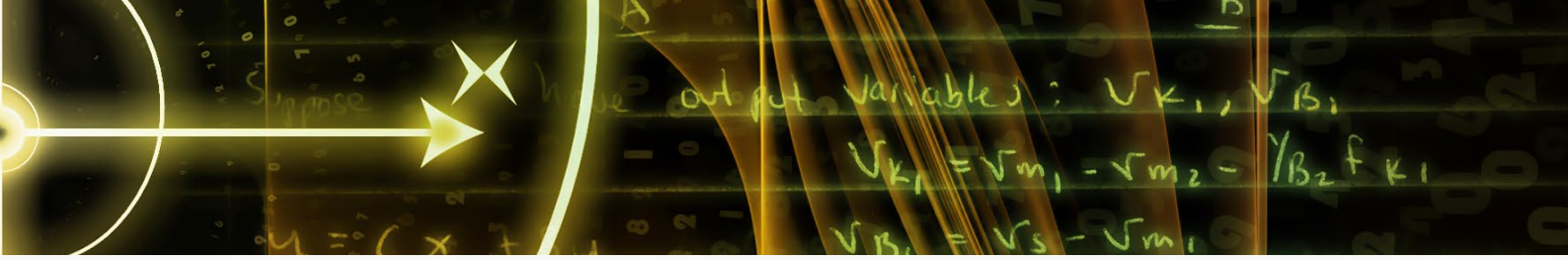
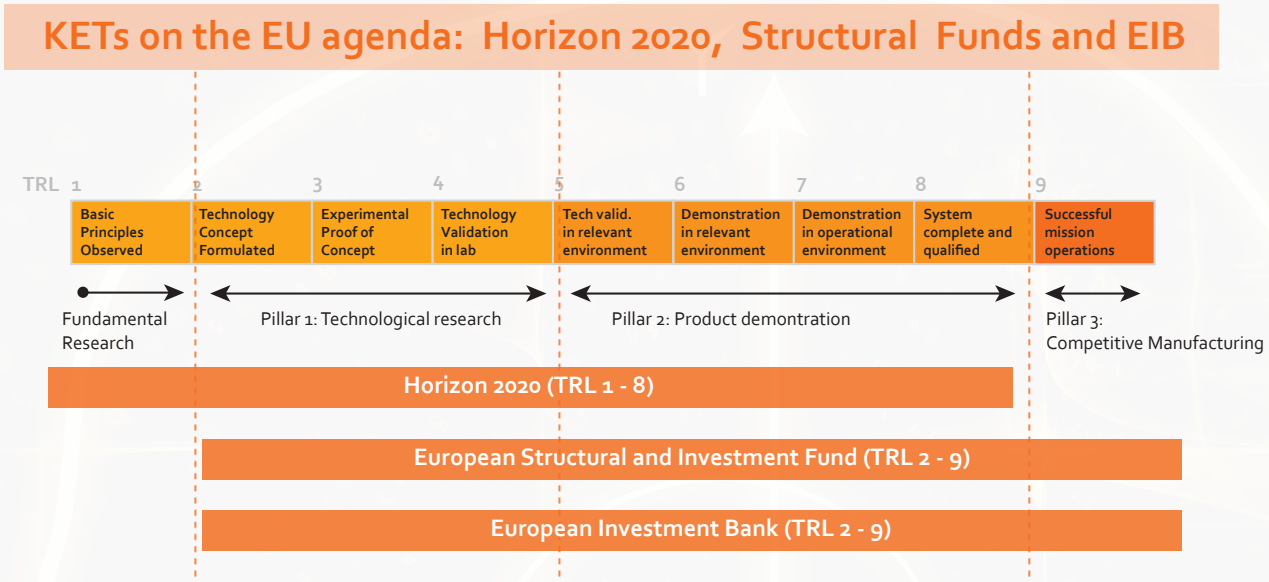


Figure: Multiple European instruments have been adapted to support closer-to-market KETs-related activities



EU support for research and innovation in KETs

Horizon 2020 is instrumental in supporting research and innovation in KETs. With a total budget of over 77 billion EUR for the period 2014-2020, almost 6 billion EUR are directly devoted to KETs. This includes 3.8 billion EUR allocated to the Nanotechnology, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing (NMBP) part of the programme, as well as a significant share of the ICT part of the programme, devoted to Micro- and Nano-electronics and Photonics.

In addition, several public-private partnership initiatives supported by the EU focus on research and innovation related to KETs. Examples include the Bio-Based Industries Joint Undertaking (BBI, supported through Horizon 2020 with more than 950 million EUR in funding) and the Electronic Components and Systems for European Leadership Joint Undertaking (ECSEL, supported through Horizon 2020 with more than 1.15 billion EUR in funding).

Furthermore, the European Fund for Strategic Investments (EFSI)[7], which is a key element of the Investment Plan[8] for Europe, could help to finance riskier, yet economically viable, large projects and investment platforms in the area of KETs. It will be crucial that interested actors – industry, private investors, and EU Member States and regions – work together and propose to EIB concrete projects that will contribute to the modernisation of the European industry.

Crossing the 'Valley of Death' through close-to-market innovation

The objective of Pillar II of the Horizon 2020 programme (Leadership in Enabling and Industrial Technologies - LEIT) is to strengthen industrial capacities in Europe and business perspectives for European enterprises. Pillar II focuses on closer-to-market research and innovation, with strong commitment from project partners to future industrial exploitation of the R&D results in Europe.

Pilot production and demonstration activities play a key role in crossing the innovation gap, but are also costly. The cost of a pilot line infrastructure typically lies between 1 and 10 million EUR, but can be up to – or even exceed - 100 million EUR. It is thus often necessary to combine funding from several sources to finance KETs

[7] http://www.eib.org/efsi/index.htm
[8] http://ec.europa.eu/priorities/jobs-growth-and-investment/investment-plan_en

demonstration and pilot production activities.

The Horizon 2020 Work Programme includes pilot lines and large-scale demonstrators in the area of KETs. Additionally, Horizon 2020 encourages applicants to seek synergies with other national or regional programmes for research and innovation, including European Structural and Investment Funds (ESIF) and private funding. Further information on synergies between existing EU programmes, including examples, can be found in the "Guide on Enabling Synergies between ESIF, Horizon 2020 and other research and innovation EU programmes"[9].

Supporting SMEs to participate in KETs research and innovation

According to the Horizon 2020 Regulation, 20% of the Pillars II and III of Horizon 2020 shall be devoted to SMEs, which accounts for more than 9.3 billion EUR in funding. This includes over 3 billion EUR devoted to SMEs through the SME instrument.

SMEs can participate in the Horizon 2020 programme for research and innovation projects in the field of KETs by:

- Joining a consortium responding to a call for proposals published in the Work Programme, in particular in the NMBP and ICT parts of the Work Programme. Some calls for proposals under Societal Challenges also build on KETs;

- Making a proposal under the SME instrument, with no need to build a consortium and the possibility to submit the proposal at any time during the year. Phase 1 of the SME instrument (lump sum of 50.000 EUR) provides support for a feasibility study to verify the technological feasibility and economic viability of an innovation. Phase 2 of the SME instrument (EU support between 0.5 and 2.5 million EUR) provides support to innovation activities such as demonstration, testing, prototyping, piloting and scaling-up.

Ensuring access of SMEs across Europe to technology services in KETs

To remain competitive, SMEs particularly in the manufacturing sector, increasingly need to innovate by integrating KETs into their products and processes. However, SMEs often lack resources to invest in technological innovation based on KETs. The weakest point of the innovation chain is typically at pilot production and demonstration, where the costs of research and innovation activities are the highest but also the related risks are high. The latter relate to the uncertainties about the future profitability of innovative products or services.

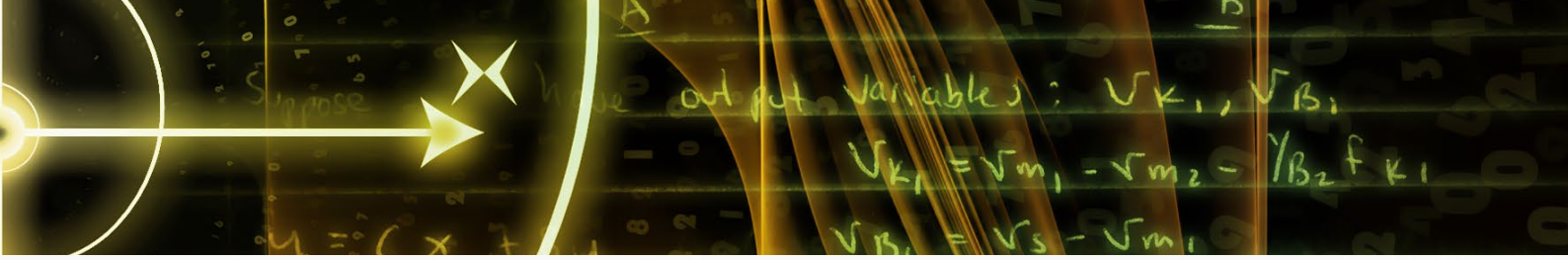
Technology infrastructures providing services and facilities can help SMEs to reduce the costs of the innovation activities, as well as the related risks. Around two thirds of technology infrastructures active in the field of KETs are, however, located in only four Member States, namely Germany, the United Kingdom, France and Spain. At the same time, SMEs are often not aware of existing technology infrastructures beyond regional or national borders.

To this end, the High Level Group on KETs has recommended the European Commission to facilitate pan-European access for SMEs to technology infrastructures active in the field of KETs. As a first step, the European Commission has published an EU inventory of existing Technology Infrastructures capable of providing technology support to SMEs in this field[10].

More actions are needed to ensure easy and pan-European access for SMEs to technological services. The European Commission is looking into the best ways to promote European networks of such organisations with a single access point for SMEs.

Examples of such networks include ACTPHAST (Access Centre for Photonics Innovation Solutions and Technology Support) and I4MS (ICT Innovation for Manufacturing SMEs), which started under the Framework Programme 7 and are further supported under Horizon 2020. Other examples refer to additional initiatives under Horizon 2020 such as the action on technology services to accelerate the uptake of advanced manufacturing technologies for clean production by manufacturing SMEs [11].

[9] http://ec.europa.eu/regional_policy/sources/docgener/guides/synergy/synergies_en.pdf
[10] More information available at: http://ec.europa.eu/growth/industry/key-enabling-technologies/eu-actions/help-smes-access/index_en.htm.
[11] https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/6088-innosup-03-2017.html



What is technology infrastructure in KETs?

Technology infrastructure can be defined as (private or public) organisations capable of providing companies with cutting-edge technology support in an industrial-friendly way and assist them in performing research and innovation activities in one or several KETs and across a range of industry sectors. Technology infrastructures are capable of providing access to highly-skilled staff and expertise, tools and equipment, scientific and engineering know-how, intellectual property, quality control and test techniques, design capabilities, and the necessary process flow to develop KETs-based products and services. Technology infrastructures are also expected to provide market expertise and assistance in business development and usually also training.

Dr. Antti Vasara
President and CEO VTT Technical Research Centre of Finland

"Europe needs creativity enabling policies. We should become forerunners and search for skills that are needed in problem-solving. Interdisciplinary approaches involving KETs can make a real difference in addressing our societal challenges. The young generations are our transferable talents who can easily learn to create with new technologies. This makes the case for teaching science and arts together, as well as offering platforms for scientists and technologists to work together with artists and designers. KETs technological infrastructures within European Research Technology Organisations can be places of risk-sharing and innovation, places where cross-fertilisation of disciplines, technologies, people and imagination take place."

A new web tool by the European Commission helps SMEs to innovate through KETs

With the launch of a new web tool[12] by DG GROW, the European Commission is making it easier for SMEs to access state-of-the-art technological services across Europe. The tool allows SMEs to find technological service centres active in the field of KETs across the EU 28. Such centres can help SMEs to speed up the commercialisation of their innovation ideas. The web tool provides details for each of the 187 technology infrastructures within service centres active in the area of KETs. For each centre, an SME contact person has been identified and their contact details are provided.

The role of regions in supporting KETs

KETs are one of the priority investment areas under the European Structural and Investment Funds (ESIF). ESIF can be used to finance close-to-market industrial innovation up to first production in the area of KETs. Under the European Structural and Investment Funds, around 100 billion EUR is available for innovation activities.

Successful implementation depends on the take-up of KETs-related actions by regions in their smart specialisation strategies. The concept of smart specialisation is a novelty for the EU regions. It aims at enabling regional comparative advantages supported by local technological specialisation to stimulate regions to position themselves in a specific market or niche. Smart specialisation provides a framework for investments which strengthen and benefit the regional ecosystems to sustain growth and jobs over the long term.

[12] The interactive map can be consulted on-line, and allows search by location and/or KETs area. The map is available at: https://ec.europa.eu/growth/tools-databases/kets-tools/kets-ti-inventory/map

As a result, the EU regions have developed their regional innovation strategies for smart specialisation in order to build competitive advantage. This was done by developing and matching research and innovation with business needs in areas where regions have strengths. Many regions plan to invest in KETs because of their transitional character to modernise, transform or diversify regional economic structure.

The Vanguard Initiative for New Growth through Smart Specialisation

The Vanguard Initiative of more than 20 European industrial regions was launched at the European Commission's High-Level Conference on Smart Specialisation in 2013. It has developed and tested promising new methodologies for developing and implementing roadmaps for co-investment in European priority areas, including three pilots in the field of Advanced Manufacturing, as well as a pilot on nano-enabled products and bioeconomy, all KETs-related. These methodologies include value chain analysis, and mapping and matching of regional capacities and actors from research and industry in specific areas related to the region's smart specialisation strategies. The goal is to facilitate industry-led roadmaps for co-investment into joint demonstrators.

Based on this experience, more regions – including their smart specialisation clusters - could make use of opportunities to engage in similar strategic partnering exercises. To facilitate this, the new INTERREG EUROPE programme, starting in 2015, will offer policy learning platforms to facilitate such strategic partnering. The aim of the programme is to maximise learning and partnering opportunities by pro-actively linking to relevant European-level thematic platforms and networks, and by providing input to INTERREG EUROPE programme calls for cluster cooperation projects.

Cristina Oyón
Head of Strategic Initiatives, SPRI, Basque Country, Spain

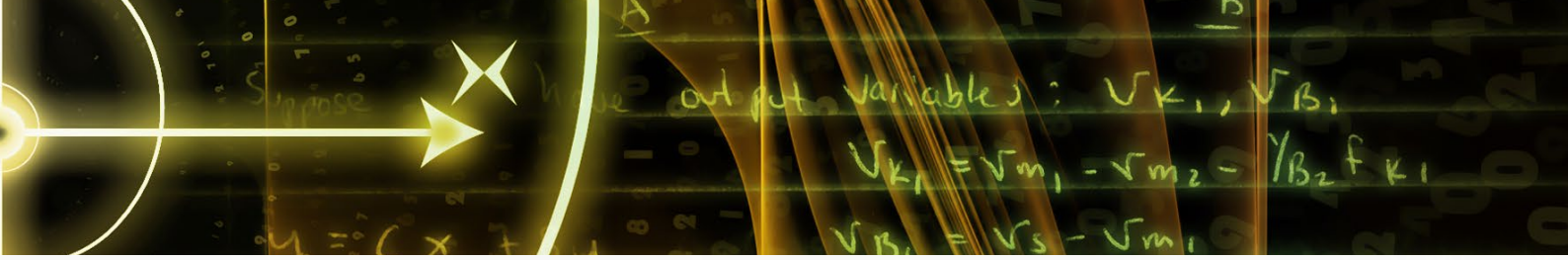
"Current Regional Innovation Strategies aim to focus on characteristics and exclusive assets of each region, emphasising its competitive advantages and bringing participants together around a shared vision. The differential regional strengths should build on a competitive business sector with the ability to exploit innovations and invest in their development. That, in turn, needs a close presence of significant scientific and technological capabilities as key enablers of the innovation process. This Regional Smart Specialisation concept will support the productive transformation that Europe needs to generate employment and well-being in a medium-long term basis."

EU State Aid rules for public support of KETs investments

The process for the Modernisation of State Aid Rules was completed in 2014. The new State Aid rules (notably for Research, Development and Innovation as well as the revision of the General Block Exemption Regulation) have a significant impact on the conditions for public funding of KETs projects. It is worth highlighting certain State Aid provisions which enable better support of KETs projects through public funds.

(1) Union funding centrally managed by the Union (institutions, agencies, joint undertakings or other bodies) that is not directly or indirectly under the control of Member States, does not constitute State Aid.

This means that aid under Horizon 2020 is not subject to State Aid rules and therefore not calculated together with other forms of public aid which is assessed according to State Aid rules.



(2) General Block Exemption Regulation (GBER)[13] sets out the conditions under which State Aid is exempted from the obligation of prior notification to the Commission (i.e. block-exempted aid).

The revised rules give granting authorities much wider margins to design and implement aid measures and Member States are able to provide a broader range of measures and higher amounts of aid without having to notify them to the Commission for prior authorisation. KETs are notably supported by the increased (doubled) notification thresholds and aid intensities for fundamental research (40 million EUR), industrial research (20 million EUR) and experimental development (15 million EUR) and by the new categories of exempted aid (e.g. aid to innovation clusters and investment aid for research infrastructure).

(3) Framework for State Aid for research, development and innovation (R&D&I Framework)[14] sets out the rules for the assessment of R&D&I aid that is not eligible for block-exemption.

The revised rules provide 'applied research' to include either or both industrial research and experimental development, thus rendering aid for pilot lines also possible under industrial research. The revised R&D&I Framework foresee higher maximum aid intensities for applied research which may go up to 60% of the eligible costs for large enterprises and up to 80% of eligible costs for small enterprises – and up to 70% and 90% respectively in cases of effective collaboration between undertakings.

(4) Guidelines on Regional State Aid[15] set out the rules to promote regional development in Member States.

The revised rules aim at granting investment aid to support the development of disadvantaged regions in the EU or to facilitate the development of economic areas where such aid does not adversely affect trading conditions to an extent contrary to the common EU interest. Regional aid Guidelines support investment in KETs manufacturing (first production) which lies outside the scope of the R&D&I Framework.

Within the State Aid Modernisation process, the Commission also adopted a Communication in June 2014 that sets out the criteria under which Member States can grant public support for the implementation of Important Projects of Common European Interest (IPCEI)[16]. This new tool aims at facilitating the implementation of ambitious European projects that make significant contribution to growth and jobs and the competitiveness of EU industry and economy. The IPCEI is an instrument open to all domains of economic activity and not only to R&D&I. It grants aid until the first industrial deployment and allows a greater variety of support instruments (e.g. loans, grants, guarantees, repayable advance etc.). Moreover, it allows for coverage of the funding gap up to 100% of the eligible costs on the basis of an enlarged list of such costs.

The IPCEI Communication highlights the importance of this new tool for the EU KETs strategy. In the area of KETs, IPCEI relates to major industrial projects for innovative products and processes that can enhance the EU competitiveness vis-à-vis its international competitors and thus contribute to the re-industrialisation of Europe.

In its final report of June 2015[17], the High Level Group on KETs published several examples of potential important projects of common European interest.

IPCEI as a tool for overcoming market failure

Where large-scale private initiatives fail to materialise because of significant technological or financial risks, or because of difficult transnational cooperation, such market failures can be overcome by the realisation of important projects of common European interest (IPCEI). IPCEIs can be an appropriate tool to leverage industrial investment by bringing together private and public actors, combining their resources in accordance with the EU State Aid rules based on the new compatibility conditions outlined in the IPCEI Communication of June 2014. Such industrial projects, should be of a European dimension and be strategic in a sense of serving the EU economy as a whole.

[13] Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty, OJ L 187, 26.6.2014
[14] Communication from the Commission, Framework for State aid for research and development and innovation, OJ C 198, 27.6.2014
[15] Guidelines for Regional State aid for 2014-2020; O.J. C209/01 23.07.2013
[16] Communication for the Commission, 'Criteria for the analysis of the compatibility with the internal market of State aid to promote the execution of important projects of common European interest', C(2014)3290; O.J. C 188/02 20.6.2014
[17] http://ec.europa.eu/growth/industry/key-enabling-technologies/european-strategy/high-level-group/index_en.htm

Framework conditions to support KETs deployment

Stimulating demand for KETs from the market will not only accelerate innovation, but will also help address societal challenges as, for example, in the fields of energy, climate and resource-efficiency. Recent European policy initiatives are prepared to face such challenges. The new Energy Union initiative, for example, will create new market opportunities for KETs along the value chain. The European Commission will in particular define an Energy Union integrated strategy for research, innovation and competitiveness to strengthen EU global leadership in low-carbon and energy efficient solutions, for which KETs can play a significant role. The European Commission has also adopted a Circular Economy Package[18], which aims to boost recycling and resource efficiency. In turn, this will foster new markets for KETs applications and solutions.

Removing regulatory barriers will also be essential to further unleash the market potential of KETs. Finally, full and successful implementation of the EU KETs strategy may be hindered by a lack of a skilled workforce. The Knowledge Innovation Community (KIC) on added value manufacturing to take off in 2016 will contribute to addressing the need for KETs multidisciplinary skills in Europe. Further actions are required to ensure the skills requirements of KETs are met in the (near) future. The issue of KETs skills will be the focus of the remainder of this brochure.

The importance of KETs skills for Europe

While KETs enable the growth of the European economy, the development and deployment of KETs themselves are enabled by people with appropriate skills. Those skills cover a wide range of advanced technical and non-technical capabilities, including entrepreneurial and ICT skills, skills related to multidisciplinarity, creativity, project management etc. The growth potential of KETs heavily relies on both the quality of skills possessed by the current and future employees, as well as the number of people qualified, available and willing to work in KETs.

Europe holds a significant share in the growth potential of KETs. KETs could create new jobs at different occupational levels - for researchers and scientists holding university and post-graduate degrees and also for a range of technicians and specialists with secondary, post-secondary and non-university tertiary education. However, skills imbalances in KETs can significantly diminish KETs growth potential and employment effects.

Europe is currently facing growing and overwhelming global competition from both developed and emerging economies, in particular of North America and East Asia. Although Europe remains in a relatively strong position, there is a clear need for it to reinforce and rapidly develop its KETs industry to compete for the future. To this end, the High Level Group on KETs s invited the European Union to engage in a radical rebalancing of resources and objectives in order to retain critical capability and capacity in these domains of vital European importance.

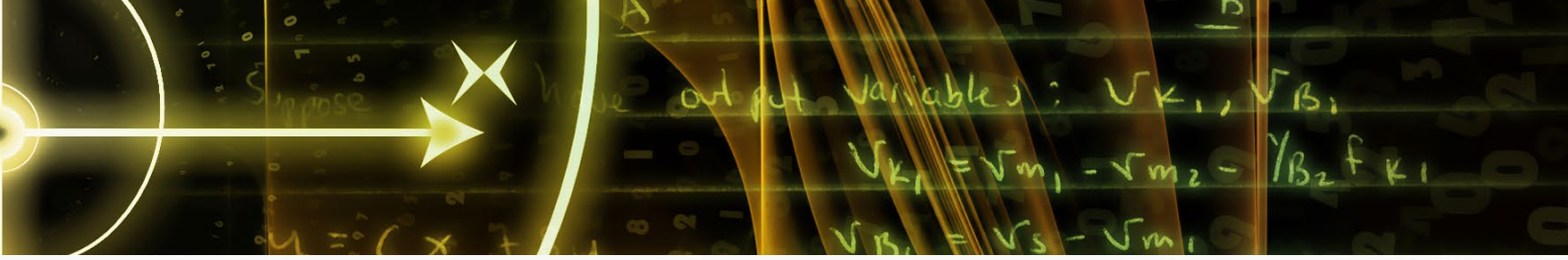
Mr. Markku Markkula
President of the EU Committee of the Regions

"We need quantitative and qualitative solutions, which better match supply with demand and continuously ensure employees have the necessary and constantly evolving skills to match labour markets needs through lifelong learning".

KETs Skills Initiative

In January 2014, the European Commission launched a dedicated initiative aiming to address the skills requirements for KETs. The initiative focuses on the current and anticipated needs of employers with regard to KETs skills and the ways to best satisfy those needs. The needs here are of both qualitative and quantitative nature. The initiative builds on the work of the High Level Group on KETs and their recommendations on skills.

[18] http://ec.europa.eu/environment/circular-economy/index_en.htm



The main intention of the initiative was to create a platform for action that is well-understood and supported by all key stakeholder groups including policy makers, large companies and SMEs, as well as educators. The initiative identified the multidisciplinary KETs skills needed by industry and, as a second step, developed an overall vision on KETs skills in Europe, including specific measures that need to be taken.

The results of this initiative are intended to help design a coherent European strategy on skills for KETs, particularly for multi-KETs. Besides representing a policy umbrella for initiatives that address the challenges of KETs skills, this horizontal strategy could aim at aligning efforts so as to make best use of public resources in a targeted and result-oriented manner. Such a strategy could help reverse the trend of European de-manufacturing and accelerate the rate of knowledge transfer, use and exploitation of KETs in the EU in order to stimulate growth and jobs.

Prof. Rudy Lauwereins
Vice-president, IMEC, Belgium

"The nano-electronics domain evolves faster than any other field and, in addition, quickly becomes more multidisciplinary in nature. This makes hiring, fast on-boarding and sustained deployability a serious challenge."

Key sources of KETs-related skills

The educational backgrounds of people working in KETs are much broader than specific KETs-related education such as Nanotechnology, Photonics, Biotechnology, Electronics etc. KETs heavily rely on people from general Science, Technology, Engineering and Math domains. Furthermore, a high diversity of educational backgrounds goes beyond STEM, with non-technical people who work in KETs having their background in Law, Economics, Business Administration, Policy Studies, Ethics, and Philosophy etc. Technical education is typically obtained at technical universities, institutes of technology, technical colleges and VET institutions. A wide variety of non-technical institutions delivers people with non-technical skills.

The type of people needed for KETs also differs depending on the pillars[19] of the KETs innovation trajectory. In terms of educational levels, the pool of people working in KETs is also highly diverse. The degrees highly demanded by employers generally include Master's and Bachelor's (or similar), with an important role also for PhDs within the Technological Research pillar, and a clear need for people with vocational education for the Competitive Manufacturing pillar. The importance of educational levels varies from company to company, depending, inter alia, on the company size and type of activities.

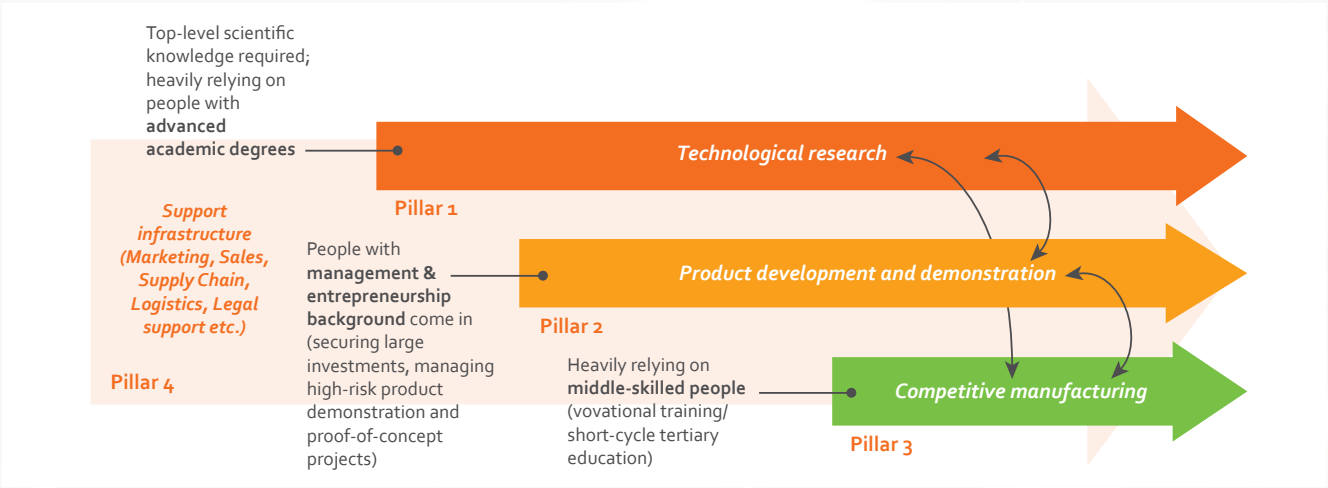
Additionally, a fourth pillar in KETs can be labelled 'Support infrastructure'. This pillar includes supporting activities such as Marketing, Sales, Supply Chain, Logistics, Legal support etc., facilitating the activities of the three main pillars. This pillar is dominated by people with non-technical skills. However, for some jobs of the fourth pillar, for example in Sales and After-Sales Services, companies often report the need to explicitly employ people with a technical background. The latter can be explained by the highly technical nature of KETs products and services requiring a good understanding of technical aspects when it comes to sales and customer support.

Mr. Carlos Freixas
Director of Marketing, Roche Diagnostics, Spain

"Competences coming from STEM are not sufficient for KETs. KETs require STEAM, with Arts included, which refers to creativity that can lead to innovations".

[19] See Report of High-Level Expert Group on Key Enabling Technologies, Final Report, June 2011; Specifically, the technological research pillar is based on technological facilities supported by research technology organisation; the product development pillar is based on pilot lines and demonstrators supported by industrial consortia; and the competitive manufacturing pillar relies on globally competitive manufacturing facilities supported by anchor companies.

Figure: Differences in skill requirements between various KETs pillars

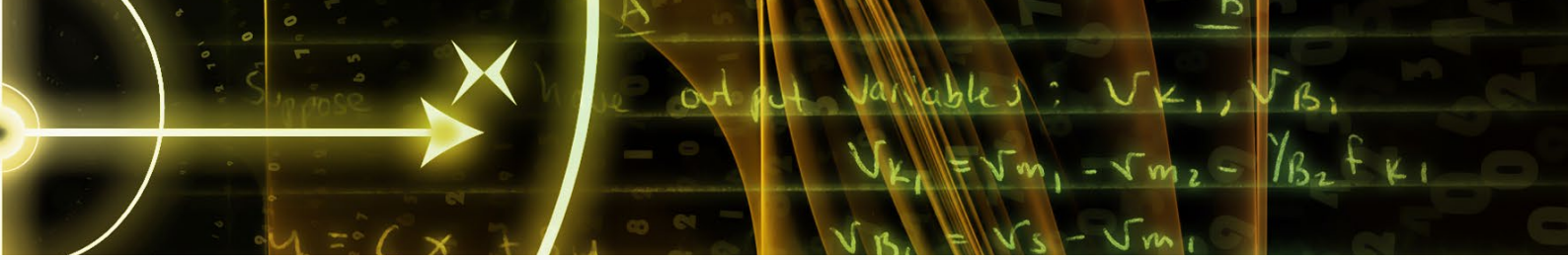


Skills requirements for KETs

KETs rely on a balance of both technical and non-technical competences. Technical competences can be considered the 'heaviest' category in terms of required knowledge and skills due to the highly knowledge-intensive nature of KETs. However, the competences needed to successfully operate within KETs go far beyond the technical field and also cover a wide range of non-technical areas.

Figure: 6 Categories of Competences for Key Enabling Technologies

1. Technical	2. Quality, risk & safety	3. Management & entrepreneurship	4. Communication	5. Innovation	6. Emotional intellegence
competences related to practical subjects based on scientific principles (e.g. characterisation, systems integration, mathematical modelling and simulation, top-down fabrication etc.)	competences related to quality, risk & safety aspects (e.g. quality management, computer-aided quality assurance, emergency management and response, industrial hygiene, risk assessment etc.)	competences related to management, administration, IP and finance (e.g. strategic analysis, marketing, project management, IP management, deal negotiation skills etc.)	competences related to interpersonal communication (e.g. verbal communication, written communication, presentation skills, public communication, virtual collaboration etc.)	competences related to design and creation of new things (e.g. integration skills, complex problem solving, creativity, systems thinking)	ability to operate with own and other people's emotions, and to use emotional information to guide thinking and behaviour (e.g. leadership, cooperation, multi-cultural orientation, stress-tolerance, self-control etc.).



Technical KETs skills

A technical background is required for the majority of jobs in KETs. What kind of technical background is needed depends on the needs of a particular job, often with a wide variety of technical backgrounds being relevant for the same job. The higher the degree of specialisation of a job profile, the more specific educational background is usually required (although, lack of relevant educational background can often be compensated by sufficient work experience in the required field). Backgrounds with a more general orientation typically include physics, mathematics, engineering, computer science and chemistry. Backgrounds in electronics, photonics, nanoscience and materials science are linked to a higher degree of specialisation both during the educational process and on the job.

Prof. Ian Phillips
Principal Staff Engineer, ARM

"No educational institute can produce engineers or scientists, but can only produce people able to become a scientist/ engineer."

Employers report the need for different degrees of specialisation, with large companies having a tendency to prefer people with higher specialisation than SMEs. At the same time, this generalisation should be treated with great caution, as some large companies massively employ people with a more general technical background, while some SMEs rely on specialists with a highly narrow field of expertise. Therefore, in terms of technical background, KETs workers 'come in all shapes and sizes'. This diversity is a natural reflection of the high complexity of the KETs domain.

Non-technical KETs skills

The non-technical competence areas include competences related to quality, risk and safety; management & entrepreneurship; communication; innovation-related competences and emotional intelligence.

When it comes to quality, risk and safety, KETs present an environment where workers need to operate with a high level of accuracy as the equipment is highly expensive, and errors are costly. This accuracy requires a specific mind-set, the ability to concentrate over a long period of time, attention to detail, and the ability to work in an environment with stringent and specific quality and safety procedures.

The complex commercialisation trajectories within KETs, including high-risk product demonstration and proof-of-concept projects, also heavily rely on advanced management skills. The latter include market analysis and strategy development in a chaotic and unpredictable environment, the need to acquire and manage large investments due to the highly capital-intensive nature of KETs, the need to coordinate multidisciplinary international teams, the need to manage complex processes with high risks and strict deadlines etc.

Given the importance of teams in KETs (which are typically formed of people with diverse professional and cultural backgrounds), communication-related competences represent another key competence category for KETs. Communication here refers to all kinds of interpersonal exchange of information, including verbal and written communication, but also virtual collaboration or communication in virtual teams. The latter refers to the ability to work productively, drive engagement and demonstrate presence as a member of a virtual team.

Innovation competences refer to the ability of KETs workers to use and integrate various disciplines into joint solutions to complex problems, the ability to find new patterns and connections between multiple fields, where these patterns and connections have never been found before. Innovation competences are central for KETs, the very nature of which is defined by their multi-disciplinarity and (potential) connection to an endless number of application areas.

Finally, emotional intelligence is related to the ability to operate with own and other people's emotions, and to use emotional information to guide thinking and behaviour, including the use of intuition or so called 'gut feeling' about market-related and other developments. Emotional intelligence emphasises the central role of human aspects in innovation.

Mr. Tomas Hedenborg
Group CEO, Fastems OY AB and CECIMO Delegate

"Production technologies have been in constant change over the last decades, but the real transformation in the machine tool industry will happen in the near future through the increased use of ICT, big data management and additive technologies. To be part of this transformation, machine tool builders need to think beyond the mechanical engineering sector when building their workforce, and invest in people who can fully integrate digital applications into manufacturing processes".

Collective KETs skills

The highly complex multidisciplinary nature of KETs requires intensive teamwork and active collaboration of multiple people simultaneously. From this perspective, KETs can be better compared to the team sports rather than individual sports, with an extra dimension of needed competences, namely collective competences. The latter refer to the fact that work in KETs requires a team to function as a unit or collective, with collective performance, and therefore the team needs to be competent also at the collective level.

Dr. Laurent Zibell
Policy Adviser, industriAll

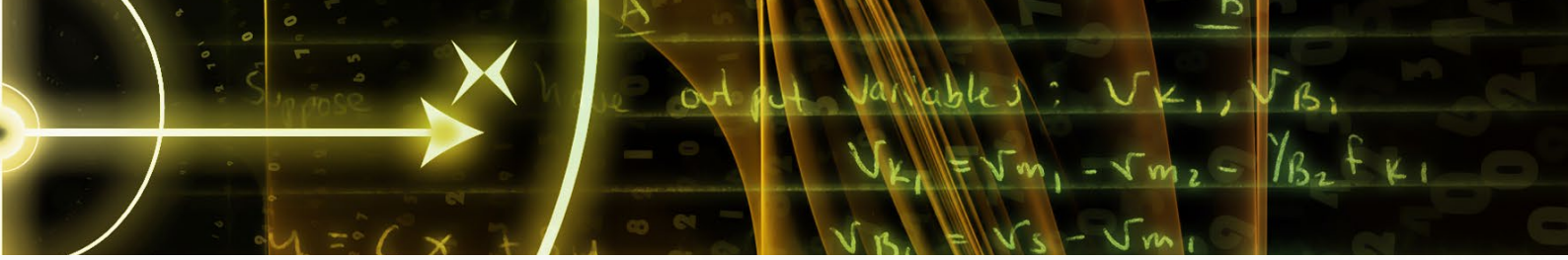
"In the context of KETs, it is not enough to focus only on individual skills; for the complete picture, it is necessary to look also at collective skills. Collective skills mean the ability to work together, cooperatively, as a team. Teamwork is a skill that can be taught. It must, however, also be supported by company institutions. Performance evaluation and remuneration should also have a collective part".

Collective competences are more than a combination of individual competences. Collective competences emerge when individual workers are able to function with a sense of awareness of one another, as well as awareness of multiple structures, processes and resources in the system that either support or inhibit them from working together. Collective competences heavily rely on trust and open communication within the team. These competences include multidisciplinarity, collective quality assurance and risk management, collective management in general, interdependence, integration, and collective emotional intelligence.

What makes KETs skills unique

The abovementioned skills, when analysed on their own, are not unique to KETs, and can be found also in other science and engineering fields. Rather, it is the combination of these previously mentioned individual and collective competences, linked to an endless number of potential application areas, that makes KETs skills requirements unique.

These skills requirements can hardly be covered by one company, let alone one individual, and thus KETs heavily rely on complex international multidisciplinary teams or 'smart' combinations of people with the required competences. These people have different technical and non-technical backgrounds going far beyond KETs themselves and even STEM. Specifically, KETs imply the emergence of teams with a mix of skills that in most cases has never been formed before. Consequently, the potential of KETs for an endless number of application areas implies that KETs commercialisation trajectories also heavily rely on knowledge and skills from literally every field of life.



Key challenges related to KETs skills

The current and anticipated mismatch in KETs skills in Europe can be explained by a number of reasons. These include both the qualitative challenges related to mismatches between skills of existing employees/ graduates and industry requirements; and the quantitative challenges related to skills shortages or the reasons why there are not enough people who are qualified, available and willing to work in KETs.

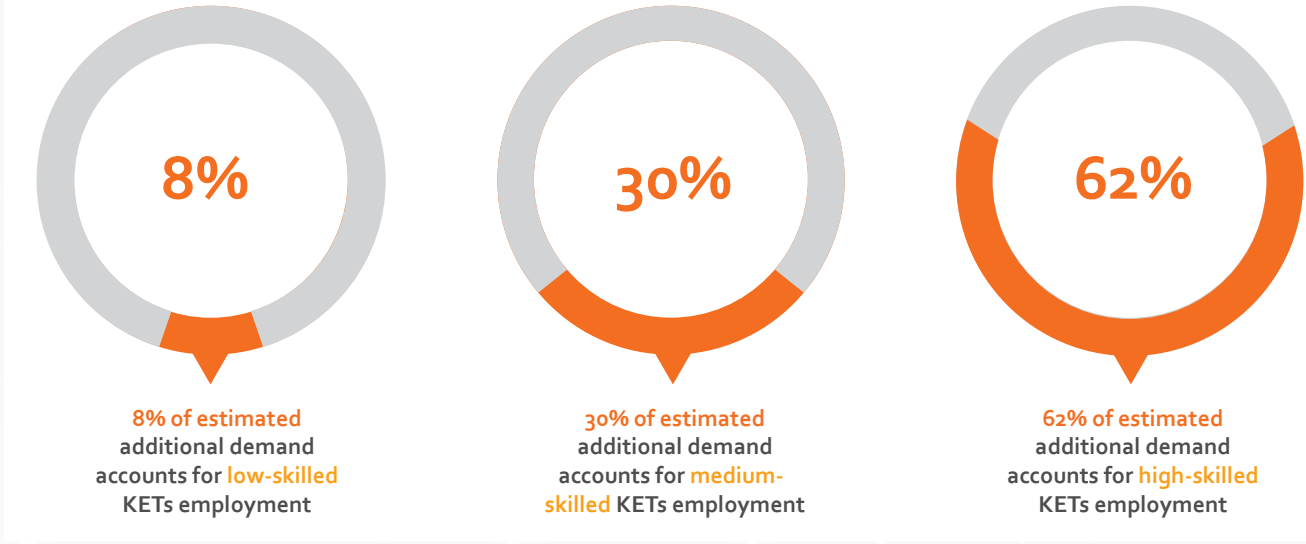
Future outlook for KETs Skills demand and supply in Europe

When considering the future demand for KETs skills, estimates show that between 2013 and 2025, an ***additional 953,000 KETs professionals and associates with technical skills*** will be needed to satisfy demand. Between 2013 and 2025, an increase in demand for KETs skills of 43% is expected.

On average, between 2013 and 2025, an additional demand of 79,000 KETs workers is expected per year. The key share of the extra demand is made up by replacement demand, for example, due to retirement or moving to other sectors, with a total of 772,000 KETs professionals and associates. Expansion demand (i.e. new jobs) is estimated to be a relatively small share of the total additional demand for KETs skills until 2025, with a total of 181,000 KETs jobs.

Most of the jobs related to additional demand (62%) will require highly skilled people, though there is also a relatively large increase in demand expected for medium skilled people in KETs (30% of additional demand).

Figure: Breakdown of future demand for KETs skills, by skill levels



KETs draw from a larger pool of STEM graduates and compete with other industries for talent

The supply of KETs graduates mainly comes from a broader pool of STEM graduates that significantly exceeds the additional demand posed by KETs. Currently, however, most of these graduates do not choose KETs, which can partially be explained by a relatively unattractive image of KETs as a field to work in. These graduates may, for instance, pursue a career in other STEM fields or even outside STEM fields, such as banking and finance. Whether these graduates turn to KETs therefore proves to be more of a distributional issue rather than an issue of availability.

Mr. Carlos Lee
Director General EPIC – European Photonics Industry Consortium, Belgium

"SMEs in general currently do not comprehend the severity of the problem related to KETs skills. Showing the numbers and explaining to SMEs that large companies 'will do anything' to acquire required employees in a market with a supply deficit, is likely to mean that SMEs will have a major difficulty to fill their vacancies".

Educational programmes not aligned with industry needs

Stakeholders report a gap between the skills that are supplied by educational institutions and the skills that are actually required by industry.

The current educational programmes focus mainly on technical skills, while professionals involved in KETs need to demonstrate an adaptive blend of both technical and non-technical skills. In terms of technical skills, students often have to work with software and equipment that are outdated, without having access to state-of-the-art developments. In terms of non-technical skills for

Dr. Dimitris Mavrikios
Member of the Industrial Research Advisory Group, EFFRA

"Students and employees should be able to address real-life problems rather than theoretical problems."

Dr. Jacques Lukasik
Secretary-General, Euro-CASE

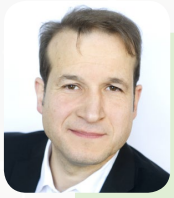
"There is a need for a scheme in which companies are rewarded for co-educating a student, in particular by providing them a guarantee that the trained student will eventually work for the respective company for a certain period of time."

technical people, educational programmes often do not pay sufficient attention to leadership skills, quality management for complex products and processes, innovation and entrepreneurship skills, as well as marketing and sales skills for KETs.

Additionally, the current educational programmes often focus on teaching facts and problem-solving skills in a series of narrow topics, while KETs require a multidisciplinary approach implying knowledge of at least the outlines of every field of life that might be relevant to the possible KETs application areas. Finally, the current educational programmes often fail to achieve the right balance between the depth of knowledge within a discipline and breadth across disciplines (general vs. specific knowledge and skills).

Dr. Luisa Tondelli
National Research Council of Italy - CNR, Co-chair of Working Group on KETs skills and education

"Europe may need a revolution in multidisciplinary education, and if the proposed long-term changes are introduced, although not KETs-specific, those are likely to positively affect both KETs and a wide variety of other domains. These changes among others refer also non-technical competences, such as training creativity, enhancing communication skills, using emotional intelligence and favouring team work already at primary and secondary schools."



Dr. Jürgen Siebel
Human Resources, Siemens AG

"The duality of theory taught in classrooms and applied learning in the workplace that has made the German, Swiss and Austrian vocational education models famous, can provide guidance for education reform elsewhere. Dual education delivers employability, the precursor for employment itself, and can be applied beyond the vocational level, too. It also works outside its traditional markets."

Mr. Robert Nefkens
Managing Director, Hembrug B.V. and CECIMO Delegate

"Owing to a high level of ICT integration and globalisation, the skills requirements of machine tool builders have deeply changed in the last decades. To sustain our competitiveness, we need a flexible and multi-skilled workforce who can integrate customized solutions to the complex systems of various user industries. This requires advanced knowledge and also practical skills which can be best developed in real working conditions. This is why work-based learning should become the essential pillar of the education system in Europe and the cooperation between companies and education providers must be strengthened at all levels."

GOOD PRACTICE EXAMPLE

METALS - MachinE Tool ALliance for Skills

METALS - MachinE Tool ALliance for Skills aims at providing the industry with the skills needed vis-à-vis emerging technologies such as additive manufacturing. The Alliance, launched by CECIMO - the European Association of the Machine Tool Industries, is built on a partnership bringing together national machine tool associations, VET providers and regulatory bodies from Germany, Spain and Italy. As the first step, the Alliance analyses emerging technologies in the sector and builds a skills panorama detecting the future skills needed by European machine tool builders. In the second phase, the Alliance will design a curriculum and gather relevant learning materials which will be available for the use of the European machine tools workforce through an e-learning platform. METALS, a 3-year project, is also expected to improve labour market intelligence in the sector by bringing together partners from the worlds of education and industry and provide policy-makers with practical insights needed to design policies and programmes boosting the competitiveness of machine tool builders and employability of its workforce. Throughout the initiative, the consortium will also organise skills workshops in Germany, Spain and Italy with the participation of relevant stakeholders. METALS, a Sector Skills Alliance, is co-funded by the Erasmus+ Programme of the European Union.

GOOD PRACTICE EXAMPLE

IMH Machine Tool Institute (Spain)

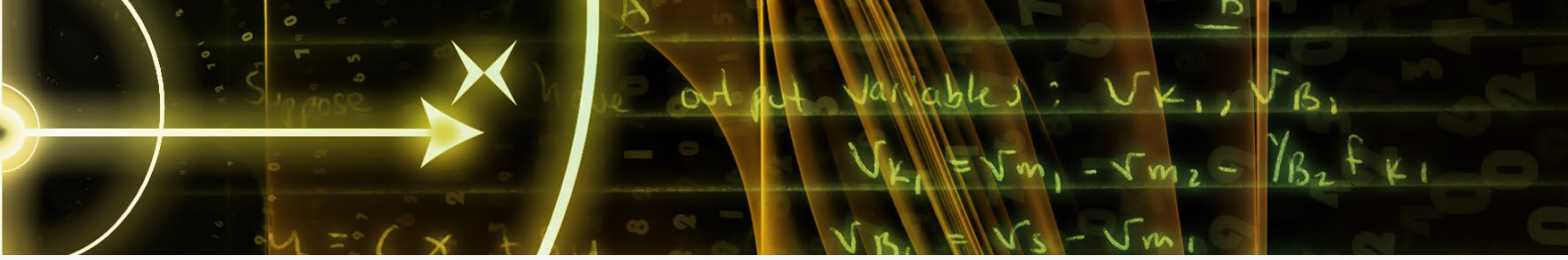
The Machine Tool Institute (IMH) is a technological innovation centre serving industry and the community, through technical training and technological diffusion in the machine tool sector. Specifically, the Dual Engineering University School of IMH offers an engineering university course combining academic training and gaining work experience in a company. This is an innovative study option which is directly related to the fact that companies require a workforce that is tailor-made to meet their needs. The project aims to improve engineers' training by integrating them in actual companies.

Since it is carried out in both the company and training centre, the IMH Dual Engineering course enables students to gain first-hand experience of the day-to-day working of a company, and to channel their studies to meet the company's specific needs.

This approach leads to professionals who are well trained and capable of taking responsibility in different technical and management areas, and who have a thorough knowledge of the working of the company.

More information on IMH can be found at: http://www.imh.eus/

Photo by IMH



Recommended actions

- **Embedding technical multidisciplinarity in the curriculum:** training students in various disciplines simultaneously so that they can work 'at the crossroads' of those disciplines (e.g. mechatronics combining mechanics, electrics and systems engineering);
- **Embedding non-technical courses in technical curricula:** offering non-technical courses for technical students in the areas of quality, risk & safety; management & entrepreneurship; communication; innovation-related competences and emotional intelligence skills;
- **Updating the skills of teachers/professors:** sending the educational personnel to companies to get insights into the latest developments, while inviting people from companies to regularly teach in the classroom;
- **Promoting innovation in teaching:** rewarding educational institutions and teachers/professors for introducing innovative approaches; these aspects need to be embedded in the assessment schemes for both organisations and individuals.

Need for regular (re-)training

Skill requirements in KETs constantly change due to factors like technological development, globalisation, industrial restructuring, increasing role of ICT and new patterns of work organisation. As a result, all specialists in the field of KETs need regular retraining and continuous professional development. Employers of all sizes agree on the importance of lifelong learning. At the same time, companies, particularly SMEs, find it challenging to provide such training.

Large companies in general agree that not all competences can and should be taught by the educational institutions, and that certain specific skills can be better taught "on the job". In fact, some large companies prefer to hire individuals with limited experience and to provide them with informal on-the-job training through work in teams and through mentoring by senior colleagues.

Prof. Rudy Lauwereins
Vice-president, IMEC

"There is insufficient attention to retraining people in highly capital-intensive environments. Hands-on training on the expensive equipment is highly challenging. New educational methods need to be developed for such environments."

Small companies, in turn, often find it difficult to continuously advance the skills of their employees within the lifelong learning approach. Firstly, training is a costly activity, and the resources that SMEs can spend on training are typically highly limited in terms of both time and money. Secondly, there is often a lack of organisational capacity within SMEs including human and intellectual resources to provide such training. Small companies can therefore hardly provide the necessary training themselves, and heavily rely on partnerships with local providers of training and local authorities.

GOOD PRACTICE EXAMPLE

1st Sustainable Nanotechnology School (Italy)

The achievement of safe nanoproducts requires an understanding of the properties, biological interactions, fate, risks and environmental impacts of manufactured nanomaterials. The Sustainable Nanotechnology School aims to transfer the state-of-the-art knowledge on these aspects from key experts to the new generation of nano environmental, health and safety (EHS) professionals. In order to do so, the school highlights the best available experimental and modeling approaches and practices for physicochemical characterisation, (eco)toxicity testing, exposure, risk, and lifecycle assessment of nanotechnologies, taking various stakeholder perspectives and ethical issues into account.

The course is structured to balance breadth and depth in these diverse topics, as well as to build an integrative understanding of them, while providing an interactive learning environment and direct access to key experts from Europe and the United States. The Sustainable Nanotechnology School is organised under the major EU 7th Framework Programme projects SUN and GUIDEnano and the MODENA Cost Action.

The 1st Sustainable Nanotechnology School is especially designed for personnel from research and academic institutions as well as from industry, governmental agencies and hospital departments. The School is aimed at senior researchers, young scientists, PhD students and, in fact, anyone dealing with nanosciences, nanotechnologies and risk assessment of nanotechnology.

More information on the 1st Sustainable Nanotechnology School can be found at: http://www.unive.it/

Prof. Antonio Marcomini
Università Ca' Foscari

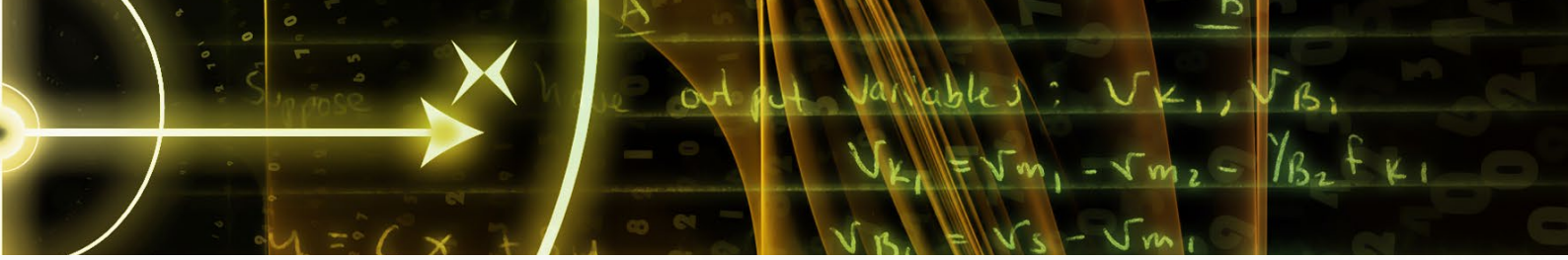
"Uncertainties around the Environmental, Health and Safety (EHS) risks of manufactured nanomaterials are raising societal concerns that can block the benefits from nanotechnology. Scientific and policy analysis on EHS implications of nanotechnologies is needed to protect innovation. There is a need to train a new generation of creative, entrepreneurial and innovative Early Stage Researchers and professionals able to face the current challenges in NanoSafety research. That is one of the key objectives of the 1st Sustainable Nanotechnology School."

Recommended actions

- **Convincing companies that the return on training and skills development investment is sufficient to offset the costs:** encouraging employers to invest in up-skilling of their personnel by offering them factual evidence and by showcasing good practices.

Low awareness of KETs among students

Critical career decisions are being made already more than a decade before a student enters the workforce. However, at that point, children are often not familiar with the development opportunities within KETs. Consequently, the promotion of KETs-related education and careers should start early in the educational process. Both parents and teachers play a crucial role in this respect. Furthermore, KETs are even less popular among girls, and with no sufficient attention to this group at an early age, half of the potential future labour market is likely to be overlooked. Consequently, another challenge for KETs is to reach a better gender balance.



GOOD PRACTICE EXAMPLE

VDW-Nachwuchsstiftung Youth Education and Development Foundation (Germany)

VDW-Nachwuchsstiftung (German Machine Tool Builders' Association Youth Foundation) was founded by VDW in 2009. Located in Bielefeld, the Foundation's overall goal is the development and employment of youth in the machine tool sector. The Foundation specifically aims at transferring knowledge between industry, vocational schools and universities; quality improvement in vocational education; and increasing the number of apprentices and trainees in the machine tool sector.

The Foundation offers around 100 applied training courses (one course takes 3,5 days on average) with the help of machines and latest technologies for vocational school teachers and company training instructors. The courses are organised in partnership with Siemens and Heidenhain (companies) at their training centres to provide access to the latest technology of control system available on the market. Additionally, the Foundation, in partnership with regional government, evaluates and certifies vocational schools in the area of computer-aided manufacturing in terms of education quality. The Foundation also organises Skills Shows at machine tool exhibitions in Germany such as EMO Hannover, METAV Düsseldorf and AMB Stuttgart in order to improve the image of the machine tool sector and to attract more young people to the sector.

More information on VDW-Nachwuchsstiftung can be found at: http://vdw-nachwuchsstiftung.de/index.php/home.html (VDW YF) or http://www.cecimo.eu/site/publications/magazine/skills/

Recommended actions

- **Developing a targeted communication strategy to increase awareness on KETs:** in order to achieve large-scale effects, mainstream media should be employed as much as possible; additionally, social media and popular Internet websites could be mobilised to effectively reach the targeted audience. The latter goes beyond young people, and also includes parents, teachers and society in general.

- **Developing a targeted communication strategy specifically for girls,** targeting also their parents and teachers, and aimed at increasing their awareness of the opportunities within KETs for girls.

Unattractive image of KETs

Companies report that the weak image of the KETs sector is the most important obstacle encountered by them when trying to attract people. Specifically, KETs careers are often associated with relatively low financial rewards and limited career opportunities when compared to other highskilled jobs. This image exists in the minds of both students and current labour market actors.

Generous financial benefits and fast career growth opportunities, in particular in the services sector often make KETs not the 'number one priority' option when it comes to career choices. Consequently, in case of people with a technical background, KETs have to compete for them not only with other technical domains, but also with non-technical sectors, where people with technical background are nevertheless in high demand, for example, in the banking sector. Additionally, KETs careers are often viewed as being less prestigious than some other high-skilled jobs, for example, in the financial and legal sectors.

GOOD PRACTICE EXAMPLE

MINATEC innovation campus (France)

The MINATEC innovation campus is a joint effort of research institutes and local government. It is part of the GIANT innovation campus, and has been established through a 150 million EUR investment from CEA Grenoble, from the Grenoble Institute of Technology, and from local government.

The MINATEC innovation campus aims to attract more students to KETs and to broaden the KETs skills base, by training undergraduates, and by reaching out to primary schools, secondary schools, and their teachers.

As a result, the initiative has attracted a large number of students and PhDs, generating 300 patents and 1,600 research articles per year. MINATEC currently enrolls 1200+ engineering students, 480 PhD students, and 140 post-doctoral students, which work and study at the Grenoble INP Phelma engineering school and the MINATEC research labs. Also, MINATEC's outreach programme Nano@School reaches 300-400 youngsters each year, and its Junior Scientist & Industry Annual Meeting has a reach of approximately 100 students per year. Teachers report that the educational programmes connect well with their curricula and create much better awareness of KETs among school-going children.

GIANT offers a wide variety of multidisciplinary programmes with access to state-of-the-art equipment and facilities. The innovation campus includes graduate and undergraduate programmes, educational tracks to train technicians in management skills, and programmes that place PhD's in companies. The GIANT campus has a renowned innovation management school (GEM) beside a scientific university (UGA) and Grenoble INP, national research organisations (CNRS, CEA) and an array of large scientific research instruments, including the European Synchrotron Radiation Facility (ESRF), the Institut Laue-Langevin (ILL), and the European Molecular Biology Laboratory (EMBL).

More information on the GIANT alliance can be found at: http://www.giant-grenoble.org/en/

More information on MINATEC can be found at: http://www.minatec.org/en/minatec

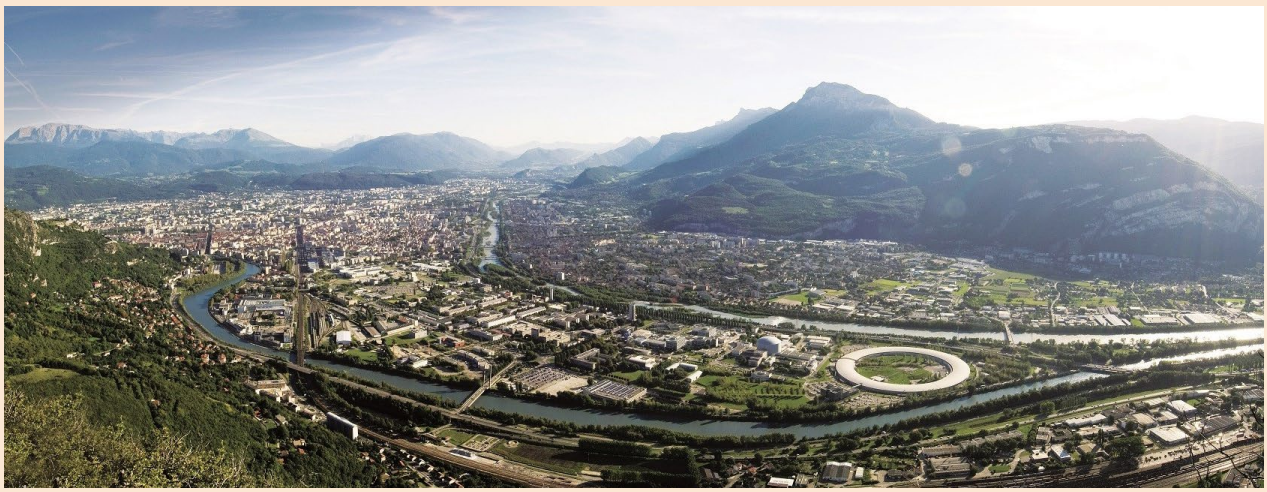


Photo by J.M. Francillon - Ville de Grenoble

Dr. Francine Papillon
Head of the GIANT Executive Committee, GIANT alliance

"The GIANT alliance aims to contribute to tackling the key challenges facing society in the fields of information technology (MINATEC), new low carbon energies (GreEN) and life Science (NanoBio). Companies, researchers and students work together closely to accelerate the development of innovative technologies and their transfer to the industrial sector."

Recommended actions

- **Improving working conditions which includes offering attractive remuneration;** offering flexible project budgets; building well-equipped laboratories; and offering safe working environment.

A wide range of measures aiming to enhance KETs skills are already applied by various stakeholder groups at the EU, Member State, regional and organisational levels. However, not all Member States are at the same level of development when it comes to tackling KETs skills issues. Leading Member States should keep up doing the work they initiated and inspire others. At the same time, other Member States should consider including KETs skills in their priorities and learn from good practices.

Key skills challenges in micro-/nanoelectronics sector in France, Germany and the United Kingdom

The sectoral pilot conducted within the KETs Skills Initiative focused on convincing the relevant stakeholder groups in the three Member States about the importance of the KETs skills-related challenges and the need to adopt the proposed policy initiatives. It aimed to serve as an impetus for action. The stakeholders were familiarised with the proposed actions, and encouraged to co-create tailored action plans for their respective Member States. The sectoral pilot focussed on the micro-/nanoelectronics sector.

The case of France

Stakeholders in France argue that a shrinking industrial base creates a clear risk of current skills rapidly vanishing, as these skills will no longer be in demand and thus workers will no longer be (re-) trained in them. Moreover, they are concerned that when a local workforce falls too far behind the state-of-the-art, the region may become entirely unattractive to high-tech companies, and the industrial base may be beyond reinvigoration.

Stakeholders also recognise the low awareness about micro-/nanoelectronics in society. Even though the use of micro-/nanoelectronics-based consumer products has dramatically increased in the last years, the understanding of the underlying technology amongst the general public still is rather limited. This lack of understanding does not help encourage student participation in technological tracks. However, it is also considered an opportunity, as it allows students to be motivated to take up technological courses through devices with which they already interact.

Technology careers in the French micro-/nanoelectronics sector are believed to be less rewarding, both financially and in terms of status and seniority. Stakeholders partially relate it to the socialstanding of engineering and technology work in general, with individuals working in management, finance, or law having gained more influence, and better status and financial rewards over the last three decades.

Regarding the key measures already in place in France to tackle the skills challenges, the French approach is characterised by collaborative efforts within clusters of micro-/nanoelectronics between high-tech companies and leading educational institutions. These are typically driven by a combination of organisational support from the private sector and financial support from local and regional government.

Dr. Francine Papillon
Head of the GIANT Executive Committee, GIANT alliance

"The French graduate students are well trained in the field of micro nanotechnologies and benefit from state-of-the-art engineering education through the CNFM network; however, only 50% of them choose to work in this sector, reducing the pool of good candidates from the industry point of view."

The case of Germany

The German micro-/nanoelectronics industry, and specifically the Silicon Saxony ecosystem, is characterised by a small-scale structure (e.g. compared to the semiconductor clusters in East-Asia and the United States, where many large companies are located). It lacks the headquarters of, for instance, large semiconductor manufacturers. Presence of these large companies, with their substantial marketing budgets and internationally renowned image, would help to increase awareness of the micro-/nanoelectronics sector in Germany. It would also attract investments in state-of-the-art research and production facilities, which are essential for state-of-the art (re)-training.

Visibility of the micro-/nanoelectronics is further hampered by the fact that German micro-/nanoelectronics companies (and European companies in general) do not excel at systems and final-products approaches, implying that they are relatively invisible to the general public.

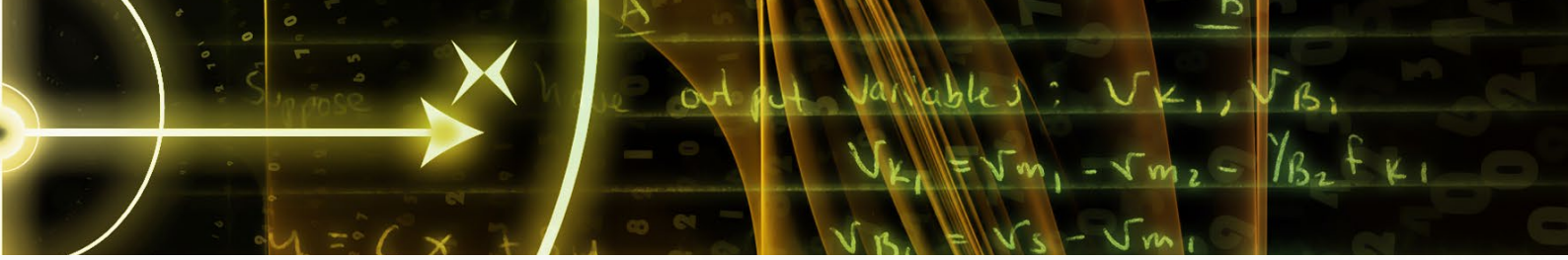
Although, the unattractiveness of the engineering profession is not reported as a key challenge in Germany, the nanoelectronics sector is lacking a 'shining star' to attract engineering talent. There is a limited awareness among students of, for example, Infineon or Global Foundries. This mainly has to do with a lack of strategic marketing amongst German nanoelectronics companies.

Skills and training measures that are already in place, are mainly aimed at raising young people's interest in electronics and encourage students to engage in research. In this context, the Federal Ministry (BMBF) supports the 'Invent a Chip' and 'COSIMA microsystems competition' for secondary and tertiary school students. These initiatives are organised on a yearly basis.

Besides these initiatives, there are not many policy measures that are specifically targeted at skills development for nanoelectronics. However, the Federal Government has launched numerous measures aimed at skills development in general. That includes a broad package of measures in the domain of lifelong learning.

Frank Bösenberg
Cluster Manager, Silicon Saxony

"In Germany, one of the key challenges for better aligning education with industry needs, is to ensure coherence and facilitation of STEM-oriented initiatives within the education system, in particular with regard to female students."



The case of the United Kingdom

Skills challenges faced by the UK not only relate to challenges concerning graduates in the field, but also to a decreasing number of experienced employees with a relevant set of skills. Although the benefits of retraining are clear, continuous training in the micro-/nanoelectronics sector is reported to be costly. Many companies indicate that they are currently unable to fund training, which creates a skills gap. This is reinforced by the fact that the UK microelectronics industry generally lacks a presence of large companies, which typically have more funds available for training.

Furthermore, prospective students are considered to have a low awareness of the career opportunities in micro-/nanoelectronics and the industry's key role in solving societal problems. Another concern raised by industry is the persistent male-female gender imbalance in the sector. Addressing this imbalance is considered an opportunity for raising the overall number of graduates in the field.

Micro-/nanoelectronics sector has a rather unattractive image in the UK. The micro-/nanoelectronics careers are often associated with relatively low financial rewards and limited career opportunities when compared to other high-skilled jobs, such as those in the financial or legal services industries. Finally, industry lacks some of the major employers that would be well-known and recognised by the average school pupil or their parents. The closure of some of the major chip production facilities in the UK may further negatively influence the public opinion of nanoelectronics as a place to work.

Dr. Derek Boyd
CEO, National Microelectronics Institute

"Developing graduates that can hit the ground running after completion of their studies has been a major focus of the industry in the UK and led to the creation of the UK Electronics Skills Foundation (www.ukesf.org). A Graduate Apprenticeship, with significant public funding to support, is seen by many as a great addition to the skills mix. Aimed at attracting school-leavers into well-paid positions, gaining hands-on experience with academic study; improving their engineering skills and focusing university modules on their individual and/or employer interests are all strong reasons why this approach should be successful. In parallel with UKESF, NMI and our partner associations in ESCO are working tackling electronic engineering skills shortages without leaving it all to Government."

The sectoral pilot confirmed that the development and maintenance of KETs skills in Europe is a complex multi-faceted challenge that requires a complex solution. This complex solution consists of various clusters of measures each targeted at specific aspects of the overall challenge. Action is required at all levels, there is a clear need to join forces and apply a comprehensive approach, thereby enabling Europe to fully benefit from the opportunities offered by KETs for decades to come.

Prof. em. Roger De Keersmaecker
IMEC, Co-chair of the KETs HLG Working Group on Skills and Education

"The education and skills development ecosystem requires an active interplay - of the European Commission, the Member States and regions and their education providers and Industry. Each of these stakeholders must contribute to raising the awareness of the skills issues, to establishing skills development partnerships and to adapting the learning environment and attitudes."

European Commission

More information

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