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KET4CleanProduction

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Report on SME needs analysis outcomes and framework conditions

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Abbreviations and Acronyms

Abbreviation / Acronym	Description
B2B	Business to Business
CIS	Commonwealth of Independent States
EC	European Commission
EU	European Union
ICT	Information and Communications Technologies
KET	Key Enabling Technologies
KET TC	KET Technology Centres
R&D	Research and Development
SME	Small Medium Enterprise
UN	United Nations

1 Executive Summary

Key Enabling Technologies (KET) exhibit the potential to revolutionize production and manufacturing process and improve industrial competitiveness. Despite the expressed intentions of the European policy to promote KETs in Europe, small and medium-sized enterprises (SMEs) are not implementing operational changes that would enhance the impact of KETs in their business. In addition, the KET observatory provides evidence that some European countries do better than others in KET diffusion and adoption.

The H2020 project KET4CleanProduction carried out research to understand whether there are specific elements of technology, strategy or skills that prevent a rapid adoption of KETs by SMEs and to observe possible common traits in European national economies with a low level of KET adoption. The findings of the study will be exploited by the KET4CleanProduction project partners to develop activities and specific measures that could better address these needs, in particular refine the micro grant requirements, the operational/ administrative procedures of the micro grant call, the services provided by KET TCs, and the facilitation services matching SMEs to KET TCs, as necessary.

The research was conducted in two parts:

Part A: An online survey was developed to collect input from European SMEs and identify their needs and potentials in using KET services to address clean technology process innovation challenges. The questionnaire is comprised of the following three parts:

1. **General information**: Analysis of the profile of the respondent and general demographic characteristics of the sample.
2. **Innovation and Key Enabling Technologies**: Analysis of how companies use and integrate Key Enabling Technologies in their innovation management processes
3. **Collaboration with KET Technology Centres**: Analysis of a) the operational context of SMEs with no experience in collaborating with KET TCs and b) the experiences and impact of the collaboration of SMEs with KET TCs.

Part B: Eight countries with relatively low level of availability and diffusion of KETs were selected: Bulgaria, Croatia, Denmark, Greece, Hungary, Latvia, Slovakia and Slovenia. A qualitative survey was prepared to gather input about the conditions and national context in these countries to understand better the cause of the insufficient offer of KETs in clean production services. The survey consisted of 5 parts:

1. **Introduction**: aims at understanding the general outlook and overview of each country
2. **Technology**: aims at understanding the level of availability of KET in each country
3. **Market/competition**: aims at understanding the dynamics of market and competition with respect to KET in the manufacturing sector in each country
4. **Regulation/legislation**: aims at understanding the legal and regulatory context for the promotion and use of KET in each country
5. **Funding/financing**: aims at describing the overall conditions of funding and financing of KET-related projects and companies in each country.

The information collected from the online survey (part A) and desk research and interviews (part B) brings to the fore common traits across the European SME community and the selected countries with low diffusion and availability of KETs.

In relation to how European small and medium-sized enterprises perceive KETs, their impact on production, and the integration of KETs in their production activities, the study concludes that:

- European SMEs acknowledge that there is great need for cleaner production in manufacturing
- External support is critical for SMEs to implement changes and improvements in production
- SMEs are not aware of the impact of KETs in manufacturing and relevant funding opportunities
- There is a growing interest among KET-aware SMEs for KET TC services

On the other hand, the national economies under study exhibit several common characteristics. With the exception of Denmark that is more advanced than the other countries in the set, the studied economies hold a strong and untapped potential for developing a growing market for KETs but are restrained by the following conditions:

- The transformational character of KETs for the national economy is inhibited by the lack of financial resources
- KET's diffusion and economic impact is limited by the low level of university-industry collaboration
- Policy aims at advancing KETs' growth but focuses on sectors and not on technologies
- Industry structure often inhibits the development of high-tech industries and KETs

The study offers three recommendations that can improve the access of SMEs to KET service providers and the usage of KETs in production. These recommendations are addressed to policy makers and those who implement such policies at the local, national or European level:

Facilitate access to finance, in particular for innovative SMEs. Financing is an enabling factor for greater collaboration within innovation ecosystems. Increased public R&D investment and greater collaboration within innovation ecosystems could foster the wider commercialisation of KETs-related products. European cascade funding instruments such as KET4CleanProduction, that are specifically tailored to drive the deployment of KETs across EU-28, should further be promoted to meet the increasing demand, especially in countries with a low diffusion of KETs. In this respect, the micro grants offered by KET4CleanProduction hold the potential to greatly facilitate innovation growth and KETs development.

Increase the awareness of the potential of KETs to business growth. Although there is a fair motivation among SMEs regarding the integration of KETs in their manufacturing process, the benefits of their use are still unclear. Also, SMEs lack efficient sources of state-of-the-art information and regular updates. Currently, they largely rely on the internet and not on specialized sources.

Enhance transnational collaboration between research and business. The lack of specialized skills and the difficulties to attract financing can be mitigated when collaboration happens at the European or international level. Skills, expertise and financing can be transferred to manufacturing companies interested in collaborating with European KET TCs. In addition, transnational collaboration can strengthen weak innovation ecosystems and enhance cooperation between industry and academia with multiplier effects for the local economies. In this respect, KET4CleanProduction's objective to increase transnational collaboration has a strong potential in order to improve the economic outlook of the SMEs that participate on the platform (ket4sme.eu), and generate positive results to the local innovation ecosystems.

2 Introduction

This study has been conducted in the frame of the KET4CleanProduction project with the aim to have a better understanding of:

1) **The needs and potentials of small and medium enterprises (SMEs) in Europe in using KET services to address clean technology process innovation challenges.**

The deliverable elaborates on the service needs and challenges of SMEs in terms of clean technology process innovation challenges. It offers insight into the operational priorities of SMEs and analyses the main factors that influence a successful collaboration between SMEs and KET TCs. Topics investigated include hindering factors for collaborating with KET TCs, priorities an aims of SMEs, etc. An online survey was disseminated to collect input from European SMEs.

2) The conditions / national context in countries with insufficient offer of KET in clean production services.

Countries with low KET diffusion index are analysed and commonalities and differences among the countries are identified. The selection of the countries was performed during the preparation of the proposal and includes Bulgaria, Croatia, Denmark, Greece, Hungary, Latvia, Slovakia, and Slovenia. The data were collected by desk research and/or interviews with experts performed by KET4CleanProduction partners.

The findings of the study will be exploited by KET4CleanProduction partners to develop activities and specific measures that could better address these needs, in particular refine the micro grant requirements, the operational/ administrative procedures of the micro grant call, the services provided by KET TCs, and the facilitation services of the project, as necessary.

The report is structured as follows: Chapter 3 describes the methodology of the study. Chapter 4 discusses the findings of the online survey. Chapter 5 investigates the status in the eight countries of the study. Chapter 6 concludes and offers a series of recommendations for KET4CleanProduction partners and policy makers. Section 7 / ANNEX 1 contains the questionnaire used to gather information for the SME needs analysis.

3 Methodology

3.1 Design of the SME needs analysis survey

To identify the SME needs a survey was conducted. The advantage of a survey is the online accessibility and therefore the possibility to reach a wider audience across a number of EU member states. The survey was based on a certain questionnaire designed to collect valid and reliable input (Annex 1) Therefore, the results of the survey exclusively reflect the findings derived from the responses collected by survey respondents.

The partners of the consortium were involved in the development and dissemination of the survey. A preliminary structure of the questionnaire was disseminated to the consortium to allow the partners to comment and provide recommendations and suggestions. The final version of the questionnaire was agreed on during the second project meeting in Spain. It was placed online on EU survey[1], on 16 March 2018. The period to gather responses ended on 30 October 2018.

The questionnaire is comprised of the following three parts:

[1] https://ec.europa.eu/eusurvey/runner/KET4CleanProductionSurvey2018

4. General Information: Analysis of the profile of the respondent and general demographic characteristics of the sample.
5. Innovation and Key Enabling Technologies: Analysis of how companies use and integrate Key Enabling Technologies in their innovation management processes
6. Collaboration with KET Technology Centres: Analysis of a) the operational context of SMEs with no experience in collaborating with KET TCs and b) the experiences and impact of the collaboration of SMEs with KET TCs.

The promotion of the questionnaire was done by the following means:

1. All project partners circulated the questionnaire link among their clients, primarily focusing on SMEs
2. The questionnaire was promoted via the social channels of the project. Partners, also promoted the questionnaire through their own social media channels.
3. In September, the questionnaire was added as an optional feature in the registration process on the project´s webpage (ket4sme.eu).

3.2 Framework Conditions

In order to capture and analyse the framework conditions in the selected countries with a low level of availability and diffusion of KETs, a qualitative survey form was prepared and distributed to the respective 8 project partners representing these countries. The survey consisted of five parts:

6. Introduction: aims at understanding the general outlook and overview of each country
7. Technology: aims at understanding the level of availability of KET in each country
8. Market/competition: aims at understanding the dynamics of market and competition with respect to KET in the manufacturing sector in each country
9. Regulation/legislation: aims at understanding the legal and regulatory context for the promotion and use of KET in each country
10. Funding/financing: aims at describing the overall conditions of funding and financing of KET-related projects and companies in each country.

The desk research was conducted from November to December 2018 via the following methods:

1. Desk research on the manufacturing sectors with high SME numbers, RIS3
2. Interviews and/or meetings with local stakeholders and experts, SMEs, business innovation clusters

4 Part A: SME needs analysis survey

The respondents of the survey originate from 12 different EU member states. Approximately 75% of the responses came from the 8 countries with low KET performance index that are in the focus of this study.

Countries	# of responses
Bulgaria, Croatia, Greece, Hungary, Latvia, Slovakia, Slovenia	73
Austria, Germany, Italy, Portugal, UK	35
TOTAL	108

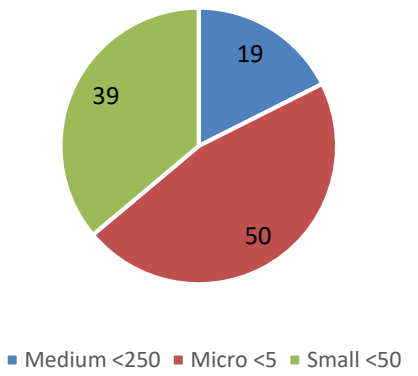
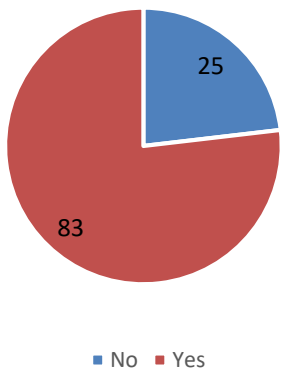


Figure 1 - Size of SMEs participating in the survey



Average R&D staff: 6

Figure 2 - SMEs with internal R&D facilities

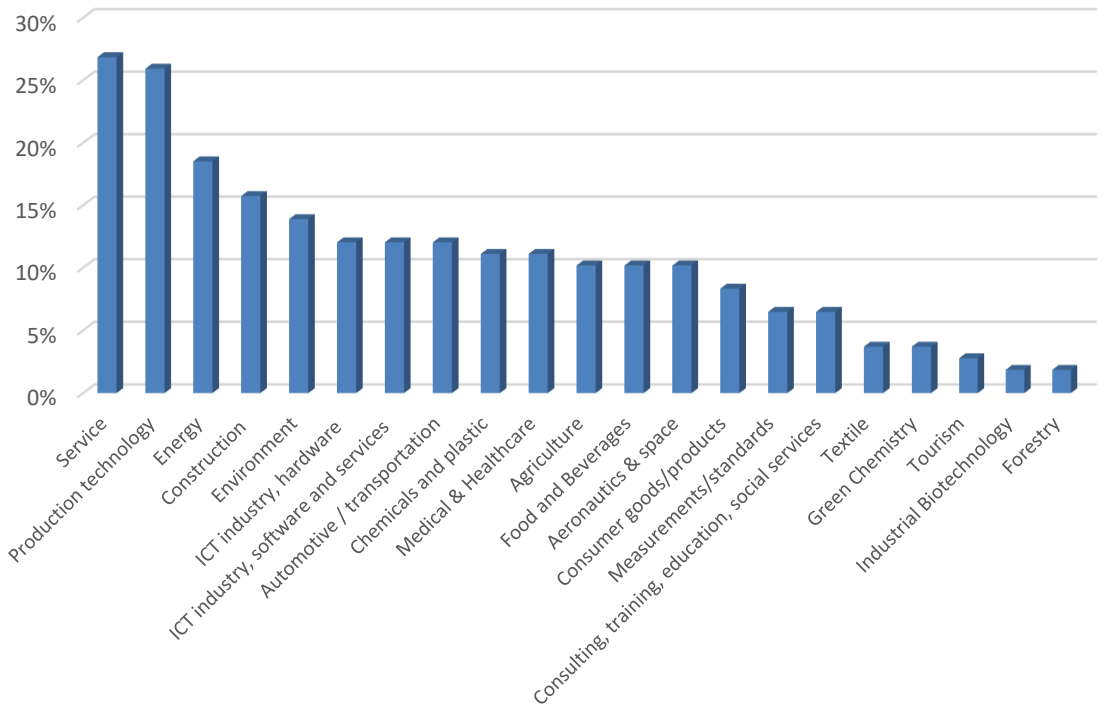


Figure 3 - Industrial sectors represented in the survey

The largest part of the responses came from micro SMEs, with less than five staff members (

Figure 1). Nearly 80% of the responding SMEs have own R&D functions within their organization, with on average six R&D staff members (Figure 2). Almost 50% of the responses came from the service and production technology industrial sectors (Figure 3).

4.1 Relation between companies, innovation and Key Enabling Technologies

The findings of the survey show, that the biggest challenge that SMEs face for innovation development and business growth is **access to finance.**

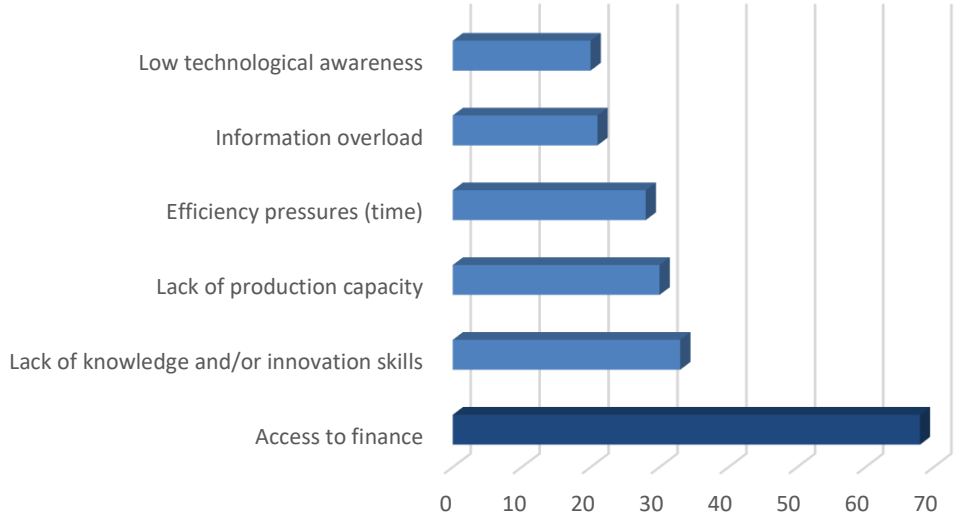


Figure 4 - Most challenging factors for SMEs, in terms of innovation development and business growth

Except from the options already included in the questionnaire (see **Fehler! Verweisquelle konnte nicht gefunden werden.**), other challenges highlighted by the respondents were:

- Missing adequately staffed and experienced business partners, distributors, external associates
- Limited marketing and selling capacity
- Regulatory frameworks – working with public authorities
- Low acceptance of new technologies by customers (often due to non-updated standards)

70% of the respondents consider **clean, sustainable and green production as important** or **very important** (**Fehler! Verweisquelle konnte nicht gefunden werden.**), whereas 80% of the respondents consider the optimization of production facilities as important or very important (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

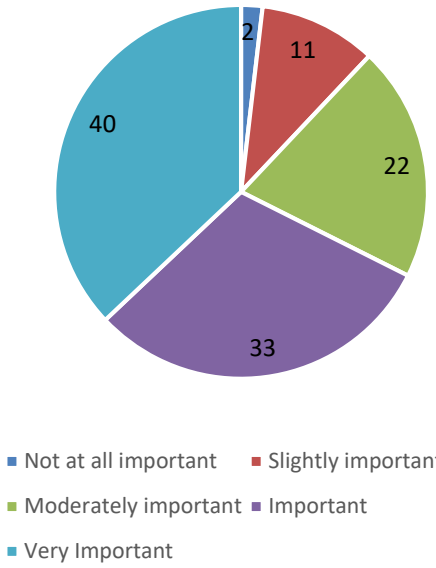


Figure 5 - How important is clean, sustainable or green production for your company

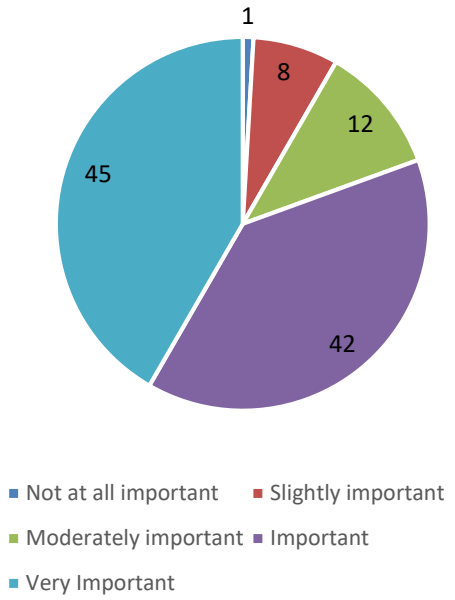


Figure 6 - How important is optimizing production facilities for your company

More than half (55%) of the SMEs noted that they plan to **use external support** to implement business and process improvements for their company. To finance these activities, companies show preference to loan and equity over less committing options such as micro grants and vouchers (Figure 7).

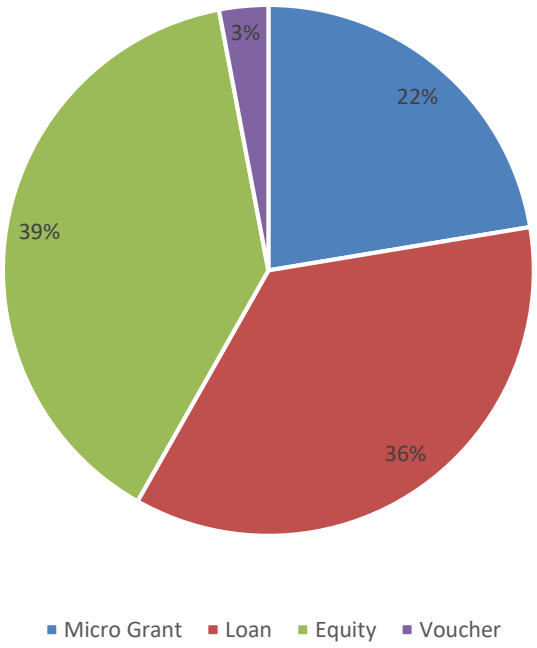


Figure 7 - How you plan to finance external support for business and process improvement

Among the six KETs, advanced materials and advanced manufacturing technologies are considered as most relevant for the business of the participating SMEs, as they gather 24% and 34% of the interest of the companies (Figure 8).

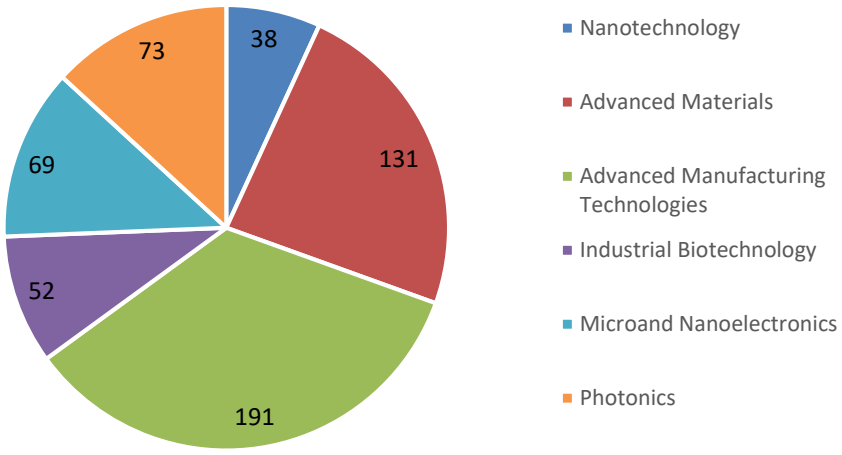


Figure 8 - Which Key Enabling Technologies are more relevant for your business?

Detailed information about the special interest of the SMEs per the Key Enabling Technologies and main subcategories is outlined in Table 1. The right-hand side of the table indicates the number of respondents per KET and KET subcategory.

Nanotechnology	38
Nano medicine	5
Nano membranes	5
Nanostructured coatings	12
Nanoparticles Nanowires and tubes	8
Nano emulsions and pigments	4
2D materials	4

Advanced Materials	131
Electronic and optical functional materials	13
Environmental materials (e.g. recycling, recourse efficiency, less impact, CO2 capture/ utilisation)	19
Industrial materials (incl. catalysts, membranes, adhesives, filters)	19
High performance materials (strong, light, weight, resistant)	25
Materials for energy storage and generation	15
Smart and multifunctional materials (incl. phase change, shape memory, self-healing, self-manufacturing)	16
Surface engineering and coatings	24

Advanced Manufacturing Technologies	191
Smart Manufacturing / Industry 4.0	26
Robotics/Human machine interaction	21
Process industry (processing novel materials, structures, etc.)	22
Monitoring and control	28
High performance computing / cloud based simulation services	12
Additive manufacturing	22
High-performance production (flexibility, productivity, precision and zero defect)	20
High -performance, high precision processing	18
Intelligent/ sensor-based equipment	22

Industrial Biotechnology	52
Vitamins	4
Polymers, bioplastics	14
High value food & feed additives	11
Enzymes	7
Amino acids	3
Antibiotics	1
Bio based chemicals	9
Biofuels	3

Microand Nanoelectronics	69
Quantum technology	1
Optoelectronics (Optical networks, optical sensors)	5
Outsides system connectivity (communication, data transfer, Wi-Fi)	5
Power electronics	5
Printed/flexible electronics	7
Memory and storage	3
Equipment technology	18
Analogue and mixed signal devices (micro-wave, RF, THz)	4
Computing (low power computing, high performance computing, new computing)	11
Heterogeneous components & more than Moore (MEMS, NEMS, sensors, transducers)	4
Heterogeneous integration embedded systems	6

Photonics	73
Displays (LCD, plasma)	6
Photodetectors (solar cells, photo diodes, photo transistors)	8
Optical fibres	1
Laser based applications	14
Intelligent/ sensor-based equipment	22
Lighting (LED, OLED)	12
Optical communication and networks	4
Optical components & systems	6

Table 1 - Interest of SMEs per Key Enabling Technology

With regards to the application of KETs - Only 22 of the 108 respondents know how KETs can enhance, improve and optimize the production/value chain of their company, which translates into a percentage of 20% of all companies surveyed. Only 19 companies have already launched specific initiatives within the KET area and only 10 of them have collaborated with a KET Technology Centre in the past. Despite the limited knowledge about the impact of KETs on production, 62% of the companies that have not launched a project for incorporating KETs in their production process plan to do so in the near future.

The most common source of information about the latest technological developments of KET applications is the internet as illustrated in (Figure 9).

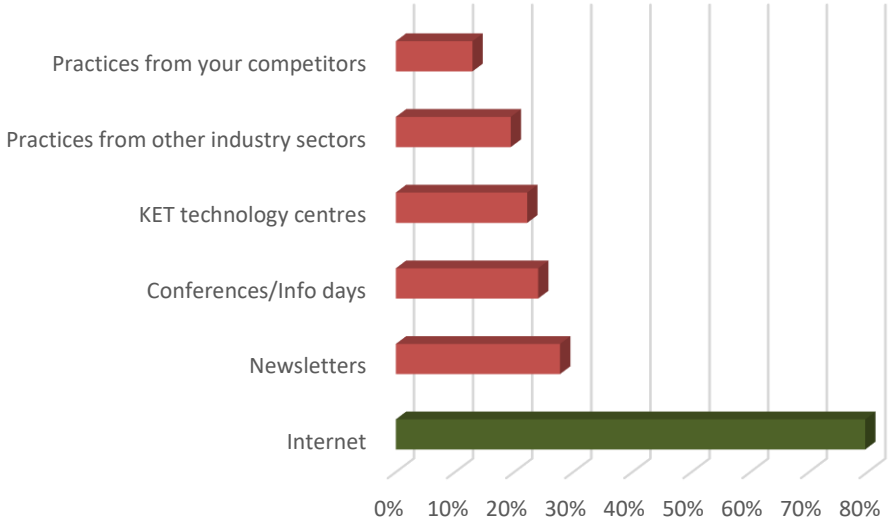


Figure 9 - What channels do you use to get information on the latest technological developments of KET applications?

4.2 Companies with no prior experience in collaborating with KET TCs

The fact that companies know little about KET technology centres and their possible contribution to the growth of the business is illustrated by the fact that 60% of the companies do not really know what services are offered by a KET TC (Figure 10).

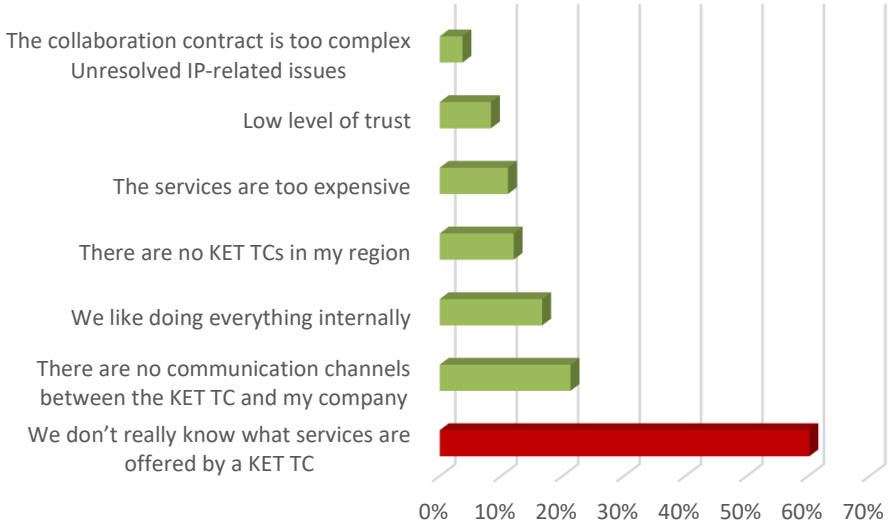


Figure 10 - What are the reasons for not having collaborated with a KET TC so far?

Nevertheless, the companies have a series of issues and challenges that could potentially be solved with the help of a KET TC, most importantly, applying to the scale up of product/process development, as well as concept development, design and prototyping (Figure 11).

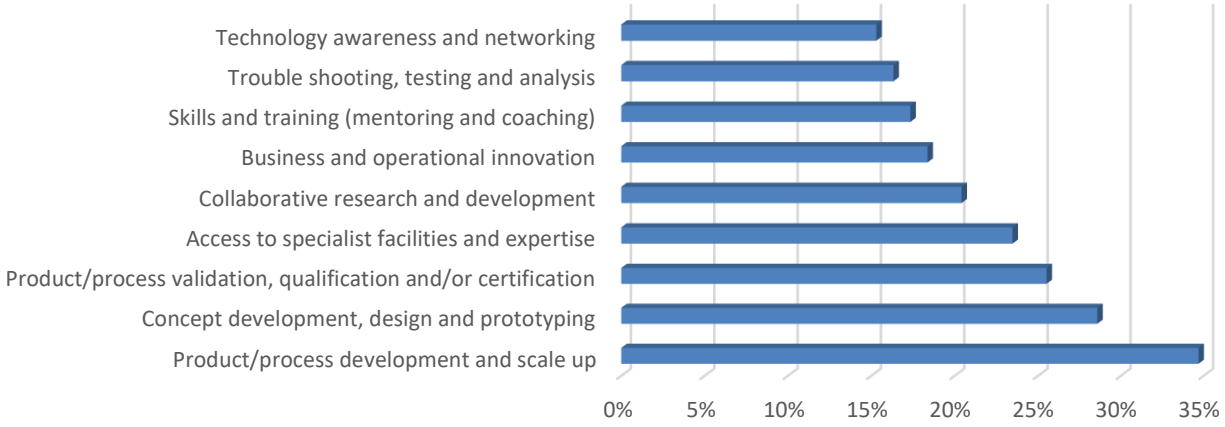


Figure 11 - Do you have a technology problem that you would expect to address with the help of KET TC services?

Only 36% of the companies that have not collaborated with a KET TC consider the **geographical proximity** to a KET partner important or very important. Indeed, 64% of the companies would be willing to travel outside of their country and region to collaborate with a KET TC, with 12.5% declaring that they would travel even outside Europe. Consequently, 85% of these companies do not consider the language as a barrier for the collaboration.

From the companies with no prior collaboration experience with KET TCs, 49% would welcome a micro grant to finance the collaboration, whereas 40% of them also considers contributing with own cash to develop the collaboration. Other options shared among the participants are loans (30%), equity (16%), and vouchers (11%). Additional options submitted include IP / licensing deals, and publicly funded projects.

Finally, 70% of the companies expressed their interest in receiving support from the KET4CleanProduction consortium in finding the right and most suitable KET TC for them.

4.3 Companies with experience in collaborating with KET TCs

The big majority of the companies that collaborated with KET TCs have engaged in the collaboration between 1 and 3 times in the last 5 years (86%), whereas one company has collaborated more than 10 times with KET TCs. The initial contact for the establishment of the collaboration with the KET TC was driven mainly by personal contact (71%) – other options being EU funded projects, KET TC web sites and online advertisements (Figure 12).

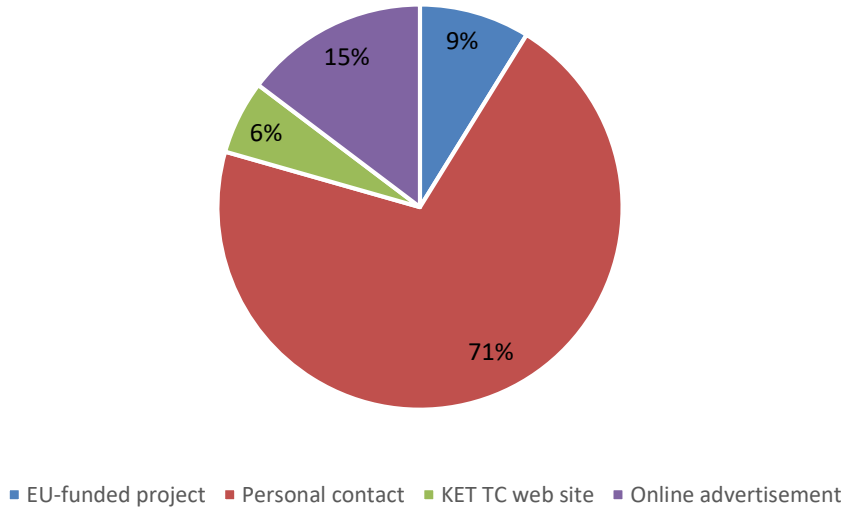


Figure 12 - How did you initiate/establish contact with the KET TC?

Despite the expressed willingness of all the companies that participated in the survey to collaborate with a KET TC outside of the confined borders of their country (see previously), only 12% of them had collaborated with a KET TC from another country. The explanation for this low proportion may be on the one hand that most contracts are driven by personal contact because trust is essential for companies to collaborate with KET TCs; on the other hand that the SMEs find it hard to secure the necessary funds for such collaborations.

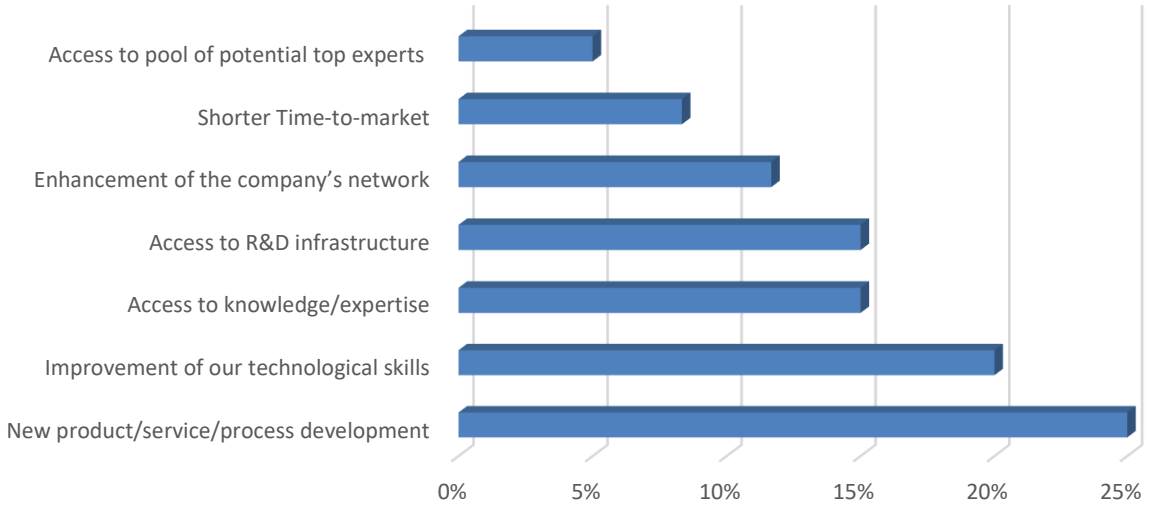


Figure 13 - What were the gains from your collaboration with the KET TC?

The most important gains from the collaboration with a KET TC are identified to be new product/ service/ process development (25% of the cases) and the improvement of the technological skills of the company (20% of the cases) – see Figure 13.

The biggest challenge faced by companies in their collaboration with KET TCs was that services were considered to be expensive, thus financing a part of the collaboration (an approach selected by KET4CleanProduction) seems to be in line with the needs of the companies and has the potential to facilitate collaborations in the sector. There were other insights on the challenges of the collaboration between SMEs and KET TCs, namely: complicated processes, low level of responsiveness and lack of alignment between technology and corporate business models. Significantly less important obstacles are language (intuitively expected), Intellectual Property issues, and the lack of expertise for the company's business needs. It is worth mentioning that 17% of the companies faced no issues in their collaboration (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Finally, the most critical criteria for collaborating with a KET TC is previous positive collaboration (i.e. trust built), experience in industrial collaboration by the KET TC, and the neutral technological and business perspective of the company's R&D partner. Recommendations from business associates is also important (Figure 15).

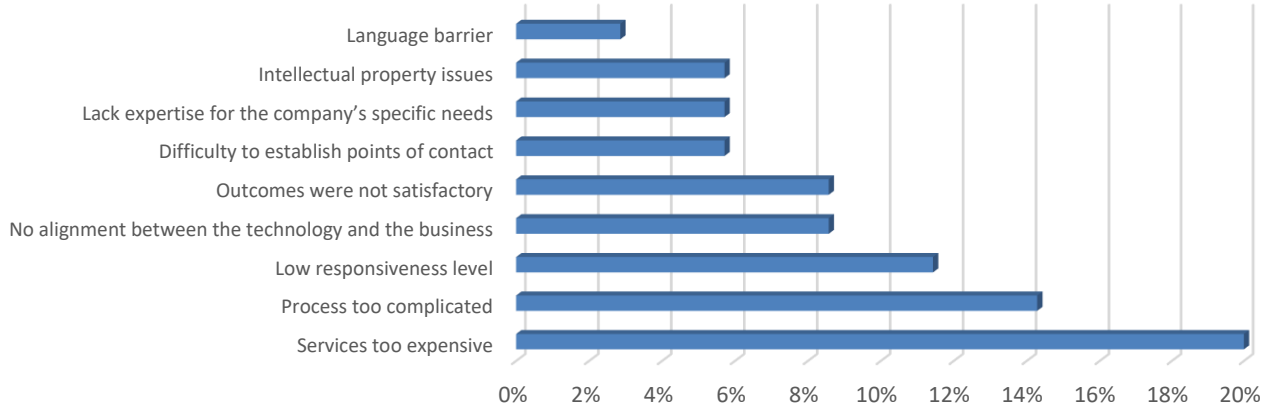


Figure 14 - Challenges of SME and KET TC collaboration

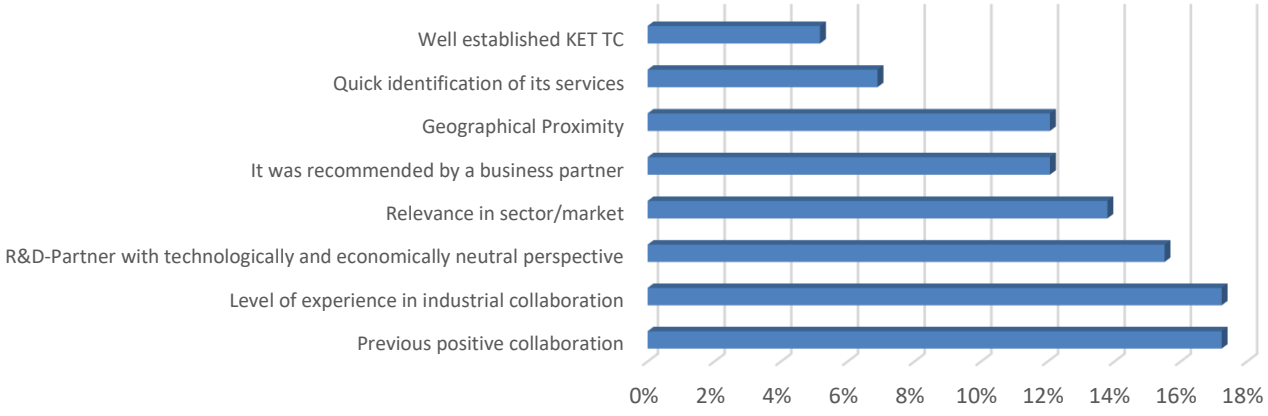


Figure 15 - Most important criteria for selecting a KET TC as partner

5 Part B: SME framework conditions

The study analyses eight countries with low KET diffusion index. These countries were selected based on the overall performance of the national economy in relation to KETs as depicted by the KET observatory and other EU and national studies. In addition, the KET4CleanProduction have partners from these countries that provided the necessary information about the respective countries.

This chapter is organized as follows: Section 5.1 presents a general overview of each country in relation to the relevant Key Enabling Technologies, according to information retrieved in country fact sheets made available by European Commission services[2]. Section 5.2 offers a series of comparisons among the selected countries and provides a comparison to the EU average when relevant, according to statistical data for each country, available by the European Commission. Section 5.3 describes specific elements at the national level and identifies differences and resemblances, according to desk research and information supplied by the partners. Annexes at the end of the deliverable include detailed information for each country, as it was provided by the relevant partner.

5.1 Overview

Bulgaria performs relatively well in Micro/Nanoelectronics microsensorics and Industrial Biotechnology while lagging behind in the deployment of other KETs within EU-25[3]. Relative to other KETs, Micro/Nanoelectronics-related products are important for Bulgaria's overall exporting activity. The country is relatively more competitive in the generation of new technologies, rather than in the wider application in the industry.

The major strengths of the country are:

- Strong economic growth in recent years, foreseen to be sustained in the medium term
- Strong performer in the development of ICT start-ups
- Good progress in the level of R&D investments in the private sector, compared to public funding
- Competitive labour costs with access to a skilled workforce, in particular in the ICT and electrical /electronic sectors
- Attractive fiscal policy with one of the lowest tax rates in the region
- Strong progress in companies' technological readiness and adoption of the latest technologies

Areas of improvement include:

- Further support to product and process innovations from private companies and in particular SMEs
- Ensuring access to high performance infrastructure
- Need to increase the level of public R&D investments levels[4]
- Access to finance to private companies and reduction of the administrative burden
- Greater collaboration within innovation ecosystems

[2] https://ec.europa.eu/growth/tools-databases/kets-tools/kets-observatory/country/profiles

[3] KET Observatory offers KET performance ranking to all EU countries except Cyprus, Luxembourg and Malta.

[4] Interviewed experts suggest to increase public R&D investments to 1% of the national GDP.

- Strengthen the country's international attractiveness by improving the level of foreign-direct investments

Croatia performs relatively well in Micro/Nanoelectronics while lagging behind in the deployment of Advanced Materials within EU-25. Relative to other KETs, Micro/Nanoelectronics-related products are important for Croatia's overall exporting activity. The country is relatively more competitive in the generation of new technologies, rather than in the wider application in the industry.

The major strengths of the country are:

- Open economy and relatively high-level of internationalisation of national companies
- Access to a pool of high-skilled workers
- Good quality infrastructures with substantial investments in the fields of transportation, telecommunications and energy
- Recent adoption of a new comprehensive tax system reform to further incentivise business activity and investments in innovation
- Strong performance in the creation of ICT Start-ups

Areas of improvement include:

- Need for further support to SMEs, in particular to facilitate access to finance
- Relatively low-level of R&D investments in the public and private sectors
- Limited collaboration between industry and academia in R&D
- Rather burdensome administrative system
- Structural weaknesses such as current account imbalance, significant private foreign debt and a trade deficit

Denmark is a strong performer in the deployment of Industrial Biotechnology within EU-25 accounting for the different stages of technology maturity and closeness to market application while lagging behind in Advanced Materials. Relative to other KETs, Industrial Biotechnology-related products are very important for Denmark's overall exporting activity. There is a high level of R&D investment in the public and private sector driving innovation.

The major strengths of the country are:

- Highly attractive and internationally competitive research system
- Strong entrepreneurial culture and high-level of opportunity-driven entrepreneurship
- High-level of R&D investments in the public and private sector
- Dynamic innovation ecosystems through strong collaboration between public and private organisations
- Strong performer in intellectual assets, in particular with a high-level of patent applications
- Access to excellent infrastructure, notably in the ICT

Areas of improvement include:

- Further support for the creation of innovative start-ups
- Facilitate investment and access to finance, in particular by increasing the level of venture capital expenditures
- Strengthen the level of employment in knowledge intensive activities
- Improve the level of exports of knowledge-intensive services and medium & high-technology products

- Further reduce the corporate tax rate

Greece performs relatively well in Advanced Materials while lagging behind in the deployment of other KETs within EU-25. Relative to other KETs, Photonics-related products are important for Greece's overall exporting activity. The country is relatively more competitive in the application of Advanced Materials technology, rather than in technology generation.

The major strengths of the country are:

- Strong entrepreneurial culture
- High-level of firm investments and access to finance
- Access to good research systems, notably in international scientific co-publications
- Substantial pool of population with tertiary education
- Attractive linkages in innovative SMEs collaborating with others
- Good performer in primary education and health

Areas of improvement include:

- Strengthen the level of supply and demand of digital skills
- Further support the digital infrastructure and transformation
- Increase the level of intellectual assets, in particular related to design and trademark applications
- Foster financial market development in terms of efficiency and confidence
- Further reduce tax rates for doing business

Hungary is a strong performer in the deployment of Micro/Nanoelectronics within EU-25, accounting for the different stages of technology maturity and closeness to market application. Relative to other KETs, Advanced Materials-related products are important for Hungary's overall exporting activity. Some of the main strengths are the country's economy based on export recovery and macroeconomic stimulus coupled with high level of firm investments and access to finance.

The major strengths of the country are:

- Dynamic ICT sector displaying a rather high level of employment in comparison to other sectors of the economy
- The country has a strong entrepreneurial culture
- High-level of firm investments and access to finance
- Attractive employment in fast-growing enterprises
- Access to good research systems, notably in international scientific co-publications
- Hungary's economy has expanded strongly, based on export recovery and macroeconomic stimulus

Areas of improvement include:

- Further support digital infrastructure and transformation
- Strengthen the level of supply and demand of digital skills
- Strengthen innovators, in particular SMEs needing more help with marketing, product and process innovations
- Increase workforce education for doing business
- Improve the transport infrastructure
- Reduce tax rates and regulations for doing business

Latvia performs moderately in the deployment of Micro/Nanoelectronics, Nanotechnology and Photonics while lagging behind in other KETs. Relative to other KETs, Micro/Nanoelectronics-related products are

important for Latvia's overall exporting activity. The country is relatively more competitive in the generation of new technology, rather than in its wider application. Latvia has one of the lowest corporate tax rates in Europe and a good entrepreneurship culture. However, exports rely heavily on low value-added, natural resource intensive products reflecting skills shortages and weak innovation.

The major strengths of the country are:

- Offers a corporate tax rate of 15%, one of the lowest within the European Union
- Geographical position puts the country between the two major economic areas of the EU and the CIS
- Good entrepreneurship culture as there is a significant interest in being self-employed compared to working as an employee
- Advanced transports infrastructure with three major ice-free international ports as well as extensive rail, road and pipeline system

Areas of improvement include:

- Exports rely heavily on low value-added, natural resource intensive products reflecting skills shortages and weak innovation.
- Weak credit recovery from insolvent firms holds back access to finance for firms with growth potential.
- Only limited training is provided to develop and upgrade ICT skills of employees.
- Weak digital infrastructure with limited internet bandwidth at the work place.

Slovakia performs relatively well in Advanced Manufacturing Technologies while lagging behind in the deployment of Industrial Biotechnologies within EU-25. Relative to other KETs, Micro/Nanoelectronics-related products are important for Slovakia's overall exporting activity. Slovakia has a high level of public R&D investment and a competitive manufacturing sector. However, there is relatively a weak innovation ecosystem with lack of cooperation between industry and academia.

The major strengths of the country are:

- Access to a pool of well-educated, skilful and relatively low-cost workforce
- High-level of public R&D investments
- Competitive manufacturing sector, in particular in the field of high and medium high-technology products
- Strong culture of entrepreneurship, in particular in the younger generations
- Access to performant ICT infrastructures
- Economy open to international trade and foreign direct investments

Areas of improvement include:

- Need for more efficient and supportive public institutions
- Further efforts to improve the digitisation of manufacturing companies
- Relatively burdensome tax rates and regulations
- Improve the overall competitiveness of the research system
- Increase private spending in R&D
- Relatively weak innovation ecosystems with lack of cooperation between industry and academia

Slovenia performs relatively well in the deployment of Photonics and Nanotechnology within EU-25, accounting for the different stages of technology maturity and closeness to market application. Relative to

other KETs, Advanced Manufacturing Technologies-related products are more important for Slovenia's overall exporting activity. There is a high-level of R&D investments in the private sector and strong collaboration within innovation ecosystems.

The major strengths of the country are:

- Access to a pool of well-educated, skilful and relatively low-cost workforce
- Competitive and attractive research system
- High-level of R&D investments in the private sector
- Strong collaboration within innovation ecosystems
- Strong entrepreneurship culture, in particular in the younger generations
- Access to extremely performant ICT infrastructures

Areas of improvement include:

- Facilitate access to finance, in particular to innovative SMEs
- Need for more efficient political institutions and administration
- Further efforts to improve the digitisation of manufacturing companies
- Relatively burdensome tax rates and regulations
- Further support to R&D from the public sector
- Increasing the efficiency and flexibility of the labour market
- Further collaboration between industry and academia

5.2 Comparison of the countries under analysis

The following tables illustrate how the eight national economies of the study perform regarding each Key Enabling Technology within the EU-25[5] and the contribution of each of these KETs to the total employment in the economy (i.e. the fraction of employment driven by a certain KET)[6]. It is interesting to notice that high performance is not necessarily linked to significant contribution to the employment in these countries. Some countries follow the intuitive norm that high performance in a certain KET links to higher contribution in the employment – such as Greece and Slovakia. This effect does not apply to other economies. For example, Croatia heavily underperforms in Advanced Materials, despite that this KET has the higher contribution in employment. The most striking example is Denmark. The country is a top performer in Industrial Biotechnologies, however, this particular KET contributes only 0.06% to the total employment in the country (Table 2 and Table 3).

Overall, Croatia, Bulgaria and Greece are the lowest performing countries of the set analysed in the study. The highest performer is Denmark. Slovakia and Latvia in are located in the lower middle range, whereas, Slovenia and Hungary in the upper range (Table 2 - Overall KETs Performance ranking*Table 2).

[5] These studies exclude Cyprus, Luxembourg and Malta.

[6] The source of the discussion in this chapter is European Commission's KET observatory. A detailed analysis of the indicators is provided to "KETs Observatory Phase II – Methodology Report", available at: https://ec.europa.eu/growth/tools-databases/kets-tools/kets-observatory/analytics

Table 2 - Overall KETs Performance ranking*

	Bulgaria	Croatia	Denmark	Greece	Hungary	Latvia	Slovakia	Slovenia
Advanced Materials	**22**	**25**	**24**	12	10	**21**	**20**	18
Advanced Manufacturing Technologies	**25**	**20**	7	**21**	19	**22**	10	13
Photonics	**22**	**21**	14	**23**	19	16	17	7
Micro-nano Electronics	**13**	10	15	**23**	9	16	19	**22**
Nanotechnology	**25**	**22**	18	**23**	**20**	16	17	11
Industrial Biotechnologies	15	**23**	1	**21**	14	12	**22**	18

Low performance
Highest performance

A count of 1 marks highest performance, a count of 25 marks lowest performance.

**among 25 EU countries (not including Cyprus, Luxembourg and Malta)*

Table 3 - Contribution of KETs in total employment

	% in total employment							
	Bulgaria	Croatia	Denmark	Greece	Hungary	Latvia	Slovakia	Slovenia
Advanced Materials	0,06	**0,06**	0,02	**0,25**	**0,27**	0,05	0,08	0,16
Advanced Manufacturing Technologies	**0,07**	0,03	**0,21**	0,03	0,06	0,02	**0,17**	**0,18**
Photonics	0,01	0	0,15	0,01	0,01	0,01	0,02	n/a
Micro-nano Electronics	0,05	0,03	0,03	0	0,15	0,02	0,05	0,06
Nanotechnology	0	0,04	0,01	0	0	n/a	n/a	0,05
Industrial Biotechnologies	0,05	0,02	0,06	0,01	0,08	**0,06**	0,08	0,1
Totals	**0,24**	**0,18**	**0,48**	**0,3**	**0,57**	**0,16**	**0,4**	**0,55**

The composite indices (provided / calculated by KET Observatory) rank the countries involved in the analysis on their performance regarding the different dimensions of technology maturity and market applications of KETs in 2015. Low scores in the composite indicators suggest that the respective country is not very competitive. The three composite indicators measure performance in generation of technology, trade/exports and production/wider application of KET-based products (Figure 16).

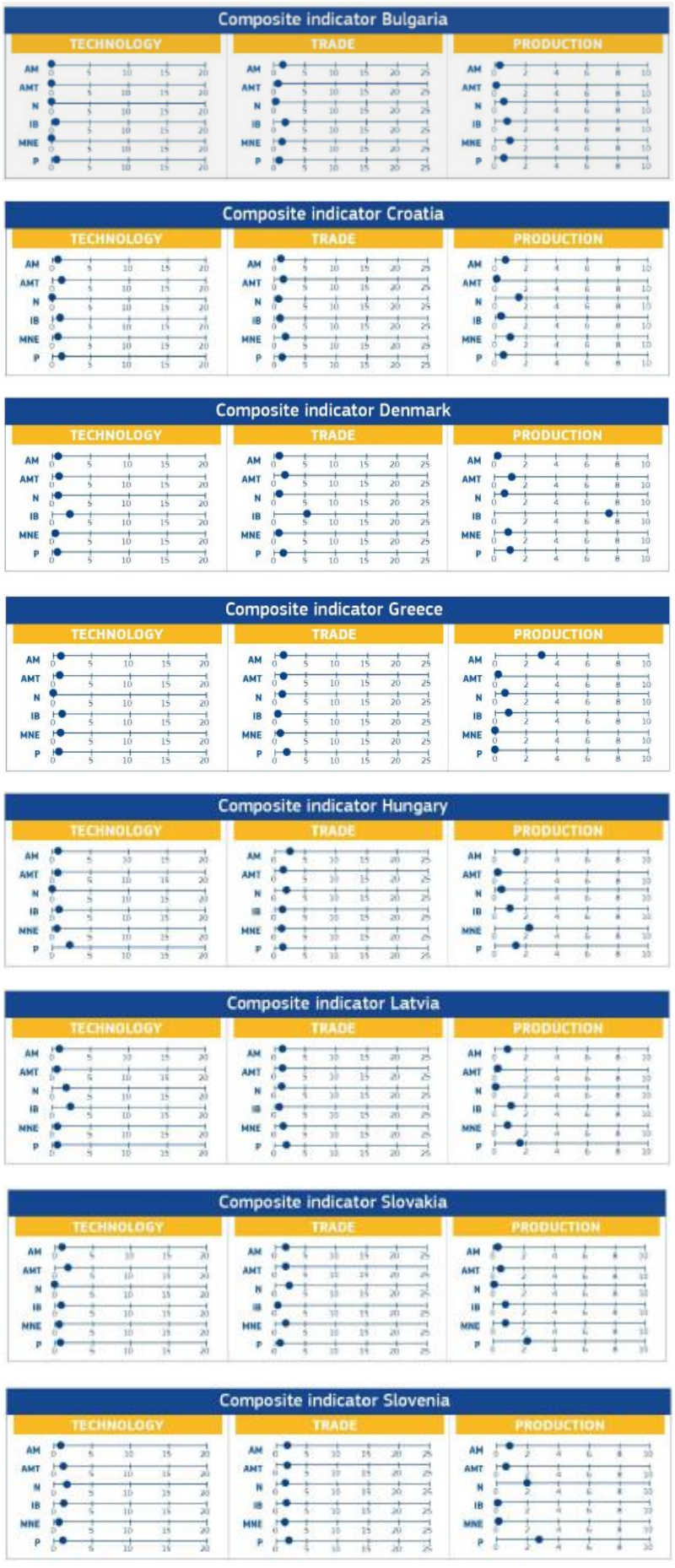


Figure 16 - Composite indicators

The above overall ranking is supported by the comparison of the performance of the countries in more specialized economic indicators[7]. Hungary and Denmark are on the top of the group with respect to country significance of production (i.e. how important is a certain KET in a country's total production) when compared for all six KETs (Figure 17). Denmark and Hungary also top the other countries in terms of KET export share of total EU exports for all KETs (Figure 15). Denmark is undisputedly the best performant among the eight countries in trade balance. It is the only country among the eight countries in the study with a positive trade balance (Figure 19)[8].

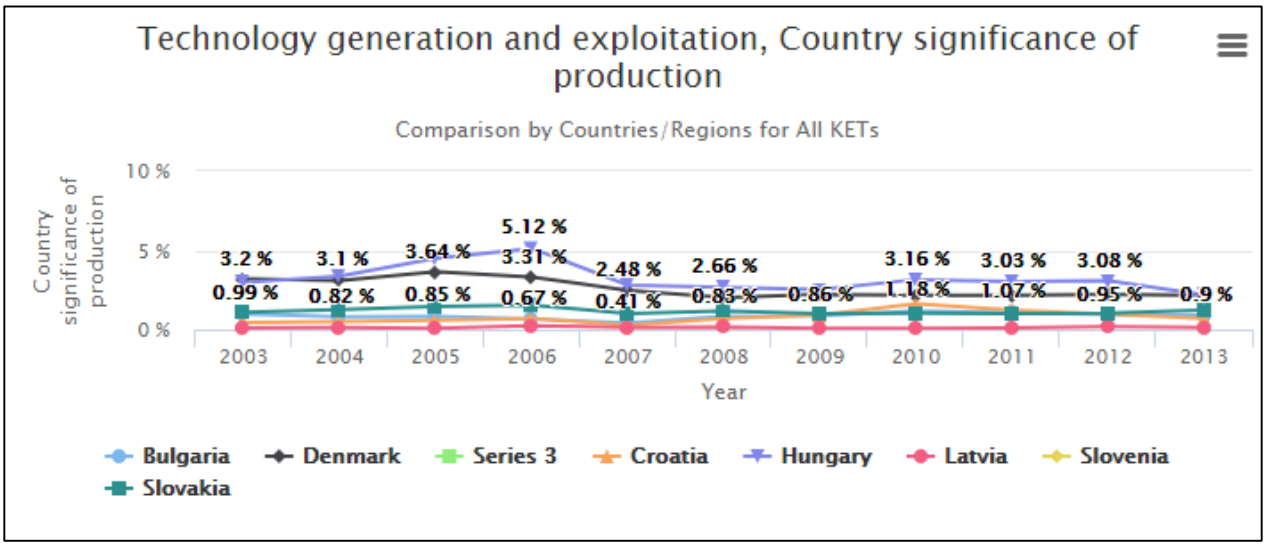


Figure 17 - Technology generation and exploitation, Country significance of production

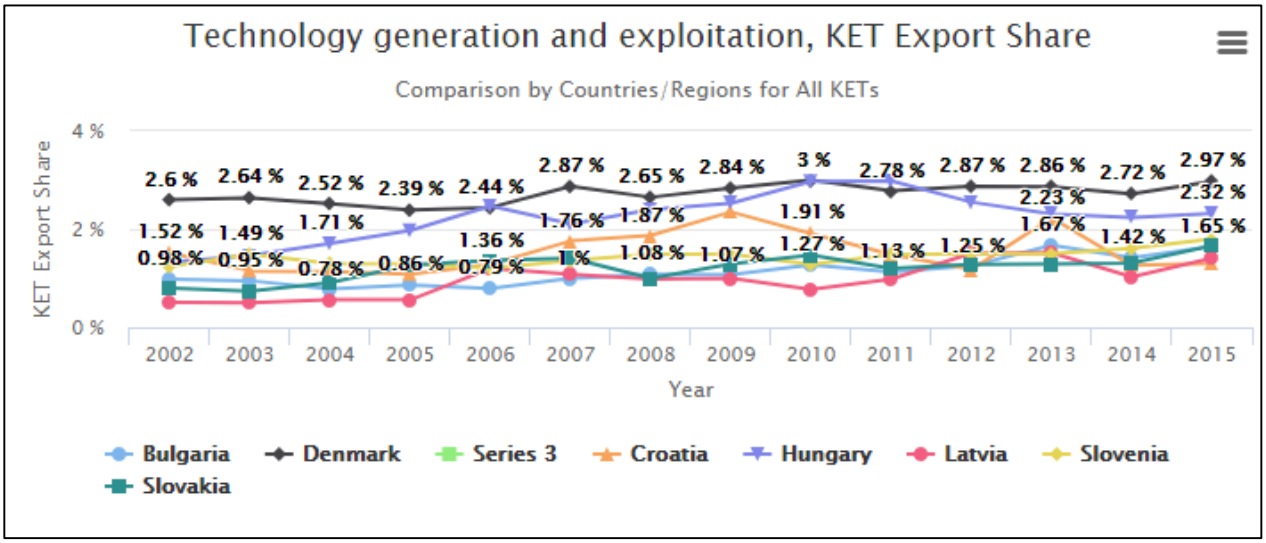


Figure 18 - Technology generation and exploitation, KET export share

[7] Indicators are analyzed for technology generation and exploitation as well as for technology diffusion.

[8] In the following graphs, series 3 correspond to Greece – Greece has no time series in this data set of the KET observatory. Country significance of production is an indicator showing how important is a certain KET in a country's total production. KET export share depicts the share of all KETs national exports against the total EU exports. In some graphs, data for certain countries are not available.

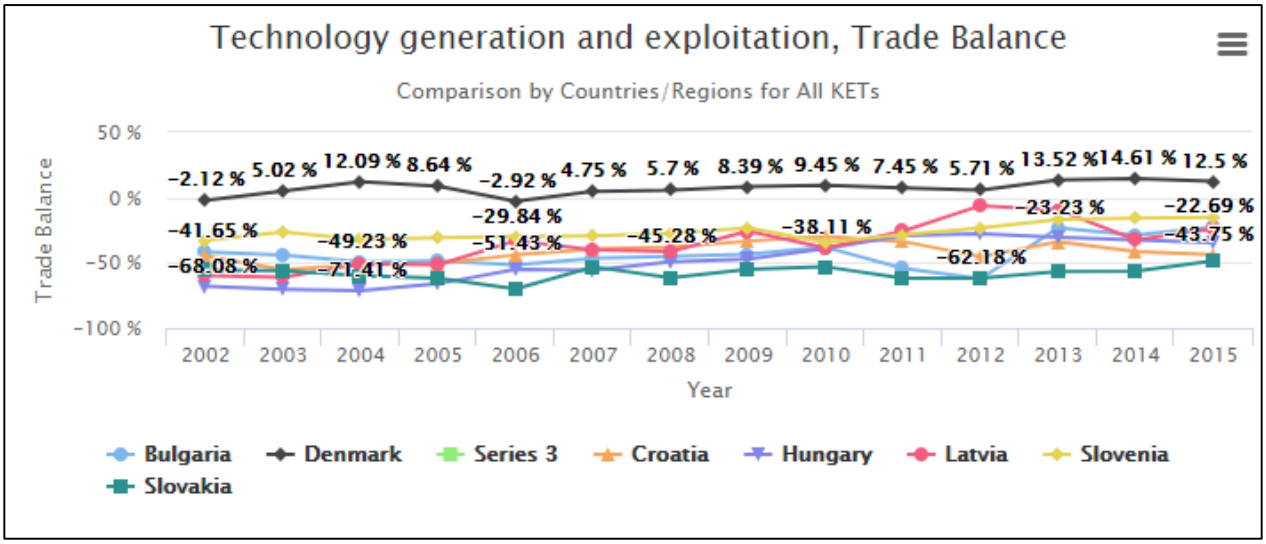


Figure 19 - Technology generation and exploitation, Trade Balance

Regarding the country significance of production in terms of technology diffusion, Slovakia and Hungary tops the set of countries analysed (Figure 20). Based on the previous findings, the data suggest that KETs diffusion has a higher impact on employment in the same countries: Hungary and Slovakia (Figure 21).

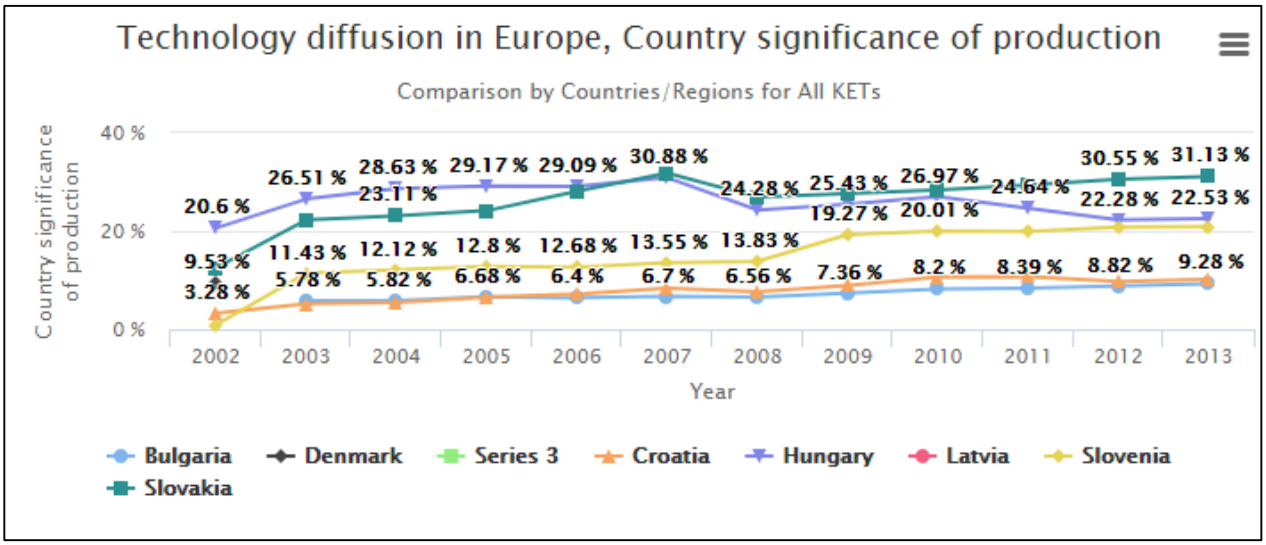


Figure 20 - Technology diffusion - Country significance of production

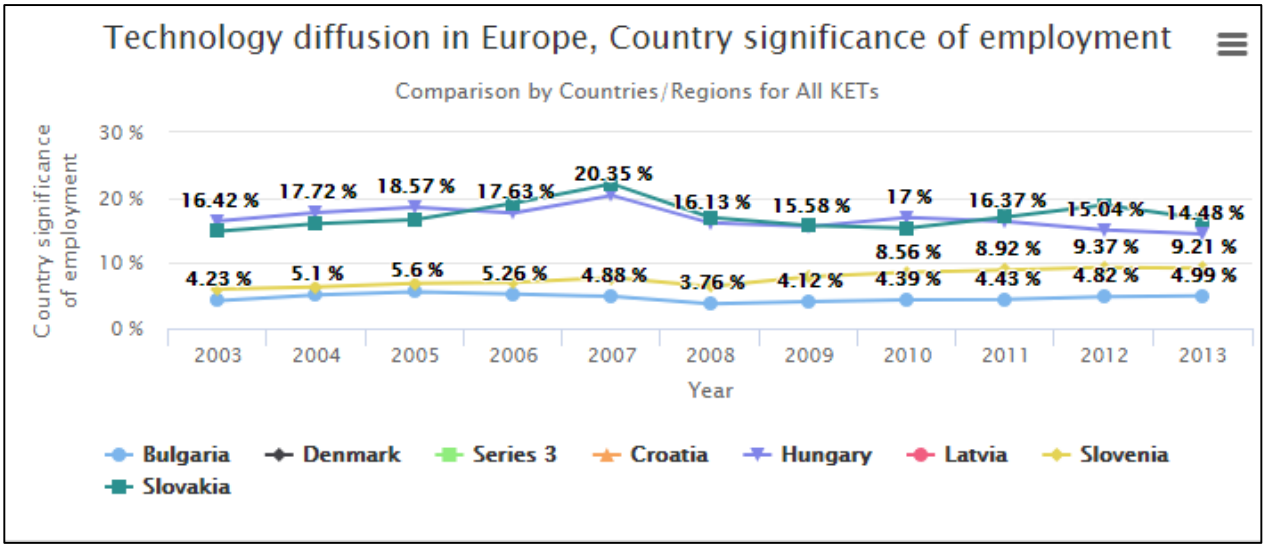


Figure 21 - Technology diffusion - Country significance of employment

Finally, the **activity on patent applications** related to KETs, that offers a proxy on the levels of research commercialization of KETs, puts Denmark in the first place, followed by Slovenia and Greece, then Hungary and finally Bulgaria, Croatia and Latvia. This observation has significance in evaluating the impact for these countries on possible policy initiatives encouraging technology transfer from the lab to the market (Figure 22)[9].

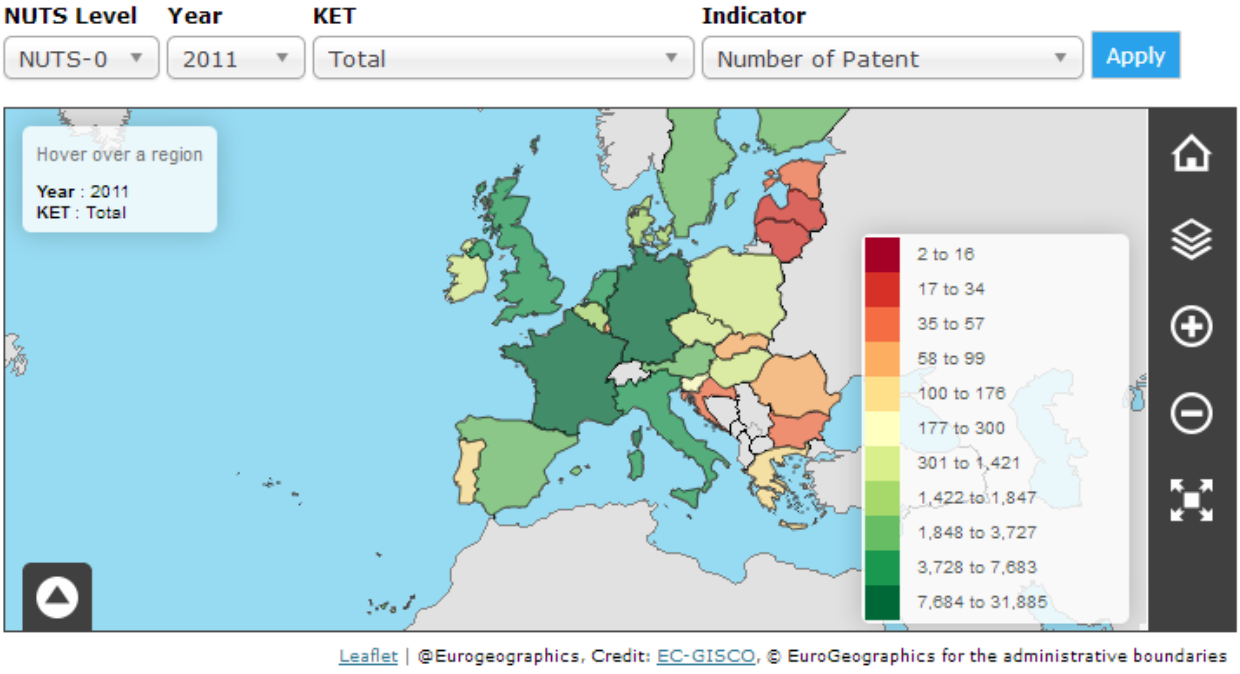


Figure 22 - Regional distribution of patents related to KET

[9] Data retrieved at European Commission's KET Observatory.

5.3 Situation at the national level

Industry development and innovation in relation to KETs

The outlook of the industry in relation to the KETs at the national level is similar across the countries under study. With the exception of Denmark, the countries face challenges in modernizing and expanding their industrial manufacturing base. Despite the fact that KETs are widely acknowledged as a critical element for the successful development of the national economy, policy and industry face its own difficulties in this respect. Across the board, public priorities are drawn towards innovation, start-ups and specific technical/industrial priorities per country. A highly visible element of the public policy is the focus on commercializing public research and on assisting high tech companies. However, public programmes and private investors do not express a distinct focus on KETs or clean production. Major barriers for using KETs and promoting innovation are a) the lack of financial resources (especially the lack of early stage financing) and b) the inadequate or missing link between research and industry. Each country faces its unique set of circumstances.

Bulgaria as a part of EU has serious economic challenges including low level of productivity and high-tech manufacturing, and demographic crisis. Bulgarian export mainly consists of low technology products. The majority of companies and employees (85%) perform low-technological activities. In this respect, the integration level of KETs in Bulgarian SMEs is extremely low, despite the fact that almost one third of the SMEs are considered innovative. The internationalization of Bulgarian SMEs is extremely low. The contribution of foreign investments for new technology transfer is limited. The energy effectiveness in production is at a very low level too. Major industrial/manufacturing sectors are:

- Processing industry
- Machines and equipment
- Medical compounds
- ICT

The Croatian economy is dominated by traditional and low technologies sectors. It also mostly focuses on services. This situation outlines the main reason why production, adoption and overall diffusion of KET is low in the country. The manufacturing industry is, along with the financial sector, real estate business, renting and business services, industry sector with the most favourable share in gross domestic product (GDP) structure and total employment of the Republic of Croatia, and the absolute largest share in total exports.

The most promising manufacturing sector in the country is wood production. The sector exhibits great growth and export potential, but lags behind in terms of technological capabilities and usage of innovative and value-added solutions in production and therefore requires further support including better cooperation with the public R&D sector. Major industrial/manufacturing sectors are:

- Food and beverage
- Marine and fresh water fisheries
- Production of pharmaceuticals
- Production of medical equipment and devices
- Fabricated metal products
- Manufacture of electrical equipment
- Manufacture of machinery and equipment
- Mining and quarrying
- Industrial production of electricity supply, gas, steam
- Transportation products
- Automotive industry
- International manufacturing chains
- Shipbuilding sector
- Wood production

In **Denmark**, the majority of companies are small or medium-sized ones, so all programs have a strong focus on this type of companies, thus providing opportunities for SMEs to get technological input from several sources. A not insignificant part of the industry is supplying the B2B market with niche products or equipment, often with few direct domestic competitors. This supports a rather developed networking culture among stakeholders, that helps them share knowledge and experiences regarding technologies, and support a number of competitive SMEs operating on the world market niches. Major industrial/ manufacturing sectors are:

- Machinery including computers
- Pharmaceuticals
- Electrical machinery, equipment
- Mineral fuels including oil
- Optical, technical, medical apparatus
- Meat
- Fish
- Furniture, lighting, signs, prefab buildings
- Vehicles
- Dairy, eggs, honey

During the last 20 years, **Greece** has undergone significant decrease in the manufacturing industry. In 2014, manufacturing sector accounted for 8% of the country's gross added-value. This decrease is also connected to the lack of modernization of industrial policy, especially when it comes to integrating innovation across value chains. Innovation in Greece is currently driven mainly by subsidies and grants provided either from EU or national budget for financing R&D activities. Greece scores last among EU-28 in private investments on R&D. Nevertheless, in order to develop innovation, Greek industry often collaborate with industrial or academic partners. Specifically, 34.1% of Greek companies implement in-house R&D activities, 33.8% seek external expertise from other industries or organisations, while 16.2% appoint R&D activities to third parties. Product and process innovation is a collaborative result for 38.2% of Greek companies, while suppliers (equipment, materials, software), clients (private sector), consultants and private laboratories are their main partners. Major industrial/manufacturing sectors are:

- Food and beverages
- Textile and clothing industry
- Pulp and paper industry
- Base metals
- Chemicals
- Leather processing industry
- Computer, electronic and optical products
- Pharmaceuticals
- Mechanical equipment

In **Hungary**, the structure of industrial production has been gradually transformed over the last 10 years. In the sectoral composition of industrial production, the proportion of the manufacturing industry, including the engineering industry has been increasing. The integration level of high-tech (primarily KET) in the SMEs' operations is low. The SME sector is underfunded, and the innovation and growth ambitions and abilities are weak compared to other countries. Finally, the innovation ecosystem exhibits a low level of seed capital investment and undeveloped technology incubation processes. Major industrial/manufacturing sectors are:

- Pharmaceutical industry
- Chemical industry
- Vehicle manufacturing
- Rubber/plastic
- Metal processing
- Health care
- Machine industry
- Electrical equipment
- ICT

The economic environment is generally supportive in **Latvia**. The Latvian government has adopted modern laws establishing copyrights, patents, and trademarks and the means of enforcing their protection. The government has adopted a number of favourable rules on the taxation of interest, and dividends, thus

fostering the holding company regime in Latvia. Latvia's economy is based on service industries, including transportation, information technology, and financial services. At the same time, the construction industry plays an important role, as well. Latvia is one of Europe's entrepreneurial hotspots, ranking third after Estonia and Sweden. In terms of total early entrepreneurial activity in Europe, it is the first, according to the World Economic Forum. SMEs and innovative entrepreneurship play a key role when it comes to innovation. They are engaged in the development and commercialization innovations. They are also adopters of innovations developed by other organizations, and they provide ideas and input to the generation of ideas that are exploited by large firms, universities/research organisations and other small firms. The Latvian start-up ecosystem is developing steadily. A unique Start-up Law has passed and a Start-up Visa is in the making in order to make the Latvian start-up ecosystem more vibrant and productive. Major industrial/ manufacturing sectors are:

- Woodworking
- Metalworking
- Mechanical engineering
- Information technology
- Green technology
- Transport and storage
- Life sciences
- Food processing

Slovakia exhibits an insufficient offer of Key Enabling Technologies for Clean Production. The legal framework and funding schemes are not as developed as in other leading countries. On the other hand, the government is trying to cover and put more focus on sectors, which are fundamental for the national economy (e.g. automotive industry, modern technologies etc.). Some key enabling technologies are specially present in the automotive industry. Major industrial/manufacturing sectors are:

- Industry
- Trade
- Business services
- Transport and information
- Construction
- Agriculture
- Accommodation and boarding

In Slovenia, the majority of manufacturing firms are not yet using key enabling technologies. Strengthening capacities of small and medium-sized companies regarding skills, local ecosystems and access to finance are perceived as key drivers for the integration of high-tech (primarily KET) in the SMEs' operations. Major industrial/manufacturing sectors are:

- Food and beverage
- Wood products
- Paper and paper products
- Chemicals
- Pharmaceuticals
- Rubber and plastic
- Basic and fabricated metal products
- Computer, electronic and optical products
- Electrical equipment
- Machinery
- Automotive industry

Collaboration between industry and academia

Collaboration between KET TC and SMEs that is the focus of the KET4CleanProduction project is a special case of the greater context of industry-academia collaboration. Analysis of the industry-academia collaboration status will provide a better understanding on the difficulties in realizing KET TC and SME cooperation. The collaboration between academia and industry can be considered rather limited as it is not expressed naturally within the economic development process. It requires funding opportunities from the public sector that take different forms. It is mainly driven by different subsidies and grants either provided

by the EU or the national budget for financing R&D consortia and partnerships. In each of the eight countries under study, there are specific state-supported calls for funding.

For example, in **Hungary** academia-industry partnerships are financed by the Cooperation for Competitiveness and Excellence call in the Economic Development and Innovation Operative Programme, whereas in **Greece**, there are specific calls for industry-research collaboration within the Research-Create-Innovate call of the General Secretariat for Research and Technology.

In **Slovakia** the industry-research collaboration is institutionalized in technology/science parks and centres of excellence. In parallel, a primary facilitator in the country is the Slovak Academy of Science. **Bulgaria** faces additional great challenges regarding the overall financing of the research activity. The national funding for research is extremely low and the salaries of researchers are among the lowest in the country. Additionally, the scientific equipment is extremely old and that makes it difficult to support research breakthroughs. In this context, Bulgarian companies are reluctant to collaborate with the Bulgarian research community, and prefer to innovate internally. In **Greece**, research is greatly oriented towards the interests of the research groups and the available national and EU funding opportunities, and is not designed to be able to address the needs of the Greek industry.

Denmark constitutes an exception to the situation. The country is characterised by dynamic innovation ecosystems through strong collaboration between public and private organisations, and is a strong performer in intellectual assets, in particular with a high-level of patent applications. Collaboration is key to many industries and is based on a high level of trust.

Public policies towards clean production and circular economy

Public policy in the countries under study is guided by central government commitments stemming from the endorsement of the United Nations 2030 Agenda for Sustainable Development and the mandates of the Paris agreement established within the United Nations Framework Convention on Climate Change. To a varying extent, public policy makes efforts to draft strategies and plans on waste management, waste prevention, innovation support and promotion, environmental protection, smart specialization, and re-use of materials. Some countries have policies in place that are more explicit than others.

In **Croatia**, the national and local government focus on eco-innovation development and on facilitating the transition to a circular economy within the context of decisive European Union directives on waste management. The public policy in **Denmark** focuses on biotech, energy, and climate and environmental sciences. In **Bulgaria**, the establishment of two centres of competences and one centre of excellence in 2018 expresses the policy priorities towards clean production and circular economy:

- Centre of Competence “Clean Technologies for sustainable environment - water, waste, energy and circular economy”
- Centre of Competence “Smart mechatronic, eco and energy saving systems and technologies
- And the new centre of excellence: National Centre of Mechatronics and Clean Technologies

In **Slovakia**, circular economy along with climate change mitigation via sustainable energy was identified as a key point in the policy priority of a “Modern single market” of the Slovak presidency. In this context, a stimulus for development of innovative solutions and partnerships was a flagship initiative as the Transition

to the Green Economy (T2gE)[10] of the Ministry of Environment and the "Bratislava Green Economy Process", both launched in 2016. These initiatives have formed a space and a basis for creation of the "Information and Learning Platform to Support the Transition to a Green Economy"[11]. This platform aims to collect and share information relevant to promoting the transition to green economy for public and business community, presenting and disseminating principles and examples of practical solutions and best practices, and discussing open questions. Improved waste management and recycling is the main challenge in the context of transiting to the circular economy in Slovakia.

Public funding available for KETs

Public funding for KETs follows the priorities of the respective national policies. As such, the Smart Specialization Strategies that are the main funding instrument of the states (except from horizontal, central financing instruments for innovation and research commercialization) do not directly focus on KETs with the exception of ICT[12]. However, they lay the funding priorities on sectors that could indirectly finance the development of KETs.

Croatia recognizes KETs as horizontal themes included in five thematic priority areas: health and quality of life, energy and sustainable environment, traffic and mobility, safety, food, and biochemistry. In the Smart Specialization Strategy for **Denmark**, priority is placed upon manufacturing, energy production and distribution, sustainable innovation, human health and social work, and agriculture, forestry and fishing.

In **Slovenia**, most of the existing incentives, funding, financial instruments and mechanisms are not tailored for financing neither Clean Production, Circular Economy nor incentivizing SMEs to use KET Technology services across borders for implementing clean production processes. The Slovenian RIS 3 strategy aims at areas where Slovenia has a critical mass of knowledge, capacities and competences, and where there is innovation potential for improving global economic ranking for the country. The Slovenian strategy focuses on developing middle- and high-tech solutions in niche fields and on transforming the Slovenian economy from a follower to a co-creator of global trends.

In **Hungary**, the priority of public policy is on promoting industrial production, the manufacturing industry and on intensifying corporate R&D. Smart production focuses on product development by manufacturing new or improving existing products through technological renewal in the innovation value chain. The main direction of the sectoral renewal according to smart production is the modernisation of an existing industry with the assistance of "Key Enabling Technologies". The Economic Development and Innovation Operational Programme (GINOP)[13] is the most relevant programme to SMEs: Its most important priorities are the competitiveness of small-and medium sized enterprises, research and innovation, and employment.

In **Bulgaria**, the clean production is one of the main thematic fields of the innovation strategy for smart specialization. The main national programs for SMEs' funding are a) Operational Programme "Innovations and Competitiveness" (Ministry of Economy), and b) Operational Programme "Science and Education for

[10] http://www.t2ge.eu

[11] http://zelene-hospodarstvo.enviroportal.sk/en

[12] **Denmark** is an exception as there are two schemes specific to clean production: MUDP and EUDP. (U and P stands for development and demonstration project)

[13] https://www.kexport.eu/en/what-we-do/ginop-project

Smart Growth" (Ministry of Education and Science). The National Innovation Fund (Bulgarian SMEs Promotion Agency) and Bulgarian Science Fund (Ministry of Education and Science) are also an opportunity for funding clean production projects.

In **Greece**, there is no direct funding for KETs available. The general aim of public funding is to improve competitiveness and internationalization of enterprises. The New Development Law is the institutional framework for establishing Private Investment Aid schemes for the country's regional and economic development. It constitutes the main public funding tool for the establishment, scale-up and diversification of production, as well as the fundamental transformation of the production process. The two more closely related financing priorities to KETs are: a) Protection of the environment – Transition to a more environmentally friendly economy, and b) Development – modernisation – completion of infrastructures for economic and social growth.

In **Slovakia**, there is no specialization in funding for the use of KETs. However, there are several funding schemes available for SMEs related to the circular economy area. These are administered by a) European Bank for Reconstruction and Development (EBRD), b) European Investment Bank (IEB), c) Government Office of the Slovak Republic, and d) International Visegrad Fund.

In **Latvia**, the policy makers developed financing instruments focused on manufacturing – however KETs are not in the core of priorities. The most relevant programmes are: a) *Innovation Voucher Support Services* that promote innovation activity in enterprises by technology transfer and support of highly skilled workers, and b) *Start-ups support programme* that promote the creation of new knowledge-driven companies as well as the use of innovative ideas, products or processes in economic activities. Funding topics of particular interest in the country are a) experimental development, b) strengthening industrial property rights, c) support for the commercialization of research results, and d) inviting experts to prepare license agreements and other intellectual property transfer agreements.

6 Conclusions and Recommendations

The aim of this study is to understand the needs of SMEs for making greater use of KETs and the framework that enables or hinders the use of KET in the select eight countries. This will be useful for the successful implementation and long-term sustainability of the KET4CleanProduction platform (ket4sme.eu). This information would be used by the KET4CleanProduction consortium to improve the offerings, service and impact of the platform, and to attract applications for funding from promising and high impact projects.

The preparation of the study involved a) an online survey to outline the major needs and challenges of manufacturing SMEs across Europe and b) a desk and field research to understand the situation of KETs in eight selected countries with a relatively low level of KET availability and use. This section summarizes the major conclusions of the study and offers a series of recommendations.

Small and Medium-Sized Enterprises

The need for cleaner production is highly visible in the manufacturing SMEs across Europe. Nearly 70% of the respondents of the survey confirm that clean, sustainable and green production is important. In addition, optimization of production facilities is also considered critical by almost 80% of the SMEs surveyed.

There is a clear need for external support to implement changes and improvements. More than half of the respondents of the survey would opt for external support to implement process and operational improvements.

Little is known by the SMEs about the impact of KETs and relevant financing opportunities. Very few companies (less than 25%) are actually aware of how KETs can enhance, improve or optimize their production process and value chain. In addition, 60% of the companies that have not collaborated with KET TC yet do not know what services are offered by KET technology centres. In addition, SMEs seem to lack information about the availability of alternative financing, as SMEs prefer loans and equity over grants and other forms of cascade funding.

There is a growing interest among KET-aware SMEs for KET TC services. Despite the limited knowledge about the impact of KETs on production, 62% of the companies that have not launched any KET initiatives plan yet. In fact, 64% of the companies would be willing to travel outside their country and region to collaborate with a KET TC, with 12.5% declaring that they would even travel outside of Europe.

Business issues have a negative effect on collaboration plans of SMEs with KET TCs. SMEs are driven by personal contacts and trust is very important for companies to collaborate with KET TCs. In addition, SMEs experience great difficulty in securing the necessary finance. Also, SMEs consider the services offered by KET TCs to be expensive. Other reasons for not yet engaging in a collaboration with KET TCs are: a) complicated processes, b) low level of responsiveness, and c) misalignment between technology solutions and corporate business models.

National economies

The transformational character of KETs for the national economy is inhibited by the lack of financial resources. Public (as well as private) national funding for KETs in the 8 countries under study is not available – especially early stage financing. The development and application of KETs are financed indirectly by laying focus on horizontal activities and sectoral objectives. As such, national specialized projects and initiatives are missing.

KET's diffusion and economic impact is limited by the low level of university-industry collaboration. The links between industry and research are inadequate or sometimes missing. The collaboration between academia and industry is not expressed naturally within the economic development process and requires public financial incentives. Funding opportunities that promote the collaboration between academia and industry. Are mainly driven by subsidies and grants provided via EU or national budgets for financing R&D consortia and partnerships.

Policy aims at advancing KETs growth but focuses on sectors and not on technologies. Across the board, public priorities are drawn towards innovation, start-ups and specific technical/industrial priorities per country. A highly visible element of public policy is the focus on commercializing public research and on assisting high tech companies. However, public programmes and private investors do not express a distinct focus on KETs or clean production.

Industry structure often inhibits the development of high-tech industries and KETs. Most of the countries face challenges in modernizing and expanding their industrial manufacturing base, including digitizing manufacturing infrastructure. In addition, low-tech industries are significant in many countries, and policy focuses on these industries as they have a significant and more direct impact on economy. In these cases, the perceived impact of KETs on the economy is low.

Recommendations

We offer three recommendations that can improve the access of SMEs to KET service providers and the usage of KETs in production. These recommendations are addressed to policy makers and those who implement such policies at the local, national or European level:

Facilitate access to finance, in particular for innovative SMEs. Financing is an enabling factor for greater collaboration within innovation ecosystems. Increased public R&D investment and greater collaboration within innovation ecosystems could foster the wider commercialisation of KETs-related products. European cascade funding instruments such as KET4CleanProduction that are specifically tailored to drive the deployment of KETs across EU-28 should be further promoted to meet the increasing demand; especially in countries with a low diffusion of KETs. In this respect, the micro grants offered by KET4CleanProduction hold the potential to greatly facilitate innovation growth and KET development.

Increase the awareness of the potential of KETs to business growth. Although there is a fair motivation among SMEs regarding the integration of KETs in their manufacturing process, the benefits of their use are still unclear. Also, SMEs lack efficient sources of state-of-the-art information and regular updates. They currently largely rely on the internet and not on specialized sources.

Enhance transnational collaboration between research and business. The lack of specialized skills and the difficulties to attract financing can be mitigated when collaboration happens at the European or international level. Skills, expertise and financing can be transferred to manufacturing companies interested in collaborating with European KET TCs. In addition, transnational collaboration can strengthen weak innovation ecosystems and enhance cooperation between industry and academia with multiplier effects for the local economies. In this respect, KET4CleanProduction's objective to increase transnational collaboration has a strong potential in order to improve the economic outlook of the SMEs that participate on the platform (ket4sme.eu), and positive results to the local innovation ecosystems.

7 ANNEX 1 Questionnaire

All the data provided will be used by the project KET4CleanProduction. The participants may be re-contacted by KET4CleanProduction consortium for further information.

Registration

Contact person	
Telephone or email	
Country (drop down)	

7.1 Part 1. General Information

1. Is your company an SME? If you are not certain that you fulfil the conditions set by the EC, please consult the SME Self-Assessment Questionnaire.

    - Yes
    - No

2. What is your company size?

    - Micro <5
    - Small <50
    - Medium <250

3. Which sector are you active in?
   Check all that apply

    - Aeronautics & space
    - Agriculture
    - Automotive / transportation
    - Green Chemistry
    - Chemicals and plastics
    - Construction & building sector
    - Consumer goods/products
    - Energy
    - Environment
    - Food and Beverages
    - Forestry and forest-based industry
    - ICT industry, hardware (including electronics, computer and communication related products)
    - ICT industry, software and services (system installation, training, etc.)
    - Industrial Biotechnology
    - Measurements/standards

- Medical & Healthcare
- Maritime & Marine
- Production technology (machinery / equipment / automation)
- Service
- Textile and Textile Products
- Tourism
- Consulting, training, education, social services
- Other……

4. Does your company conduct in-house research for new product development?

   - Yes
   - No

   If yes, please indicate the number of employees involved in R&D activities.
   ……

7.2 Part 2. Innovation and Key Enabling Technologies (KET)

5. In terms of innovation development and business growth, what are the factors that you find most challenging?
   Check all that apply

   - Access to finance
   - Efficiency pressures (time)
   - Lack of production capacity
   - Low technological awareness
   - Lack of knowledge and/or innovation skills
   - Information overload
   - Other, please specify……

6. How important is clean, sustainable or green production for your company?

   - Not at all important
   - Slightly important
   - Moderately important
   - Important
   - Very Important

7. How important is optimizing production facilities for your company?

   - Not at all important
   - Slightly important
   - Moderately important

- Important
- Very Important

8. Do you use external support to implement business and process improvement within your company?

   - Yes
   - No

   If yes, how do you finance this support?

   - Micro Grant
   - Loan
   - Voucher
   - Equity
   - Other……

9. Which Key Enabling Technologies are more relevant for your business?
   Choose all that apply

   Nanotechnology
   - Nano medicine
   - Nano membranes
   - Nanostructured coatings
   - Nanoparticles Nanowires and tubes
   - Nano emulsions and pigments
   - 2D materials

   Advanced Materials
   - Electronic and optical functional materials
   - Environmental materials (e.g. recycling, recourse efficiency, less impact, CO2 capture/ utilisation)
   - Industrial materials (incl. catalysts, membranes, adhesives, filters)
   - High performance materials (strong, light, weight, resistant)
   - Materials for energy storage and generation
   - Smart and multifunctional materials (incl. phase change, shape memory, self-healing, self-manufacturing)
   - Surface engineering and coatings

   Advanced Manufacturing Technologies
   - Smart Manufacturing / Industry 4.0
   - Robotics/Human machine interaction
   - Process industry (processing novel materials, structures, etc.)
   - Monitoring and control
   - High performance computing / cloud based simulation services
   - Additive manufacturing
   - High-performance production (flexibility, productivity, precision and zero defect)
   - High -performance, high precision processing

- Intelligent/ sensor-based equipment

Industrial Biotechnology

- Vitamins
- Polymers, bioplastics
- High value food & feed additives
- Enzymes
- Amino acids
- Antibiotics
- Bio based chemicals
- Biofuels

Micro- and Nanoelectronics

- Quantum technology
- Optoelectronics (Optical networks, optical sensors)
- Outsides system connectivity (communication, data transfer, Wi-Fi)
- Power electronics
- Printed/flexible electronics
- Memory and storage
- Equipment technology
- Analogue and mixed signal devices (micro-wave, RF, THz)
- Computing (low power computing, high performance computing, new computing)
- Heterogeneous components & more than Moore (MEMS, NEMS, sensors, transducers)
- Heterogeneous integration embedded systems

Photonics

- Displays (LCD, plasma)
- Photodetectors (solar cells, photo diodes, photo transistors)
- Optical fibres
- Laser based applications
- Intelligent/ sensor-based equipment
- Lighting (LED, OLED)
- Optical communication and networks
- Optical components & systems

10. Do you know how KETs can enhance, improve and optimize your production/value chain?

    - Not really
    - Moderately
    - Yes

11. Has your company launched specific initiatives within the KET area?

    - Yes

- No

If yes, please provide a short description of the initiative
……

12. Does your company plan to initiate any KET initiatives in the next period?

- Yes
- No

If yes, would your company need external support to launch a KET initiative?

- Yes
- No

13. What channels do you use to inform yourself on the latest technological developments of KET applications?

- KET technology centres
- Newsletters
- Internet
- Conferences/Info days
- Practices from your competitors
- Practices from other industry sectors
- Other, please specify……

7.3 Part 3. Collaboration with KET Technology Centres (TCs)

KETs Technology Centres help SMEs cross the 'Valley of Death' and go from lab to market to develop and produce new KETs-based products. They help companies reduce the time-to-market for new ideas. KETs Technology Centres are public or private organisations carrying out applied research and close-to-market innovation (Technology Readiness Levels TRL 3 to 8, not necessarily the whole range) in Key Enabling Technologies (KETs). Please find a map of the KET TCs here.

14. Have you ever collaborated with a KET TC?

Yes
No

If you answer **Yes** in Question 19, please skip Part 2.a and go directly to part 2.b

7.3.1 Part 3.a Questions for SMEs without experience in collaboration with KET TCs

15. What are the reasons for not having collaborated with a KET TC, so far?
Check all that apply

- We like doing everything internally

- There is no need for collaboration
- We don't really know what services are offered by a KET TC
- There are no KET TCs in my region
- The services are too expensive
- The collaboration contract is too complex
- Unresolved IP-related issues
- The services that we need are not available in KET TC service portfolios
- Low level of trust
- There are no communication channels between the KET TC and my company
- The most suitable KETC TC does not have a good reputation
- Other……

16. Do you have a technology problem that you would expect to address with the help of KET TC services?

    - Yes
    - No

    If yes, please indicate below the area or areas where you would need support from a KET TC:

    - Technology awareness and networking
    - Access to specialist facilities and expertise
    - Trouble shooting, testing and analysis
    - Product/process validation, qualification and/or certification
    - Concept development, design and prototyping
    - Product/process development and scale up
    - Skills and training (mentoring and coaching)
    - Business and operational innovation
    - Collaborative research and development
    - Custom Manufacturing
    - Other……

17. How important is the geographical proximity with a KET TC partner?

    - Not at all important
    - Somewhat important
    - Important
    - Very important

18. How far (geographically) would your organisation be willing to travel to access a KET TC?

    - Only within my region
    - Only within my country
    - Across my country and neighbouring countries
    - Across Europe

- Globally

19. Would you consider language to be a barrier for future collaboration with a KET TC in another country?

    Yes
    No

20. How would your company finance a possible collaboration with a KET TC?

    - Micro Grant
    - Loan
    - Voucher
    - Equity
    - Own cash
    - Other, please specify ……

21. Would you need our support to find the right / most suitable KET TC for you?

    - Yes
    - No

7.3.2 Part 3.b Questions for SMEs with experience in collaboration with KET TCs

22. How many times have you collaborated with a KET TC in the last 5 years?

    - 1 to 3 times
    - 4 to 6 times
    - 7-9 times
    - More than 10 times

23. Did any of these collaborations involved a KET TC from another country?

    - Yes
    - No

    If yes, please indicate the number of collaborations and the different countries involved.
    ……

24. How did you initiate/establish contact with the KET TC?
    Check all that apply

    - Personal contact
    - Online advertisement
    - KET TC web site

- EU-funded project
- Other……

25. What type of services did you receive from the KET TC?
Check all that apply

- Technology awareness and networking
- Access to specialist facilities and expertise
- Trouble shooting, testing and analysis
- Product/process validation, qualification and/or certification
- Concept development, design and prototyping
- Product/process development and scale up
- Skills and training (mentoring and coaching)
- Business and operational innovation
- Collaborative research and development
- Custom Manufacturing
- Other services……

26. Why did you choose to collaborate with a KET TC?
Check all that apply

- To increase awareness of technology area
- To access or gain skills
- For access to facilities
- For access to expertise
- To solve a current problem
- To validate products or processes
- To collaborate with on a wider project
- Other……

27. What were the gains from your collaboration with the KET TC?
Check all that apply

- New product/service/process development
- First/Second source for production
- Shorter Time-to-market
- Improvement of our technological skills
- Enhancement of the company's network
- Access to knowledge/expertise about latest technology trends, scientific achievements, inventions
- Strengthening our competences and competitiveness in new areas of expertise that would take long period to achieve without KET TC collaboration
- Access to pool of potential top experts and new employees (e.g. young researchers/PhDs)
- Access to R&D infrastructure (equipment, space, expert service)
- Other……

28. What challenges did you encounter when collaborating with the KET TC?

Check all that apply

- Services too expensive
- Process too complicated
- Difficulty to establish points of contact
- Low responsiveness level
- No alignment between the technology and the business model of the company
- Lack of understanding of the company's business needs by KET TC
- Outcomes were not satisfactory
- Language barrier (if you collaborated with a TC abroad)
- Lack expertise for the company's specific needs
- Intellectual property issues
- No challenges
- Other…….

29. What are the most important criteria for choosing a KET TC?
Check all that apply

- Previous positive collaboration
- Well established KET TC
- Geographical Proximity
- Quick identification of its services
- R&D-Partner with technologically and economically neutral perspective
- Level of experience in industrial collaboration
- Relevance of KET TC services
- Relevance in sector/market
- It was recommended by a business partner
- Other……..

30. When collaborating with a KET TC, how important is geographical proximity for you?

- Not at all important
- Somewhat important
- Important
- Very important

31. How far (in terms of distance) would your organisation be willing to travel to access a KET TC?

- Only within my region
- Only within my country
- Across my country and neighbouring countries
- Across Europe
- Globally

32. Do you consider language to be a barrier for international collaboration with a KET TC?

- Yes
- No

Stay in touch!

Would you be interested in receiving updates from the KET4CleanProduction project and more information about its services and opportunities for your business?

- Yes
- No