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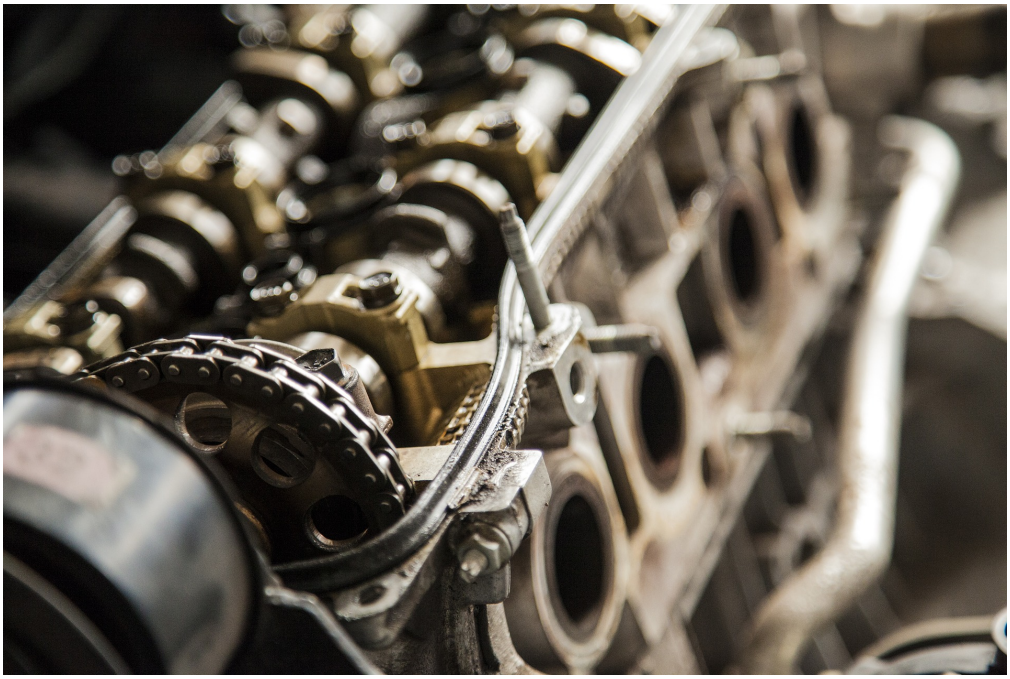
Industrial technologies



EUROPEAN FUNDING LANDSCAPE

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1. EXECUTIVE SUMMARY

With more than 32,000 employees, the manufacturing sector in Luxembourg represents 8.3% of total national employment and 4.6% of the national added value. The implementation of new, innovative and improved production technologies to boost productivity and competitiveness at the international level is a central consideration of the manufacturing sector.

Industry is central to Europe's economy. It contributes to Europeans' prosperity through business in global and local value chains, and provides jobs to 36 million people - one out of five jobs in Europe. Recent years have seen a reversal in the decline of EU manufacturing, with impressive growth rates with regards to:

- industry's share in total value added (plus 6 % since 2009);
- employment: with over 1.5 million net new jobs in industry since 2013;
- labour productivity: 2.7 % per year growth on average since 2009, higher than both the US and Korea (0.7 % and 2.3 % respectively).

However, Europe and its industries are still facing several challenges. The first critical issue is how already-developed and emerging technologies are deployed: the full shift towards Industry 4.0 can take many years, due to the necessity of helping the growth of new companies entering the market, and to support the increase of productivity in the already existing companies that face difficulties in implementing innovative technologies. A second issue relates to increasing global competition. Global players, such as China, are progressively turning their attention to increasing their industrial base and are focusing on particular – often advanced - technologies and strategic value chains. Thirdly, increasingly globalised value chains and digital transformation are structurally changing the labour market and the nature of work. Major investments are necessary to adapt the work force and education systems as new skills are needed.

The European Commission has identified Key Enabling Technologies (KETs) as instrumental in modernising Europe's industrial base and in driving the development of entirely new industries. The original KETs identified in 2009 are a group of six technologies: micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies. KETs are a key priority in Horizon 2020, and were recently the subject of an in-depth revision to verify whether they were still relevant to the current economic and technological framework. Indeed, considering the increased relevance of digital technologies in the current Industry 4.0 paradigm shift, artificial intelligence, connectivity, and cybersecurity were added to the original list, while industrial biotechnology was widened in scope being replaced by life science technologies. The economic impact of KETs is considerable. KETs are the essential technology building blocks which underpin Europe's global leadership in various industries, especially in high value added and technology-intensive products and services. As an example, Europe has a global market share of 33 % in robotics, 30 % in embedded systems, 55 % in automotive semiconductors, 20 % in semiconductor equipment, and 20 % in photonics components.

The European Commission works on a range of actions as part of its strategy to trigger the manufacturing of KETs-based products in Europe. These actions include supporting investments in KETs and enhancing the policy environment, helping small businesses access KETs technology platforms, promoting multidisciplinary skills for KETs, stimulating important industrial projects and ensuring a level playing field for KETs.
KETs are a priority for the European Structural and Investment Funds (ESIF) and EUR 110 billion were made available for innovation activities. The Structural Funds can be used to finance KETs projects that are much closer to the market, even up to the first production stage of development.
The Leadership in Enabling and Industrial Technologies (LEIT) part of Horizon 2020, the EU Framework Programme for Research and Innovation, includes:

- a dedicated budget for projects related to KETs of almost EUR 6 billion in the seven years;
- rebalancing of research, development, and innovation (RD&I) support towards closer-to-the-market projects (including pilot manufacturing lines and demonstrators);
- priority for cross-cutting KETs projects (30% of the KETs budget);
- industry-oriented selection criteria to increase participation along value chains (business and exploitation plans, commitment to first manufacturing, introduction of Technology Readiness Levels in topics, etc.).

Specific funding schemes are available in H2020 to support European industries in their innovation, some of them horizontally, like the SME Instrument, where the budget for KETs is not ring-fenced anymore, and others specifically dedicated to industrial technology.

The **EIC SME Instrument** addresses small and medium-sized enterprises (SMEs) with a radically new idea underpinned by a business plan for rolling out **marketable innovation solutions** and with **ambitions to scale up**. It supports high-risk, high-potential SMEs to develop and bring to market new products, services and business models that could drive economic growth.

Open Innovation Test Beds are a new instrument introduced in the Nanotechnologies, Advanced Materials, Biotechnologies and Processes Work Programme 2016-2017. In practice, they start calls for proposals where their resulting winning projects are entities, established in at least three Member States or Associated Countries, offering **access to physical facilities**, **capabilities and services** required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments. The objective of the Open Innovation Test Beds is to bring nanotechnologies and advanced materials within the reach of companies and users in order to advance from validation in a laboratory (TRL 4) to prototypes in industrial environments (TRL 7).

Digital Innovation Hubs are one-stop-shops that help companies to become more competitive with regard to their business/production processes, products or services using digital technologies. They are based upon technology infrastructure (competence centre) and provide access to the latest knowledge, expertise and technology to support their customers with piloting, testing and experimenting with digital innovations. DIHs also provide business and financing support to implement these innovations, if needed across the value chain.

Although we do not have detailed information on how the next Framework Programme, Horizon Europe, will be implemented, we can understand from the current documents that KETs will remain fundamental in the future representing a paramount component of the Digital, Industry and Space pillar.

Networking is crucial for increasing chances of success in Horizon 2020. Getting involved in the strategic prioritisation process is even more relevant, to include the own priorities in the strategic roadmaps that are the basis of the call for proposals in each work programme. The contractual Public-Private Partnerships (cPPPs) originate from the European Economic Recovery Plan back in 2008 with the purpose of helping innovation in key industrial sectors. To date, there are ten cPPPs covering a variety of industrial sectors and technological domains: Factories of the Future (FoF), Energy-efficient Buildings (EeB), Green Vehicles Initiative (EGVI), 5G, Sustainable Process Industry (SPIRE), Robotics, Photonics, High Performance Computing (HPC), Big Data, and Cybersecurity.

In addition, to ensure synergies and maximise the impact of projects active in common areas of application, the EC has encouraged the clustering of such projects. Such clusters represent open fora where experts are working together in identifying research priorities, writing roadmaps for future activities, providing tools for common exploitation and implementation purposes, including international cooperation. In the industrial technologies domain, these partnerships are formed in horizontal areas, namely characterisation, modelling, pilot production, carbon fibers and composites, and safety.

This document tries to offer to stakeholders in Luxembourg a review of policy and technical reports in the field of industrial technologies, to provide them with a comprehensive guide in the related funding landscape at European level. It does not therefore represent an official position of Luxinnovation.

2. INTRODUCTION

With more than 32,000 employees, the manufacturing sector in Luxembourg represents 8.3% of total national employment and 4.6% of the national added value. The sector currently specialises in composites, nanomaterials, high performance steel, biodegradable and recyclable materials, glass, concrete and plastics, and demonstrates expertise in the functionalisation of surfaces. The implementation of new, innovative and improved production technologies to boost productivity and competitiveness at the international level is a central consideration of the manufacturing sector. Its main fields of interest and expertise include:

- Highly automated production lines;
- Cyber-physical manufacturing systems;
- Robotics;
- Additive manufacturing;
- Reduction of energy consumption and waste production.

Within this framework, this document has been prepared to inform all the actors involved in industrial and manufacturing technologies and in their innovation and development in Luxembourg about the wide range of initiatives from the European Commission to support the digitalisation of the manufacturing sector in Europe.
In 2012, the European Commission has identified Key Enabling Technologies (KETs) as instrumental in modernising Europe's industrial base and in driving the development of entirely new industries. KETs are a key priority in Horizon 2020, and are seen as essential to initiatives such as Innovation Union and the Digital Single Market. Recently, with the increasing importance of digital technologies and their impact in the manufacturing sector, the Industry 4.0 concept, a review on the first KETs highlighted the necessity of including artificial intelligence, cybersecurity and connectivity into the first identified technologies, originating from the so called "**KETs 4.0**".
The research, development, and innovation in this field is therefore strongly supported by the European Commission, in particular by means of partnerships whose key mission is facilitating the creation of high added value networks between all the stakeholders in the industrial value chain: networking is indeed crucial to establish bridges between research intensive Universities, Research and Technology Organisations, SMEs, and large enterprises to have a faster translation of innovative solutions from the research environment to the market. Hence, a substantial part of this document serves as a guide in the partnerships landscape, highlighting their focus, strategy, and funding initiatives, with the aim of supporting strategic decisions also with the view of getting involved in these networking tools.

3. STATE OF THE ART

3.1. Industry in Europe

Industry is central to Europe's economy. It contributes to Europeans' prosperity through business in global and local value chains, and provides jobs to 36 million people - one out of five jobs in Europe. In particular, the manufacturing sector is hugely important because of its major role in driving productivity and innovation. An hour of work in manufacturing generates nearly EUR 32 of added value. With a share of approximately 16 % of total value added, manufacturing is responsible for 64 % of private sector R&D expenditure and for 49 % of innovation expenditure. Every new job in manufacturing creates between 0.5 and 2 jobs in other sectors. More than 80 % of EU exports are generated by industry[1].

[1] Eurostat — Extra-EU trade in manufactured goods — April 2017

Finally, recent years have seen a reversal in the decline of EU manufacturing, with impressive growth rates as regards[2] :

- industry's share in total value added (plus 6 % since 2009);
- employment: with over 1.5 million net new jobs in industry since 2013;
- labour productivity: 2.7 % per year growth on average since 2009, higher than both the US and Korea (0.7 % and 2.3 % respectively).

As well as increasing productivity, ensuring the EU is a global leader in a wide range of industrial technologies promises greener production (increased energy efficiency and CO2 utilisation), new and safer jobs (with some hazardous work performed by robots), and innovative and more customised goods and services. Evidence shows, at the level of firms and industries, that productivity enhancing technology causes job losses in some cases and job gains in others. However, on balance, the number of companies and industries that experience employment growth exceeds the number in which jobs are cut. Part of a strategy for coping with today's rising shares of high- and low-wage jobs — job polarisation — must involve growth in technology-intensive production work and the development of related new skills. Europe must therefore strongly pursue technological leadership in industry, not least for its net positive effects on the labour market.

However, Europe and its industries are still facing several challenges.

The first critical issue is how already-developed and emerging technologies are deployed. The full shift towards Industry 4.0 can take many years, due to the necessity of 1. helping the growth of new companies entering the market, and 2. to support the increase of productivity in the already existing companies that face difficulties in implementing innovative technologies. The second is particularly relevant in the case of SMEs, where CAPEX investments needed to introduce new technologies represent a significant barrier. The development periods for research and innovation are long and production processes include complex assembly methods. For private investors, Key Enabling Technologies (KETs) are associated with high risks. Coupled with insufficient access to appropriate sources of risk capital in the EU (on which start-ups and small businesses are particularly dependent), this results in many innovations never reaching the market. As a result, only one fifth of EU companies are highly digitised[3], and only one in five manufacturing companies has already used advanced manufacturing solutions[4]. Fostering this transition requires tailored policy initiatives and subsidies schemes to address both new companies and existing ones.

A second issue relates to increasing global competition. Global players, such as China, are progressively turning their attention to increasing their industrial base and are focusing on particular – often advanced - technologies and strategic value chains. The Made in China 2025[5] strategy aims to upgrade China's industrial base by focusing on 10 key industries: next-generation IT; high-end numerical control machinery and robotics; aerospace and aviation equipment; maritime engineering equipment and high-tech maritime vessel manufacturing; advanced rail equipment; energy-saving vehicles and neighbourhood electric vehicles; electrical equipment; agricultural machinery and equipment; new materials; biopharmaceuticals and high-performance medical devices. In the short and medium term, this strategy can present attractive opportunities for some European businesses to provide critical components, technology, and management skills. In the long term, market access for European business can be expected to shrink, especially in areas where Chinese companies are able to close the technology gap.

[2] Eurostat, taken from COM(2017) 479 final, 13.9.2017
[3] Europe's Digital Progress Report, SWD(2017) 160
[4] Innobarometer, 2016
[5] http://english.gov.cn/2016special/madeinchina2025/

Thirdly, increasingly globalised value chains and digital transformation are structurally changing the labour market and the nature of work. Major investments are necessary to adapt the work force and education systems as new skills are needed. There is a global race for talent and the European workforce needs to acquire high-level skills, which will need to improve continuously. Businesses are increasingly reporting difficulties in finding employees with adequate skills. For example, the automotive industry lacks science, technology, engineering and mathematics (STEM) profiles and is facing stiff competition for skills from other sectors[6].

3.2. Key Enabling Technologies – state of play

Key enabling technologies (KETs) have been a priority for EU industrial policy since 2009. KETs were defined in 2009 as being 'knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and high-skilled employment. They enable innovation in process, goods and service innovation throughout the economy and are of systemic relevance. They are multidisciplinary, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technology leaders in other fields to capitalise on their research effort'[7].

The six KETs identified in 2009 were:

- advanced manufacturing technologies;
- advanced materials;
- nanotechnology;
- micro- and nano-electronics;
- industrial biotechnology;
- photonics.

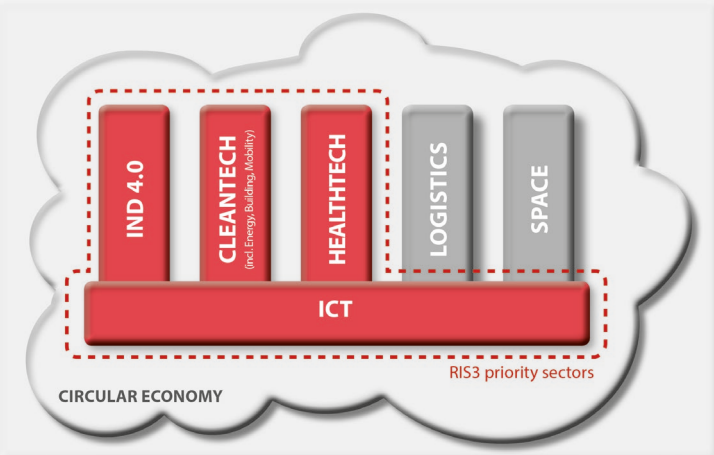


Figure 1: Smart specialisation priority sectors in Luxembourg

The programme structure and technological scope of the "Leadership in enabling an industrial technologies pillar" of Horizon 2020 are based on the 2009 list of KETs. KETs are also a priority under the Structural Funds. 65% of EU regions and 15 Member States indicated one or more KETs as a smart specialisation priority[8]. KETs are the second highest chosen priority for R&I under the regional smart specialisation strategies. Luxembourg published the final version of its Smart Specialisation Strategy in December 2017[9]. In line with the process of diversification of the national economy, the document proposes Industry 4.0, Cleantech (including Energy, Building, Mobility), Health Technologies, Logistics, Space, and ICT as an horizontal enabler. It is worth noticing that HealthTechs are among the new KETs recently introduced in the recent report of the independent High Level Group on Industrial

[6] http://ec.europa.eu/social/BlobServlet?docId=17027&langId=en
[7] COM(2009) 512.
[8] Preliminary report on KETs priorities declared by regions in the context of their work on Research and Innovation Strategies for Smart Specialisation (RIS3), 2014.
[9] https://meco.gouvernement.lu/fr/publications/rapport-etude-analyse/minist-economie/RIS3/Luxembourg_Research_and_Innovation_Smart_Specialisation_Strategy_2017.html

Technologies. State aids rules have also been modernised in 2014 to help Member States better support investments in KETs.

3.2.1. The economic relevance of KETs

The economic impact of KETs is considerable. KETs are the essential technology building blocks which underpin Europe's global leadership in various industries, especially in high value added and technology-intensive products and services. As an example, Europe has a global market share of 33 % in robotics, 30 % in embedded systems, 55 % in automotive semiconductors, 20 % in semiconductor equipment, and 20 % in photonics components.[10] Germany is the strongest European player in these areas, except for the automotive semiconductors sector, where the Netherlands are leading, and the semiconductor equipment sector, where Italy is the strongest European player.

In 2013, KETs-based products represented 19 % of total EU-28 production (EUR 950 billion), compared with 16 % in 2003. KETs were associated with 3.3 million jobs, with the biggest share being in advanced manufacturing technology and micro- and nano-electronics[11]. Approximately 10,000 SMEs based their business on the development and commercialisation of KETs. Exports from EU countries account for 30% of world exports in KETs-based products.

These sizeable markets sustain significant employment in the EU. Small and medium-sized enterprises (SMEs) are expected to account for the majority of future jobs in KETs.

Countries and regions that fully exploit KETs will be at the forefront of advanced and sustainable economies. KETs deployment will contribute to achieving reindustrialisation, energy, and climate change targets simultaneously, making them compatible and reinforcing their impact on growth and job creation. An “analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies” performed by Fraunhofer ISI under a tender contract by EASME[12] analysed in detail the advantages of users of advanced manufacturing and ICT-enabled technologies in comparison with companies not using them. In general terms, the use of advanced manufacturing technologies has positive correlation with the companies’ performance. Use of any of the four technologies is accompanied by a higher added value per employee and/or share of firms with a return on sales. Correlations between the use of specific technologies and firms’ performance with respect to employment and revenue growth, in contrast, differ in terms of both direction and amplitude. Robotics and automation, for example, go along with lower rather than higher revenue growth and users of nanotechnology display lower employment growth than non-users, even if the share of firms with high return on sales is greater. While the production performance among users of industrial robots and handling systems and/or technologies for safe human-machine cooperation is generally higher, that of users of processing of alloy construction materials remains lower. The use of automated warehouse management systems, finally, is accompanied by a higher production lead time (Table 1).

The use of ICT-enabled technologies goes along with an about one percentage point higher share of innovating firms that introduce products new to the market as well as a higher share of turnover generated by products new to the market among innovating firms - with the exception of ‘supply chain management’. Finally, the uptake of any ICT-enabled technology is found correlated with an up to 11 percentage points lower share of turnover generated by old products, although none per se correlates with a lower share of firms manufacturing such products (Table 2). It is worth highlighting that these data points are taken from 2011 figures, and while they show

[10] COM(2017) 479 final, 13.9.2017

[11] Van de Velde, E. / Debergh, P. / Wydra, S. / Som, O. / de Heide, M. (2015). Key Enabling Technologies (KETs) Observatory: Second report: European Commission, DG GROW.

[12] An analysis of drivers, barriers and readiness factors of EU companies for adopting advanced manufacturing products and technologies. Project EASME/COSME/2014/014.

the trend in the adoption of ICT technologies in manufacturing firms, they are probably catching its economic relevance. A recent report from the World Economic Forum[13] suggests indeed a major impact of digital transformation in production and supply chains (Figure 2).

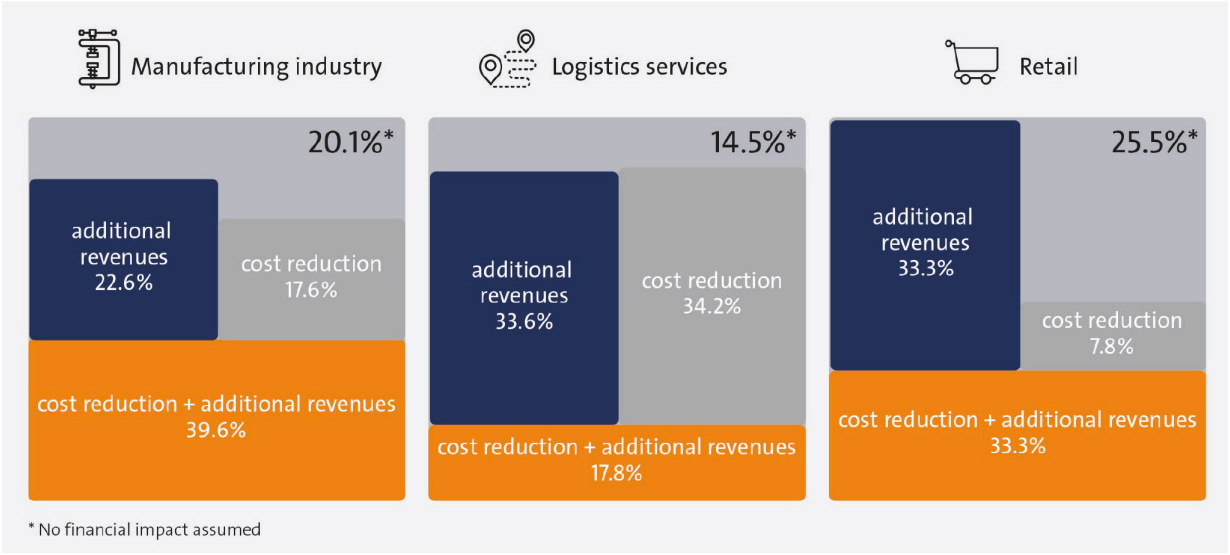


Figure 2: Expected impact of digital transformation on the cost situation in companies

[13] Impact of the Fourth Industrial Revolution on Supply Chains, WEF 2017

Table 1: Differences in various dimensions of firm performance between users and non-users of high performance manufacturing technologies (documented when significant) Source: EASME/COSME/2014/014

Performance indicator	Unit	Industrial robots and handling systems	Automated warehouse management systems (internal)	Technologies for safe human-machine cooperation	Processing alloy construction materials	Processing composite materials	Manufacturing Micromechanical components	Nano-technological production processes	use of any (at least one) high-perform manufacturing technology
TECHNICAL PERFORMANCE									
Production lead time	work days	-6,1	3,4	-10,7	13,3				
Order Delivery on time (main product)	%	1,4%		2,0%	-2,4%				
Rework/scrap (main product)	%	-0,4%		-0,2%	0,4%				
ECONOMIC PERFORMANCE									
Added value	(Revenue - Input p. Employee. 1000 €)	5,8	20,4	60,9					4,4
Return on sales (before taxes 2011) > 2%	% surveyed firms		5,9%		4,2%			8,3%	3,9%
Employment growth (2009-2011)	% annually				0,1%		1,3%	-2,3%	
Revenue Growth (2009-2011)	% annually	-1,2%	-0,2%		3,1%		7,5%		0,6%
Total Factor Productivity	(turnover - input / depr.+staff cost)		0,1	0,29	-0,56				
INNOVATIVE PERFORMANCE									
New products	% surveyed firms	10,7%	17,8%	14,8%	10,0%	17,8%	18,4%	16,9%	14,3%
Turnover generated by new products	*% (among innov.)*			3,0%					
Turnover generated by new products	*% (among all)*	1,9%	3,4%	4,4%	1,1%	3,2%	4,4%	2,4%	2,8%
Products new to the market	*% innovative firms*	6,2%	9,9%	10,8%			23,3%	20,1%	6,8%
Products new to the market	*% surveyed firms*								
Turnover gen. by prod. new to market	*% (among innov.)*	-0,6%	1,6%	0,4%	-1,1%	0,4%	-0,2%	-0,5%	0,0%
Turnover gen. by prod. new to market	*% (among all)*	0,7%	2,2%	1,6%		1,7%	2,5%	2,1%	1,0%
Old products (over 10 years old)	**% surveyed firms**								
Turnover generated by old products	*% (among all)*	-4,3%	-6,5%		-7,0%		-8,5%	-7,7%	-4,5%

Green: positive impact; Red: negative impact; light grey: p<0.001; dark grey: p<0.05

Table 2: Differences in various dimensions of firm performance between users and non-users of ICT technologies (documented when significant) Source: EASME/COSME/2014/014

Performance indicator	Unit	Virtual reality/simulation in production reconfiguration	Virtual reality/simulation in product design	Supply chain management with suppliers/costumers	Product lifecycle management systems	use of any (at least one) ICT-enabled technology
TECHNICAL PERFORMANCE						
Production lead time	work days	11,9	19,3			4,7
Order Delivery on time (main product)	**%**		-0,2%	1,3%		
Rework/scrap (main product)	**%**					
ECONOMIC PERFORMANCE						
Added value	**(Revenue - Input p. Employee. 1000 €)**			26,6	31,7	27,4
Return on sales (before taxes 2011) > 2%	**% surveyed firms**		4,5%	7,8%	8,8%	6,0%
Employment growth (2009-2011)	**% annually**					
Revenue Growth (2009-2011)	**% annually**	1,4%	-1,3%			-0,3%
Total Factor Productivity	**(turnover - input / depr.+staff cost)**					
INNOVATIVE PERFORMANCE						
New products	**% surveyed firms**	10,3%	24,7%	10,1%	21,9%	17,5%
Turnover generated by new products	*% (among innov.)*				3,0%	
Turnover generated by new products	*% (among all)*	2,5%	5,2%	1,2%	5,7%	3,7%
Products new to the market	*% innovative firms*		1,1%	1,1%	1,2%	1,1%
Products new to the market	*% surveyed firms*					
Turnover gen. by prod. new to market	*% (among innov.)*	2,2%	1,8%	-0,7%	0,6%	1,3%
Turnover gen. by prod. new to market	*% (among all)*	1,4%	2,7%	0,7%	2,4%	1,8%
Old products (over 10 years old)	**% surveyed firms**					
Turnover generated by old products	*% (among all)*	-4,3%	-11,0%	-8,1%	-9,5%	-8,7%

Green: positive impact; Red: negative impact; light grey: p<0.001; dark grey: p<0.05

3.3. Key Enabling Technologies for the Future – "KETs 4.0"

As regards future technologies, several foresight studies indicated that the current set of six KETs are still among the technologies that are most likely to disrupt economies and societies over the next 10-15 years. The OECD, based on several technology foresight exercises in its member countries and Russia, identified 40 key and emerging technologies that might best tackle the various 'grand challenges' the world faces (such as ageing, climate change, natural resource depletion, health inequality)[14]. Foresight studies conducted or commissioned by national authorities show that KETs will continue to play a very important role in the future.

In the framework of a revision of its Research, Development and Innovation strategy for the future, the EC asked an independent group of experts to assess the major challenges European industry is facing, and whether the current KETs were appropriate to tackle such challenges. In addition to the broader economic and social ones, such as rapid population ageing, slowing growth in labour productivity, rising inequality, protracted unemployment, and climate change, there are three main challenges that Europe's industry indeed needs to address:

- *Increasingly knowledge-intensive production*
  Knowledge is becoming the most important resource of our time. Thanks to digital technologies, knowledge is now generated and disseminated at greater speed than at any time in the past. Knowledge is also the new social question of the 21st century, as equal access to knowledge is crucial to reduce disparities.
- *Digitisation, which is closely linked to the first challenge*
  Progress in digital technologies, in combination with other key enabling technologies, is changing the way we design, produce, commercialise and generate value from products and related services. Advances in technologies such as the Internet of Things, 5G, cloud computing, data analytics and robotics are transforming products, processes and business models in all sectors of the economy, ultimately reshaping global value chains and patterns of industrial specialisation. To cope with this paradigm shift, new policies addressing infrastructures, research and development, education and training, data management, and regulations are needed.
- *Globalisation, and in particular competition from a number of emerging market economies, of which China is the most significant*
  The Industry 4.0 revolution results from a confluence of fast-developing technologies, ranging from a variety of digital technologies (such as 3D printing, the Internet of Things, advanced robotics), new materials (bio- and nano-based) and new processes (for example, data-driven production, artificial intelligence and synthetic biology). Europe possesses considerable strengths, and in some cases global leadership, in a number of these technologies. This is particularly true of artificial intelligence, digital security and connectivity.

3.3.1. The next generation of key enabling technologies

KETs must contribute to European competitiveness, aiming at creating balanced, cohesive, educated, healthy societies. Within this framework, KETs should be selected according to four criteria: impact, relevance, key capacity, and enabling power.

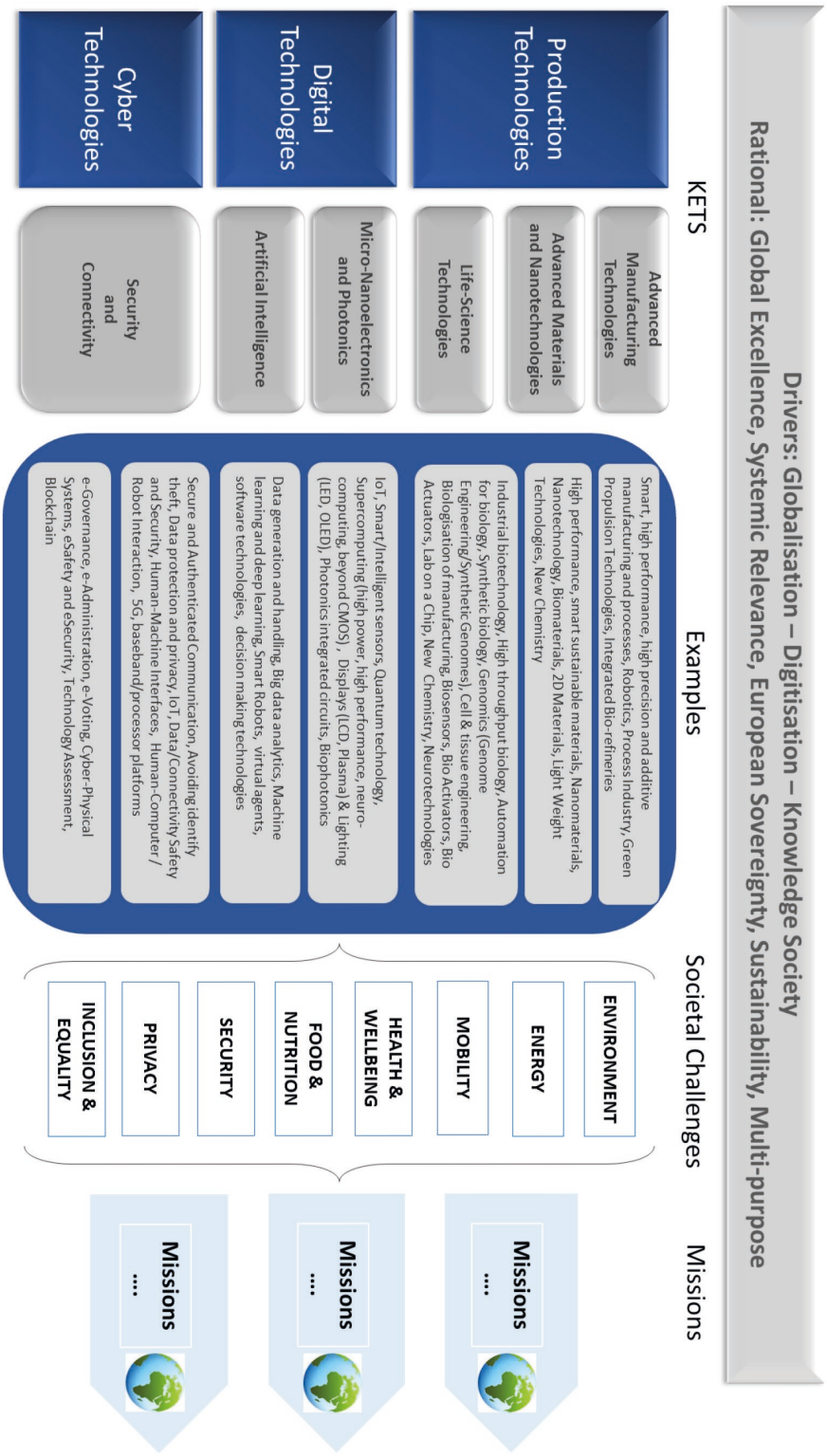
- KETs have substantial impact in terms of creating high quality jobs, improving people's lives and creating future prosperity;

[14] OECD (2016). Science, Technology and Innovation Outlook 2016.

- KETs have systemic relevance for all phases of product development, ensuring Europe remains a leader across industrial value chains. This also includes societal participation to support democratic engagement;
- KETs have the capacity to improve people's health, safety and security, supporting sustainable development and secure connectivity and communication among systems and individuals;
- KETs enable multiple and cross-sectoral industrial applications, helping to generate global excellence, new knowledge and new forms of participation. This creates economic progress and can help to reduce inequalities, while supporting the EU's industrial leadership. KETs are instrumental in sustainably supporting a circular economy and green growth.

On this basis, the independent High Level Group on Industrial Technologies recommended:

- confirming the existing six KETs while merging four of them into two broader categories (materials and nanotechnology, photonics and micro- and nano-electronics);
- broadening the KET 'biotechnology' to 'Life Sciences technologies';
- adding two new main fields, namely:
    - artificial intelligence;
    - digital security and connectivity.


Drivers: Globalisation – Digitisation – Knowledge Society
Rational: Global Excellence, Systemic Relevance, European Sovereignty, Sustainability, Multi-purpose
KETS
Examples
Societal Challenges
Missions
Production Technologies
Digital Technologies
Cyber Technologies
Advanced Manufacturing Technologies
Advanced Materials and Nanotechnologies
Life-Science Technologies
Micro-Nanoelectronics and Photonics
Artificial Intelligence
Security and Connectivity
Smart, high performance, high precision and additive manufacturing and processes, Robotics, Process Industry, Green Propulsion Technologies, Integrated Bio-refineries
High performance, smart sustainable materials, Nanomaterials, Nanotechnology, Biomaterials, 2D Materials, Light Weight Technologies, New Chemistry
Industrial biotechnology, High throughput biology, Automation for biology, Synthetic biology, Genomics (Genome Engineering/Synthetic Genomes), Cell & tissue engineering, Biologisation of manufacturing, Biosensors, Bio Activators, Bio Actuators, Lab on a Chip, New Chemistry, Neurotechnologies
IoT, Smart/Intelligent sensors, Quantum technology, Supercomputing (high power, high performance, neuro-computing, beyond CMOS), Displays (LCD, Plasma) & Lighting (LED, OLED), Photonics integrated circuits, Biophotonics
Data generation and handling, Big data analytics, Machine learning and deep learning, Smart Robots, virtual agents, software technologies, decision making technologies
Secure and Authenticated Communication, Avoiding identify theft, Data protection and privacy, IoT, Data/Connectivity Safety and Security, Human-Machine Interfaces, Human-Computer / Robot Interaction, 5G, baseband/processor platforms
e-Governance, e-Administration, e-Voting, Cyber-Physical Systems, eSafety and eSecurity, Technology Assessment, Blockchain
ENVIRONMENT
ENERGY
MOBILITY
HEALTH & WELLBEING
FOOD & NUTRITION
SECURITY
PRIVACY
INCLUSION & EQUALITY
Missions ....
Missions ....
Missions ....

The above section provides an explanation of the economic and policy background for Key Enabling Technologies. This background has been the basis for developing a wide range of initiatives launched to foster the realisation of the innovation potential that such technologies bring, notably at European level. Such initiatives represent a wide range of support tools, including research and innovation programmes, financial aids, partnerships and infrastructures, to allow the European R&I actors to fully exploit the potential of KETs.

4. KETS AND EUROPEAN COMMISSION INITIATIVES

The European Commission works on a range of initiatives as part of its strategy to trigger the manufacturing of KETs-based products in Europe. These initiatives include supporting investments in KETs and enhancing the policy environment, helping small businesses access KETs technology platforms, promoting multidisciplinary skills for KETs, stimulating important industrial projects and ensuring a level playing field for KETs.

4.1. Supporting investments in KETs

4.1.1. Smart Specialisation Platform for industrial modernisation

The European Commission launched the Smart Specialisation Platform for industrial modernisation. This new initiative offers hands-on support to regions to foster interregional cooperation based on matching smart specialisation priorities related to industrial modernisation, such as Key Enabling Technologies, service innovation or resource efficiency. The aim of this initiative is to create an investment pipeline of mature projects in new growth areas across the EU, by providing tailored advice and helping regions establish links with the business and research communities. Particular support will be given to regions to combine different EU investment instruments.

4.1.2. Horizon 2020

The Leadership in Enabling and Industrial Technologies (LEIT) part of Horizon 2020, the EU Framework Programme for Research and Innovation, includes:

- a dedicated budget for projects related to KETs of almost EUR 6 billion in the seven years;
- rebalancing of research, development, and innovation (RD&I) support towards closer-to-the-market projects (including pilot manufacturing lines and demonstrators);
- priority for cross-cutting KETs projects (30% of the KETs budget);
- industry-oriented selection criteria to increase participation along value chains (business and exploitation plans, commitment to first manufacturing, introduction of Technology Readiness Levels in topics, etc.).

The first two Horizon 2020 work programmes (2014-2015 and 2016-2017) provided funding for more than 40 KETs pilot lines[15] in four areas of high industrial interest and innovation potential identified by the KETs High-level Group (high-performance production, embedded energy, smart structures, and industrial processes using renewable resources).

While the information regarding **Horizon Europe**[16] is still subject to changes and to the political approval, still we can see a strong relevance of KETs, in particular in the planned Digital, Industry and Space cluster, which will foster technology development to support European Industries in generating innovation-based growth.

[15] https://www.eppnetwork.com
[16] https://ec.europa.eu/info/sites/info/files/horizon-europe-presentation_2018_en.pdf

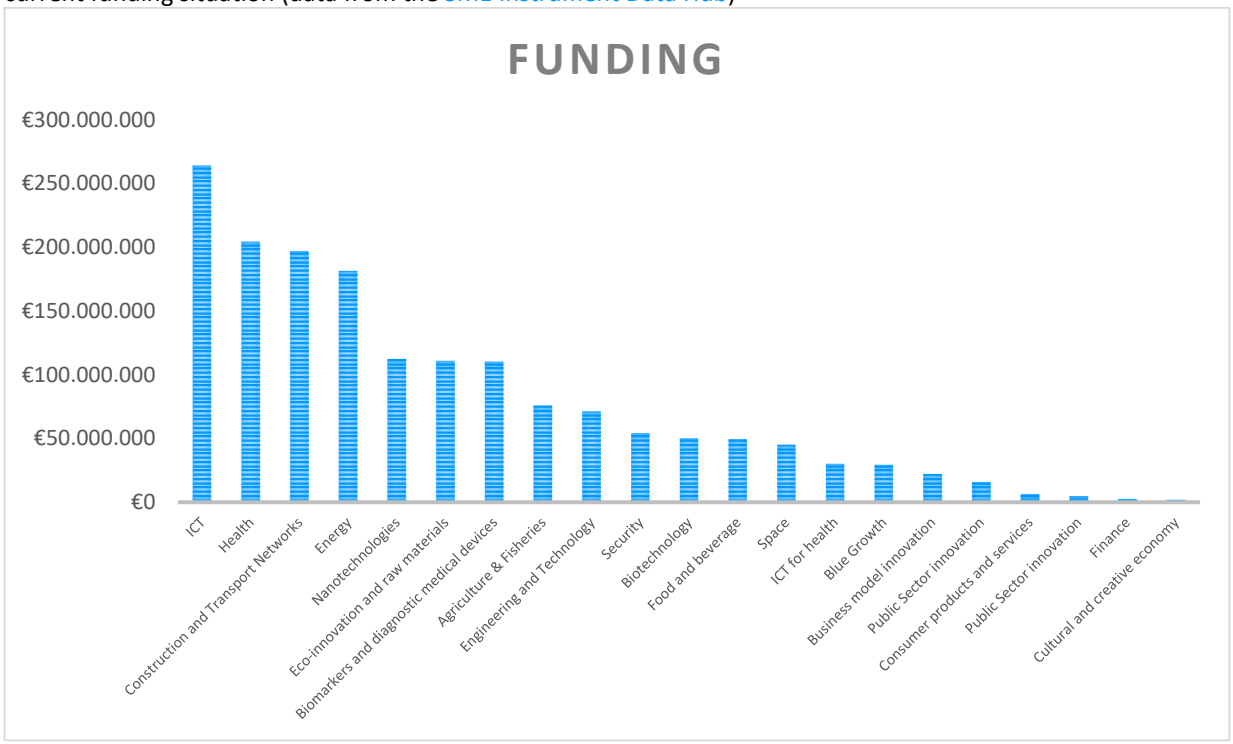
4.1.3. European Structural and Investment Funds

KETs are a priority for the European Structural and Investment Funds (ESIF) and EUR 110 billion were made available for innovation activities. The Structural Funds can be used to finance KETs projects that are much closer to the market, even up to the first production stage of development.
Successful implementation depends on the take-up of funding by regions in their research and innovation smart specialisation strategies. Sixty percent of regions registered in the smart specialisation platform have already indicated a KETs-related priority, and cluster-specific actions are being promoted.
Combining Horizon 2020 and ESIF funds has now been made possible to allow combined public support for ambitious industrial KETs projects. A guide on synergies between ESIF and other EU instruments has been published.

4.2. Helping companies access KETs technology infrastructures

4.2.1. The EIC SME Instrument

The SME Instrument is now part of the European Innovation Council (EIC) pilot that supports top-class innovators, entrepreneurs, small companies and scientists with funding opportunities and acceleration services. The main focus of the EIC pilot is on radical, market-creating innovations to improve productivity and international competitiveness and generate new jobs and higher standards of living.
The SME Instrument addresses small and medium-sized enterprises (SMEs) with a radically new idea underpinned by a business plan for rolling out **marketable innovation solutions** and with **ambitions to scale up**. It supports high-risk, high-potential SMEs to develop and bring to market new products, services and business models that could drive economic growth. The budget for KETs related project is not ring-fenced anymore, given the full bottom-up approach of this scheme; however, as shown in the figure below, KETs are very well represented in the current funding situation (data from the SME Instrument Data Hub)



4.2.2. Open Innovation Testbeds

Open Innovation Test Beds are a new instrument introduced in the Nanotechnologies, Advanced Materials, Biotechnologies and Processes Work Programme 2016-2017. In practice, they start calls for proposals where their resulting winning projects are entities, established in at least three Member States or Associated Countries, offering access to physical facilities, capabilities and services required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments. The objective of the Open Innovation Test Beds is to bring nanotechnologies and advanced materials within the reach of companies and users in order to advance from validation in a laboratory (TRL 4) to prototypes in industrial environments (TRL 7).

The Open Innovation Test Beds cover all activities from the prototyping to industrial production, and especially the testing in an industrial environment, the validation of the characteristics of the materials and the control of the respect of legal and regulatory constraints. The EU funding mainly supports the above described upscaling and engineering process, and further support is available for a number of demonstration cases and dissemination activities to showcase capabilities and services to ensure sustainability.

Open Innovation Test Beds have the further European Added value of being open and accessible to any interested party from the EU or outside the EU. On top of that, Open Innovation Test Beds will stimulate collaboration by pooling resources and existing knowledge at the EU level while supporting all kinds of users independently from their geographical location, and thus contributing to the creation of a more open and connected European innovation ecosystem.

Open Innovation Test Beds will also set up networks amongst themselves, to offer additional services, to allow experiments and knowledge to be shared, and to provide users with a single entry point to their capabilities and services in materials development. They are expected to form European networks of competences along the entire value chain, and match the needs of industry by providing users with easy access to facilities, at different locations as needed. These networks should reach out to users across different regions of Europe. This is especially important to European regions that are building up or improving their capacities. Since they are a new tool, the selection of the first Open Innovation Test Beds is still not yet completed, however, the main aim follows the path established by Research Infrastructures, in which Luxembourg entities have a limited experience. The participation of Luxembourg participants is to be encouraged, and it will benefit in particular institutions and companies which have a business model oriented to the provision of services to SMEs and other enterprises. Given the scope and the domain, there is indeed a particular alignment with the activities of the Materials and Manufacturing Cluster.

4.2.3. Digital Innovation Hubs

Digital Innovation Hubs are one-stop-shops that help companies to become more competitive with regard to their business/production processes, products or services using digital technologies. They are based upon technology infrastructure (competence centre) and provide access to the latest knowledge, expertise and technology to support their customers with piloting, testing and experimenting with digital innovations. DIHs also provide business and financing support to implement these innovations, if needed across the value chain. As proximity is considered crucial, they act as a first regional point of contact, a doorway, and strengthen the innovation ecosystem. A DIH is a regional multi-partner cooperation (including organizations like RTOs, universities, industry associations, chambers of commerce, incubator/accelerators, regional development agencies and even governments) and can also have strong links with service providers outside of their region supporting companies with access to their services.

The rationale behind this initiative is to help European Industry, small or large, high-tech or not, to grasp the digital opportunities. The Commission will focus 500M€ over the next 5 years from Horizon 2020 budget to support the development of DIHs. It is the Commission's ambition that all companies should have a DIH within their region, through which they should be able to access competences in order to digitise their organisations and their

products and services. Furthermore, the services provision by existing Hubs can be strengthened by the establishment of a pan-European network of DIHs.
The Smart Specialisation Platform is working together with DG CONNECT to develop an online tool to visualise DIHs' geographic distribution, to improve their networking and provide information on available services and competencies. The collaboration includes activities to improve the evidence base for sound policies in the area of digital regional growth, by providing examples of how DIHs participate in Smart Specialisation development and implementation, how DIHs network, and different strategies of DIHs depending on their socio-economic context. Within this tool, four DIHs are identified for Luxembourg, namely the Interdisciplinary Center of Security Reliability and Trust (SnT) of the University of Luxembourg, the Luxembourg Institute of Science and Technology (LIST), the Technoport, and Luxinnovation.

4.3. Private-Public partnerships

Networking is crucial for increasing chances of success in Horizon 2020. Getting involved in the strategic prioritisation process is even more relevant, to include own priorities in the strategic roadmaps that are the basis of the call for proposals in each work programme. The aim of the following sections is to map the most relevant partnerships that are active in the domain of KETs and Industrial Technologies, to guide the stakeholders from Luxembourg in their participation and their involvement beyond the application phase to the calls for proposals.

4.3.1. Purpose of Contractual Public-Private Partnerships (cPPPs)

The contractual Public-Private Partnerships (cPPPs) originate from the European Economic Recovery Plan back in 2008 with the purpose of helping innovation in key industrial sectors. At that time, three research Public-Private Partnerships (PPPs) were initiated (i.e. Factories of the Future (FoF), Energy-efficient Buildings (EeB), and Green Cars (EGVI in Horizon 2020)). The final assessment of the research PPPs in the European Economic Recovery Plan, published in June 2013, concluded that the leverage effect for private investment was far superior in the PPPs (57%) compared to the standard seventh framework programme (FP7) (34%). The 366 projects, launched under FP7 with a total investment of 2.4 billion €, accordingly proved that they could significantly support innovation within their sectors.
These results paved the way for including the cPPPs into Horizon 2020. To date, there are ten cPPPs covering a variety of industrial sectors and technological domains: Factories of the Future (FoF), Energy-efficient Buildings (EeB), Green Vehicles Initiative (EGVI), 5G, Sustainable Process Industry (SPIRE), Robotics, Photonics, High Performance Computing (HPC), Big Data, and Cybersecurity.
The cPPP instrument is designed to implement strategies to increase the competitiveness impact of European R&D funding through Horizon 2020: it offers a more active role to industry in defining roadmaps, in significantly contributing to work programmes and calls and in promoting higher technology readiness levels (TRLs) for new technologies funded under the projects concerned.
A recent report[17] performed by an Independent Expert Group has shown that although a relevant part of the impact of cPPPs has still to materialize and there are differences from one cPPP to another, they have broadly achieved the purpose for which they were created. That is a more structured shift from a top-down to a bottom-up approach in defining R&I European strategies, spanning the whole innovation cycle and relevant actors. Nevertheless, the European Commission and the Industry Association should take concrete actions on some of the dimensions analysed, especially governance, transparency, challenging roadmaps and KPIs definition. In

[17] Mid-term review of the contractual Public Private Partnerships (cPPPs) under Horizon 2020, 2017

addition, the "**Industry, Partnerships - a new impetus**[18]**"** conference, held in Brussels on June 26th, 2018, kick-started the discussion towards the definition of the concept of new partnerships in the next framework programme, Horizon Europe, with a clear focus on the issues of transparency, impact, and governance. This is expected also to have a substantial impact in Luxembourg as well, as it will result in changes to the opportunities our stakeholders will have to participate in funded projects, but also to decide about their membership of future partnerships.

4.3.2. The KETs cPPPs

- **EFFRA - https://www.effra.eu**

The key objective of EFFRA is to promote pre-competitive research on production technologies within the European Research Area by engaging in a public-private partnership with the European Union called 'Factories of the Future'.

EFFRA was established to shape, promote and support the implementation of the 'Factories of the Future' public-private partnership. The partnership aims to bring together private and public resources to create an industry-led programme in research and innovation with the aim of launching hundreds of market-oriented cross-border projects throughout the European Union. Such projects will produce demonstrators and models to be applied in a wide range of manufacturing sectors. With the strategic shift on Industry 4.0 in the whole European industrial ecosystem, EFFRA produced a second prioritisation document setting the five key priorities focus areas to be implemented to foster the implementation of advanced ICT technologies in manufacturing in synergy with advanced material processing technologies and mechatronics systems[19]. So far, Luxembourg participation has not been successful as for the rest of Horizon 2020, with just three proposals funded between 2014 and 2017, over 38 participations. It is therefore very important to ensure a better comprehension of the priorities of the FoF, and to efficiently network with the key players in this area (Figure 3).

The FoF calls for proposals are published together with the NMBP Work Programme, and normally they are calling for applications for single stage proposals, with a deadline in February, each year.

- **EeB - http://e2b.ectp.org**

The contractual PPP on Energy-efficient Buildings aims to develop cost effective innovative solutions for buildings and districts.

The vision is to drive the creation of a knowledge-based building industry, which turns energy efficiency into sustainable business. The general objectives of EEB are to:

- Develop technologies and solutions which enable speeding up the reduction in energy use and GHG emission in line with the 2020 goals, e.g. through a higher renovation rate of the building stock at lower cost and to meet regulatory needs;
- Develop energy efficiency solutions in order to turn the building industry into a knowledge-driven sustainable business, with higher productivity and higher skilled employees;
- Develop innovative and smart systemic approaches for green buildings and districts, helping to improve the competitiveness of EU building industry by providing cost-effective, user-friendly, healthy and safe products for smart cities.

[18] Report of the European Commission conference "Industry Partnerships - a new impetus": https://publications.europa.eu/en/publication-detail/-/publication/3d2c822b-9ac2-11e8-a408-01aa75ed71a1/language-en/format-PDF/source-74302207

[19] https://www.effra.eu/factories-future-roadmap

This would ultimately create a solid foundation for continuous innovation in the building sector through sustainable partnerships, fostering an innovative eco-system across value chains, which is not project based, with episodic innovation activities as current practices.
The participation in Luxembourg to the EEB calls has been very limited so far, with 2 projects funded and 13 participations between 2014 and 2017.
The EEB calls for proposals are published together with the NMBP Work Programme, and normally they are calling for applications for single stage proposals, with a deadline in February, each year.

Figure 1: Key stakeholders in the FoF domain

SPIRE - https://www.spire2030.eu

SPIRE (Sustainable Process Industry through Resource and Energy Efficiency) is a contractual Public-Private Partnership dedicated to innovation in resource and energy efficiency enabled by the process industries. SPIRE is addressing three fundamental European challenges:

- Urgency to create growth and increase the competitiveness of Europe in a global market:
- Need to rejuvenate the European process industry that is at the basis of the European economy in terms of turnover, employment and generation of technologies for all industrial sectors;
- Imperative to reduce resource and energy inefficiency and the environmental impact of industrial activities.

SPIRE aims at integrating, demonstrating and validating systems and technologies capable of achieving two key resource and energy efficiency targets across all SPIRE sectors:

- **a reduction in fossil energy intensity of up to 30% from current levels** through a combination of, for example, introduction of novel energy-saving processes, process intensification, energy recovery, sustainable water management, cogeneration heat-power and progressive introduction of alternative (renewable) energy sources within the process cycle;
- **a reduction of up to 20% in non-renewable, primary raw material intensity compared to current levels**, by increasing chemical and physical transformation yields and/ or using secondary and renewable raw materials;
- a significant contribution to the political and societal objectives of **drastic efficiency improvement in CO2-equivalent of up to 40%.**

Luxembourg participation in this area is limited, with three projects funded over 9 applications in total between 2014 and 2017. A stronger involvement in this partnership, also considering its increasing convergence towards digitalisation, would be extremely relevant for Luxembourg stakeholders.

The SPIRE calls for proposals are published together with the NMBP Work Programme, and normally they are calling for applications for single stage proposals, with a deadline in February, each year.

4.3.3. Other cPPPs

EGVI - https://egvi.eu

The European Green Vehicles Initiative is a contractual public-private partnership dedicated to delivering green vehicles and mobility system solutions which match the major societal, environmental and economic challenges ahead. With a focus on the energy efficiency of vehicles and alternative powertrains, the EGVI PPP aims at accelerating research, development and demonstration of technologies allowing the efficient use of clean energies in road transport.

The Partnership involves all industry, research and associate members of the European Green Vehicles Initiative Association (EGVIA) and the various Directorates General of the European Commission engaged in the PPP. Public and private partners collaborate to identify research and innovation activities to be proposed for financial support under Horizon 2020 - the EU Framework Programme for Research and Innovation in the period 2014-2020. Three rounds of biennial calls for proposals are expected to be launched within the EGVI PPP.

The European Green Vehicles Initiative is established in the continuation of the European Green Cars Initiative (2009-2013). The latter was created in an ad-hoc manner in the 7th Framework Programme, in response to the 2008 global economic crisis, and led to the joint funding of more than 80 collaborative research projects. Although the scopes of the two Initiatives slightly differ – the EGVI PPP specifically focuses on the energy efficiency of vehicles and alternative powertrains and covers additional vehicle types – the approach and working methods developed are similar.

The Multiannual Roadmap for the EGVI Contractual Public-Private Partnership is the document of reference for the implementation of the PPP. It takes into account the roadmaps from the three European Technology Platforms involved - ERTRAC, EPoSS and SmartGrids, and outlines the vision, research and development strategy, as well as the expected impact and governance model of the European Green Vehicles Initiative.

Between 2014 and 2017, Luxembourg entities had a limited but very successful participation in the EGVI calls, with 6 proposals funded over 12 applications, hence with a 50% success rate.
The EGVI calls are published as a part of the Societal Challenge 4 - Smart, Green and Integrated Transport, and normally they are calling for applications for single stage proposals, with a deadline in April, each year.

5G-PPP - https://5g-ppp.eu

The 5G Infrastructure Public Private Partnership (5G PPP) is a joint initiative between the European Commission and European ICT industry (ICT manufacturers, telecommunications operators, service providers, SMEs and researcher Institutions). The 5G-PPP is now in its second phase where 21 new projects were launched in Brussels in June 2017. The 5G PPP will deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade. The challenge for the 5G Public Private Partnership (5G PPP) is to secure Europe's leadership in the particular areas where Europe is strong or where there is potential for creating new markets such as smart cities, e-health, intelligent transport, education or entertainment & media. The 5G PPP initiative will reinforce the European industry to successfully compete on global markets and open new innovation opportunities. It will "open a platform that helps us reach our common goal to maintain and strengthen the global technological lead".
The key challenges for the 5G Infrastructure PPP are:

- Providing 1000 times higher wireless area capacity and more varied service capabilities compared to 2010;
- Saving up to 90% of energy per service provided. The main focus will be in mobile communication networks where the dominating energy consumption comes from the radio access network;
- Reducing the average service creation time cycle from 90 hours to 90 minutes;
- Creating a secure, reliable and dependable Internet with a "zero perceived" downtime for services provision;
- Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people;
- Ensuring for everyone and everywhere the access to a wider panel of services and applications at lower cost.

The call for proposals of the 5G-PPP are implemented through the Information and Communication Technologies Work Programme.

SPARC - https://eu-robotics.net/sparc/

SPARC is a Public-Private Partnership between the European Commission, and European industry and academia to facilitate the growth and empowerment of the robotics industry and value chain, from research through to production.
To maintain and extend Europe's leadership and secure the economic and societal impact for Europe, the European Commission decided in 2012 to initiate the Public-Private Partnership in Robotics (now SPARC) by building on Europe's scientific excellence and its history of successful industries that have changed the world.

SPARC is a contractual Partnership of the European Commission and the European Robotics Community. euRobotics AISBL, a non-for-profit association according to Belgian law based in Brussels was founded in September, 2012, to provide the European Robotics Community with a legal entity to engage in a contract with the European Commission. SPARC is the largest research and innovation programme in civilian robotics in the world, with €700 million in funding from the European Commission between 2014-2020, which is tripled by European industry to yield a total investment of €2.8 billion

The call for proposals of SPARC are implemented through the Information and Communication Technologies Work Programme.

Photonics PPP - https://www.photonics21.org

The Photonics PPP represents a long-term commitment between the European Commission and the photonics stakeholders to invest in Europe with the aim of securing Europe's industrial leadership and economic growth, a highly skilled workforce, and the capability to generate new jobs that attract young people. A seven years Multiannual Strategic Roadmap – Towards 2020 – Photonics Driving Economic Growth in Europe underpins the proposed activities of this Key Enabling Technology of growing photonics manufacturing and employment and acts as a basis of the new Public Private Partnership.

Photonics21 President Michael Mertin, CEO Jenoptik, stressed that: "Boosting economic growth and the creation of jobs in Europe through strengthening its innovation capacity will be the major challenges of Horizon 2020. Through the establishment of a Public Private Partnership, the photonics community fully commits to strive for photonics innovation in Europe and to reinforce the cooperation between public and private sectors. Our innovation capacity will substantially contribute to Europe's economy and thus benefit European citizens".

The entry into the "photon century" requires a shared European initiative that enables industry and research to uphold their outstanding initiatives to explore the nearly limitless future applications of light and to reap the expected benefits in terms of creating both jobs and wealth. Many important European industries, from chip manufacturing and lighting, health care and life sciences, to space, defence and the transport and automotive sectors rely on the same fundamental mastery of light. Without strong European leadership in photonics technologies, these industries will be left vulnerable to strong competition from the USA and Asia.

To achieve this leadership for the benefit of Europe and our citizens, an ambitious programme is required to:

- Supply the necessary research environment capable of supporting the visionary and industrially relevant R&D activities for photonics components, systems and their application over a broad range of industry sectors;
- Establish strategic links between mainly SME-based photonics industries and principal user industries to share their long term vision and to mobilise a critical mass resources;
- Foster co-operation and smooth out the current fragmentation of national and European R&D activities.

The call for proposals of the Photonics PPP are implemented through the Information and Communication Technologies Work Programme.

HPC cPPP - http://www.etp4hpc.eu/cppp.html

The HPC cPPP's main goals and high-level objectives are to:

- Develop the next generation of HPC technologies, applications and systems towards exascale;
- Achieve excellence in HPC applications delivery and use.

The HPC cPPP brings together technology providers and users via the ETP4HPC Association and Centres of Excellence (CoE) for computing applications. The cPPP focuses on technologies and usage and applications (pillars a & c) of the European HPC strategy along with training, education and skills development.

The cPPP works in close cooperation with the EU co-funded PRACE e-infrastructure initiative providing access to the best supercomputing facilities and services in Europe to both industry (including small and medium enterprises (SME)) and academia, thus spanning all aspects of the value chain of HPC and all three pillars of the European Commission HPC strategy in Horizon 2020. While the calls so far just attracted one proposal from Luxembourg, this area will become more and more important for the country thanks to the recent decision of establishing the **European High-Perfomance Computing Joint Undertaking**[20] in Luxembourg[21]. The EuroHPC Joint Undertaking (JU)

[20] https://ec.europa.eu/digital-single-market/en/eurohpc-joint-undertaking
[21] https://www.luxinnovation.lu/news/luxembourg-host-european-hpc-headquarters/

is a legal and funding entity which will enable pooling of the Union's and national resources on High-Performance Computer (HPC) with the aim of:

- acquiring and providing a world-class pre-exascale supercomputing infrastructure to Europe's scientific and industrial users, matching their demanding application requirements by 2020;
- developing exascale supercomputers based on competitive EU technology that the Joint Undertaking could acquire around 2022/2023, and that would be ranking among the top three places in the world.

The call for proposals of the HPC cPPP are implemented through the Future and Emerging Technologies and e-Infrastructures Work Programmes.

BDVA - http://www.bdva.eu

The Big Data Value Association AISBL (BDVA) is a fully self-financed non–for-profit organisation under Belgian law. The Big Data Value Association (BDVA) is the private counterpart to the EU Commission to implement the BDV PPP programme (Big Data Value PPP). BDVA has over 190 members all over Europe with a well-balanced composition of large and small and medium-sized industries as well as research organisations. BDVA is open to new members to further enrich the data value ecosystem and play an active role. These include Data Users, Data Providers, Data Technology Providers and Researchers. The BDV PPP was launched in 2014, but its operationalisation has been especially pushed forward with the launch of the LEIT work programme 2016/2017 The objectives of the Association are to boost European Big Data Value research, development and innovation and to foster a positive perception of Big Data Value. In particular BDVA aims at:

- strengthening competitiveness and ensuring industrial leadership of providers and end users of Big Data Value technology-based systems and services;
- promoting the widest and best uptake of Big Data Value technologies and services for professional and private use;
- establishing the excellence of the science base of creation of value from BIG DATA.

The Association carries out acts, takes steps and commits to all activities that are appropriate or useful in view of achieving its objectives. This includes:

- collaborating with the European Commission (including to establish a Public-Private Partnership, and to develop and implement a strategic roadmap for research, technological development and innovation in the Big Data Value and other ICT domains);
- developing strategic goals of European Big Data Value research and innovation and supporting their implementation;
- improving industrial competitiveness of Europe through innovative Big Data Value technologies, applications, services, solution
- strengthening networking activities of the European Big Data Value community;
- promoting European Big Data Value offerings and organisation;
- reaching out to existing and new users;
- contributing to policy development, education and technology ramification in the widest possible sense and addressing ethical, legal and societal issues.

The call for proposals of the BDVA cPPP are implemented through the ICT Work Programme.

ECSO - https://ecs-org.eu

As part of the EU cybersecurity strategy, the European Commission and the European Cyber Security Organisation (ECSO) signed a cPPP on 5 July 2016. The aim of the partnership is to foster cooperation between public and private actors at early stages of the research and innovation process in order to allow people in Europe to access innovative and trustworthy European solutions (ICT products, services and software). These solutions take into consideration fundamental rights, such as the right for privacy. It also aims to stimulate the cybersecurity industry,

by helping to align the demand and supply sectors to allow industry to elicit future requirements from end-users, as well as sectors that are important customers of cybersecurity solutions (e.g. energy, health, transport, finance). The cPPP will be instrumental in structuring and coordinating digital security industrial resources in Europe. It will include a wide range of actors, from innovative SMEs to producers of components and equipment, critical infrastructure operators and research institutes, brought together under the umbrella of ECSO.
The EU will invest up to €450 million in this partnership, under its research and innovation programme Horizon 2020. Cybersecurity market players are expected to invest three times more.
The call for proposals of the ECSO PPP are implemented through the Information and Communication Technologies and Security Work Programmes.

Other partnerships and councils

To ensure synergies and maximise the impact of projects active in common areas of application, the EC has encouraged the clustering of such projects. Such clusters represent open fora where experts are working together in identifying research priorities, writing roadmaps for future activities, providing tools for common exploitation and implementation purposes, including international cooperation. In the industrial technologies domain, these partnerships are formed in horizontal areas, namely characterisation, modelling, pilot production, carbon fibers and composites, and safety.

EMCC – European Materials Characterisation Council

Characterisation is a central pillar across the spectrum from research development via engineering and upscaling to production and product quality control. A survey of 100 FP7 projects carried out in 2014 under the umbrella of the Engineering & Upscaling Cluster clearly demonstrated the central role of characterisation. The objectives of the EMCC are:

- To support establishing a community of European stakeholders in the process of developing and improving characterisation tools in order to bring the development of nanomaterials and advanced materials in Europe into end products more successfully;
- To gather the needs and requirements of that community for characterisation tools and supporting actions;
- To provide a forum for discussion, problem solving and planning R&I activities in Europe;
- To establish the formation of standard methodologies on nanocharacterisation in Europe, and create a common background;
- To create a platform for nanocharacterisation, with the attempt to act with Open Research Data;
- To link nanometrology with in-situ monitoring and industrial needs;
- To provide a suitable background for regulation and nanosafety;
- To support EC policy development, underpinning the relevant EC priorities, with a stakeholder driven roadmap for characterisation techniques for engineering and upscaling of nanomaterials and advanced materials in Europe. This activity is to support the strengthening of Europe's industrial capacity and competitiveness.

The EMCC seeks close interactions with other Clusters/Councils, in particular the European Materials Modelling Council (EMMC), European Pilot Production Network (EPPN), NanoSafety Cluster (NSC) and the Engineering &Upscaling Cluster, the EuMaT – European Technology Platform for Advanced Engineering Materials and Technologies, the Research Data Alliance (RDA) and the Nanofutures initiative. There is a strong link to the Alliance for Materials (A4M) as well as to the large European Materials Research Society (EMRS) and the Federation of European Materials Societies (FEMS).

EMCC also seeks interactions with relevant players outside of Europe, in particular NIST Material Measurement Laboratory (MML), NIST Integrated Data Management for Materials Discovery, and a link with e.g. NIMS/Advanced Materials Characterisation Unit in Japan.

EMMC – European Materials Modelling Council

The development of new and improved materials is a significant innovation driver for the global competitiveness and sustainability of European industry and society in general.

It has been demonstrated in many individual cases that materials modelling is a key enabler of R&D efficiency and innovation. Companies reported that computational modelling benefits include reduced R&D time and cost, more efficient and targeted experimentation, more strategic approach to R&D, a route to performance optimisation, wider patent protection, improved supply chain control, enhanced decision making and early understanding of application performance aiding faster and more assured market introduction.

The EMMC enhances **the interaction and collaboration** between all stakeholders engaged in different types of materials modelling, including discrete and continuum modellers, software owners, translators and manufacturers; it **networks with all existing activities taking place in the field of materials modelling, and builds on existing activities in Europe.**

A particularly relevant initiative is a set of recommendations that the EMMC has developed for the Industrial Leadership applicants[22]. In details, **the EMMC strongly advises all LEIT proposers to adhere to the RoMM Language and the CEN Workshop Agreement "Materials modelling – terminology, classification and metadata wherever possible.**

EPPN – European Pilot Production Network

The 2014/15 calls for proposals for pilot action projects resulted in 24 projects with total funding of 115 M€, and another 80 M€ are being invested under the 2016/17 work-programme. These pilot facilities respond rapidly and with simple contracting mechanisms to industry needs which is essential for SMEs and start-ups. Pilot facilities can potentially help create new business, jobs and growth across Europe. This potential can only be fully exploited if the actions started by the European Commission under H2020 are followed-up by complementary initiatives at national/ regional level, to promote coordination mechanisms among these pilot facilities.

One of the recommendations developed by a task-force composed of a group of external experts (mandated by the European Commission) is the implementation of regional innovation hubs that should coordinate efforts, share good practices, facilitate access and promote business development of existing pilot lines across regions and member states.

The overall goal of the coordination and support action managing the EPPN is to boost European competitiveness through the exploitation of the existing European pilot line production facilities in the area of nanotechnology and advanced material technologies, by creating a network of fully connected and collaborating pilot lines, and to boost the effectiveness and the efficiency of existing (and future) pilot line facilities and by creating a digital ecosystem acting as an interactive marketplace for professional members. The action will ensure the delivery of a series of horizontal coordination and support action services to the (European level) network of pilot line facilities and will set the scene for the establishment of innovation hubs across the Member States and/or regions.

CFPC – Carbon Fibres and Advanced High Performance Composites Cluster

Composites are popular as they allow component weight to be reduced without affecting part strength. One of the driving forces is the huge potential market for low cost carbon fibres and high performance composites due to the increasing global demand for lightweight materials across many sectors. In many applications, weight

[22] https://emmc.info/advice-for-leit-proposers/

reductions lead to energy savings during the service-life of the product – there is an oft-quoted statistic that every kilogram of weight saved in the manufacture of a plane reduces emissions by 1 tonne of CO_2 per year.
Specific objective of the CFPC Cluster is to build a high-level expert group to debate on the following topics:

- Optimisation of precursor characteristics to further improve carbon fibre performance properties and costs, through the fostering of collaborations between partners from different countries and effective exchange of innovative ideas;
- Implementation of pilot/industrial facilities capable of manufacturing innovative carbon fibres, as well as carbon fibre preforms and semi-finished products;
- Focus on more efficient and sustainable products and processes based on life cycle assessment studies;
- Development of modelling and simulation tools to provide further understanding of properties and phenomena towards the optimisation of innovative composite materials based on carbon-based reinforcements (nano-fillers as carbon-nanotubes or graphene spheres/platelets and/or carbon fibres) as well as carbon fibre preforms and semi-finished products and related manufacturing processes;
- Development of new or improved characterisation methods/protocols integrating experimental, numerical and analytical techniques;
- Networking and interaction with other networks to promote multidisciplinarity and cooperation in the production of carbon fibres based materials;
- Current failure models must be improved by multi-scale laminate-based analyses incorporating manufacturing defects;
- Cost analysis should be expanded to life-cycle cost;
- Sustainable composite design will require more advanced design concepts such as design for disassembly, reuse/recycling and life cycle assessment;
- The hi-tech material is wasteful to produce and difficult to recycle;
- SMEs tend to require support on a broad spectrum of issues: product stewardship, managing intellectual property, managing internal capacity constraints and managing different types of risk, connected to different TRLs;
- SMEs often require adoption of a ‘trial and error’ approach to address their research needs not just due to a lack of provision but also because they frequently cannot be certain (especially at early stages of exploration) of what type of support / provision they require;
- Financial limitations can affect the search ‘pathway’ since the time this takes can have detrimental impacts on the SME’s financial sustainability;
- Breakthrough testing is more expensive, while incremental (more mainstream) demand can be easier to satisfy.

Nanosafety Cluster

The EU NanoSafety Cluster maximises the synergies between European-level projects addressing the safety of materials and technologies enabled by the use of nanoparticles. The studied aspects include toxicology, ecotoxicology, exposure assessment, mechanisms of interaction, risk assessment and standardisation, with a focus on regulatory aspects.
The Cluster is an initiative of the European Commission Directorate-General for Research and Innovation (DG RTD), which sponsors these large projects. Overall, Europe targets safe and sustainable nanomaterials and nanotechnology innovations. Cluster projects contribute to assuring environmental health and safety (EHS) of this Key Enabling Technology.
The Cluster also is an open platform for dialogue and exchange between researchers, regulators, administrators, industry and civil society representatives. Its main objectives are the synergy among these projects, collaboration

for maximising impact, policy elaboration, planning of future actions, and international cooperation are the main aims of the NanoSafety cluster, projects and stakeholders open forum. In details it aims:

- To facilitate the formation of a consensus on nanotoxicology in Europe;
- To provide a single voice for discussions with external bodies;
- To avoid duplicating work and improve efficiency;
- To improve the coherence of nanotoxicology studies and harmonise methods;
- To provide a forum for discussion, problem solving and planning R&D activities in Europe;
- To provide industrial stakeholders and the general public with appropriate knowledge on the risks of nanoparticles and nanomaterials for human health and the environment.

5. CONCLUSIONS AND THE OPPORTUNITIES FOR LUXEMBOURG

This document summarises the landscape of European Policies and initiatives in support of Industrial Technologies, with a specific focus on the technologies enabling the transition towards a digitalisation of the manufacturing sector. This report also provides an oversight of the different partnership schemes active in this domain, to guide stakeholders in their application process but also to promote their active involvement into such partnerships. This latter is particularly important as these partnerships provide the European Commission with strategic and scientific advice in the definition of the work programmes. Being active members in those fora will offer the unique opportunities of having a direct input in the process leading to the publication of calls for proposals, with a clear understanding of the background information, networking with the most influential stakeholders in these areas.
Several connections exist between national priorities and the activities performed within the Clusters initiatives supported by Luxinnovation, and the initiatives described in the above sections. In particular, the Materials and Manufacturing sector is extremely well aligned with the priorities set up in the European KETs strategy. The European Funding Team of Luxinnovation will be keen to support the national stakeholders in the identification of the most relevant partnerships and their involvement. Our aim is indeed to provide strategic advice to all potential players through the whole proposal preparation process, from the concept development to the submission, and then in the management of successfully funded projects.

For further information, please visit our website: www.horizon2020.lu

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