European Commission

RE-FINDING INDUSTRY

Report from the High-Level Strategy Group on Industrial Technologies

Conference Document

23 February 2018

Research and Innovation

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EUROPEAN COMMISSION

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Directorate-General for Research and Innovation
Key Enabling Technologies

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1 Introduction

With the stabilisation of the euro, the election of the President of the European Commission by the European Parliament and the Future of Europe process launched at the 60th anniversary of the Rome Treaty, Europe has recovered its capacity to act.

Growth was low and unemployment high between 2000 and 2017. However, the most striking feature over this period is the dissimilarity between Member States: average annual rates of GDP growth varied from 0.4 % to 4.4 %, average rates of unemployment from 4.6 % to 15.5 % and youth unemployment from 8.3 % to 35.7 %. The target to invest 3 % of the EU's gross domestic product (GDP) in Research and Development (R&D) and the associated job creation[1] has not been met. In fact, the R&D investment rate stagnated at 2 % of GDP, with differences among Member States ranging from 0.6 % to 3.3 %.

These figures contrast with the EU's repeated policy ambitions to become the world's most competitive and dynamic knowledge-based economy. It would seem that there is no deficit of awareness, but of implementation. The EU's Research and Innovation (R&I) policy is underfinanced and not sufficiently aligned with national policies. Member States have cooperation and financing problems. In short, the EU did not manage to implement a common economic and industrial policy, which would reduce disparities. Achieving this will be crucial for the future of Europe: it is founded on the values of equality and solidarity and, in a world of global competition, has filled these values with life probably better than any other continent.

While some argue that technological innovation leads to more inequality in wages and wealth[2], it is more likely that today's increasing inequality is the result of insufficient uptake of technological innovations and a failure to diffuse them widely.[3] Economic growth no longer reduces inequality.

Therefore, Europe not only needs to complete the internal market but also to develop a new industrial policy aiming at inclusive productivity growth and convergence across its Member States. This will help the EU to deliver on the objective of a 'highly competitive social market economy' (Article 3 of the

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[1] Up to 3.7 million jobs in 2025, P. Zagamé (2010), The Cost of a non-innovative Europe.

[2] Frey and Osborn, The future of employment, 2013.

[3] W. Naudé, P. Nagler (2017). Technological Innovation and Inclusive Growth in Germany, Bertelsmann Stiftung Gütersloh, arguing that the welfare state has to increase low incomes and at the same time improve the conditions for competition so that companies can increase wages and invest.

Lisbon Treaty), which seeks to guarantee everyone a chance for upward social mobility and a balance in living standards between urban and rural areas.

Industry is typically the largest source of business R&D in advanced economies, has larger technological and economic multipliers than other sectors, and is closely linked to knowledge-intensive services.

It is against this background that we see the mandate given to us by the European Commission to review key enabling technologies and suggest the best possible ways to maximise their industrial deployment, leadership in strategic technologies of the future and societal impact.[4]

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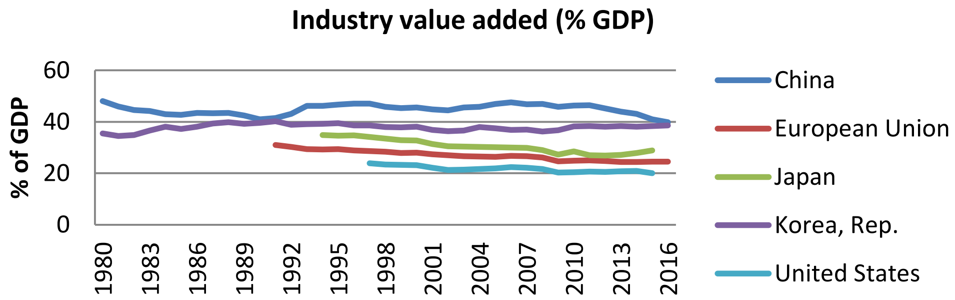
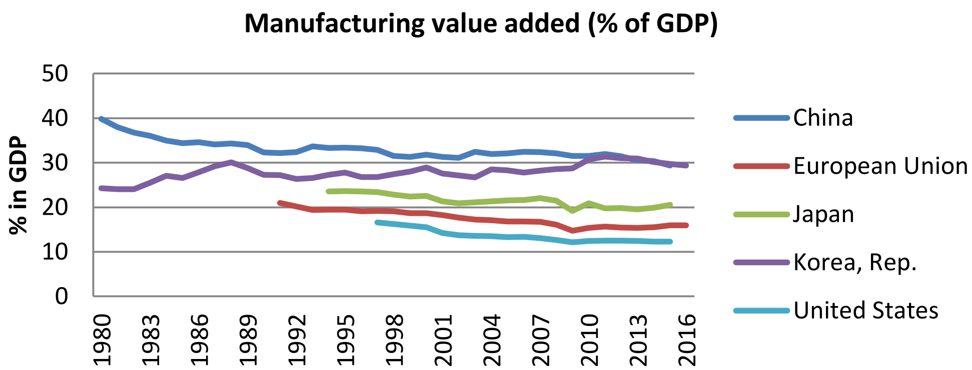
[4] Terms of reference of the Horizon 2020 High-level Strategy Group on Industrial Technologies (E03540) http://ec.europa.eu/transparency/regexpert/index.cfm, Renewed EU Industrial Policy Strategy — 27.6.2017, COM(2017) 479 final.

2 Industry in Europe

Since 2000, Europe has experienced a significant de-industrialisation. For instance, the contribution of manufacturing to European GDP decreased from 18.5 % in 2000 to 15 % in 2012, and 3.8 million jobs were lost between 2008 and 2012 in this sector.

Figure 1: Share of industry in GDP in selected economies (industry and manufacturing value added)





Source: World Bank

However, this does not mean that industry is going in the same direction as agriculture about a century ago, with a slow but continuous reduction in its overall role in the economy.

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[5] 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

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5 These figures include manufacturing, extractive industries and utilities industries. They exclude business services and construction which are, however, closely linked to EU industry, not least against the backdrop of the growing role of value chains and servitisation.

and 2 jobs in other sectors. More than 80 % of EU exports are generated by industry.[6]

In addition, strengthening the industrial base builds more resilient economies. For example, following the economic crisis, EU Member States with a strong industrial base recovered more quickly.

Finally, recent years have seen a reversal in the decline of EU manufacturing, with impressive growth rates as regards[7]:

- 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 CO_2 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.[8] However, on balance, the number of companies and industries which 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.

Despite this increased productivity, Europe's industry faces several challenges.

The first critical issue is how already-developed and emerging technologies diffuse. By one estimate, even in Germany, leader in industrial production, 'the full shift to industry 4.0 could take 20 years'[9]. The issue is twofold. Firstly, it is about increasing the numbers of new companies entering the market and helping them to grow. Secondly, it is about increasing productivity in established companies which face obstacles to implement new technology. In the second case, small and medium-sized enterprises (SMEs) in particular tend to use key enabling technologies less frequently than larger companies. In Europe, for instance, 36 % of surveyed companies with 50-249 employees use industrial robots, compared to 74 % of companies with over 1 000 employees.[10]

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

[7] Eurostat, taken from COM(2017) 479 final, 13.9.2017.

[8] Miller, B. and R. Atkinson (2013), 'Are robots taking our jobs, or making them?', The Information Technology and Innovation Foundation, http://www2.itif.org/2013-are-robots-taking-jobs.pdf.

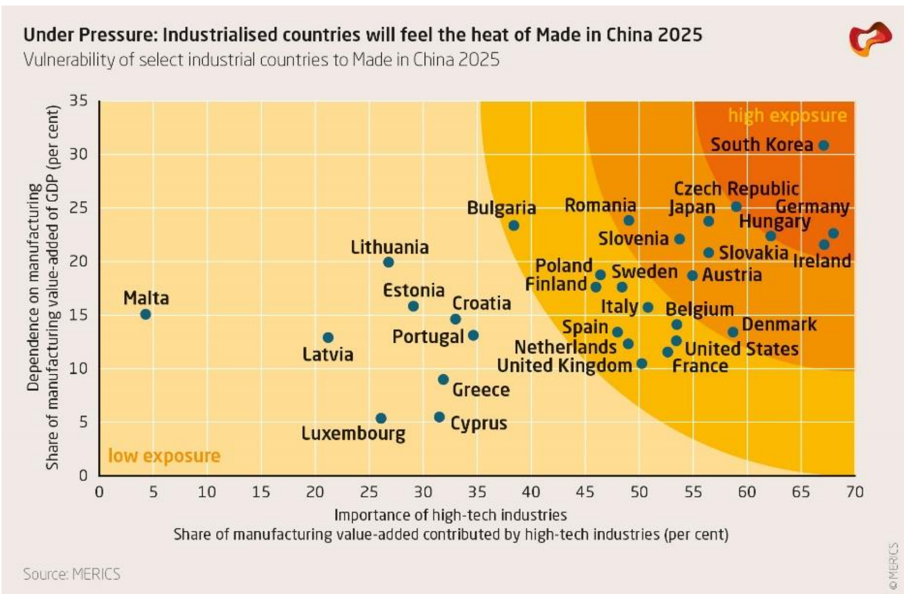
[9] Lorentz, m. et al. (2015), 'Man and machine in Industry 4.0: How will technology transform the industrial workforce through 2025?, The Boston Consulting Group, https://www.bcgperspectives.com/content/articles/technology-business-transformation-engineered-products-infrastructure-man-machine-industry-4/.

[10] Fraunhofer (2015), 'Analysis of the impact of robotic systems on employment in the European Union',https://ec.europa.eu/digital-single-market/news/fresh-look-use-robots-shows-positive-effect-automation.

Only one fifth of EU companies are highly digitised[11]. Only one in five manufacturing companies has already used advanced manufacturing solutions.[12] Addressing these two aspects of technology diffusion — firm entry and growth, and more general adoption — involves different policy instruments.

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 strategy aims to upgrade China's industrial base by focusing on 10 key industries.[13] In the short and medium term, this strategy can present attractive opportunities for some European businesses to provide critical components, technology, and management skills. However, in the long term, Made in China 2025 amounts to an import substitution plan. Market access for European business can be expected to shrink, especially in areas where Chinese companies are able to close the technology gap[14] (Figure 2). The increased international competition is also visible in the decline of total manufacturing employment in advanced economies. In the United States for instance, between 2000 and 2014 the decrease was about 10 %,[15] and 10 out of 19 manufacturing sectors produced less in 2015 than in 1999. This means it is essential for the EU to support the competitive development of strategic value chains in which most future manufacturing jobs are likely to be created in Europe.

Figure 2: Vulnerability of selected countries to Made in China 2025



[11] Europe's Digital Progress Report, SWD(2017) 160.

[12] Innobarometer, 2016.

[13] 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.

[14] The European Union Chamber of Commerce in China.

[15] From 19.5 million jobs in 2000 to 15 million in 2014.

Thirdly, increasingly globalised value chains and digital transformation are structurally changing the labour market and the nature of work. This is expected to have significant repercussions for the types of work available. Accordingly, 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 continuously improve, to boost employability and competitiveness. By current estimates, more than 70 million adults in the EU are affected by gaps in basic skills.[16] 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.[17]

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[16] COM(2017) 479 final, 13.9.2017.

[17] European Commission Blueprint for Sectoral Cooperation on Skills: Automotive. (http://europa.eu, 2017).

3 Key enabling technologies — State of play

3.1 EU policy on KETs since 2009

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'.[18]

The six KETs identified in 2009 were:

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

The concept of KETs has been instrumental in policy-making and programming in the run-up to the current Multiannual Financial Framework (2014 – 2020).

The programme structure and technological scope of the "Leadership in enabling and industrial technologies pillar" of Horizon 2020 are based on the 2009 list of KETs.[19] KETs are also a priority under the Structural Funds.[20] 65 % of EU regions and 15 Member States indicated one or more KETs as a smart specialisation priority. KETs are the second highest chosen priority for R&I under the regional smart specialisation strategies. State aids rules have also been modernised in 2014 to help Member States better support investments in KETs.

A Memorandum of Understanding between the European Commission and the European Investment Bank facilitates access to finance for investments in KETs (with EUR 11.8 billion in EIB lending in the period 2013-2016).[21]

A communication on the criteria for important projects of common European interest (IPCEI) has been adopted, and highlights the importance of these projects for the KETs policy. Several IPCEI projects are currently under preparation, and build on KETs research under Horizon 2020.

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18 COM(2009) 512.

19 For example, the MIDES project (http://midesh2020.eu/) aims at giving millions access to drinking water thanks to advanced microbial desalination materials using a low-energy process of producing safe drinking water; the project SONO (http://cordis.europa.eu/project/rcn/92 784_en.html.) uses nanotechnologies to fight hospital-acquired infections by impregnating hospital textiles, such as bedding and bandages, with antibacterial copper oxide and zinc oxide nanoparticles.

20 Article 5 of the European Regional Development Fund highlights in particular 'pilot lines, early product validation, advanced manufacturing capabilities and first production, in particular in KETs'.

21 http://ec.europa.eu/growth/content/memorandum-understanding-between-european-commission-and-european-investment-bank-eib_en.

Actions have also been taken to address the need for multidisciplinary skills in KETs and to develop a vision for KETs skills, including through specific measures such as support to develop and adapt curricula under the COSME, Europe's programme for small and medium-sized companies.

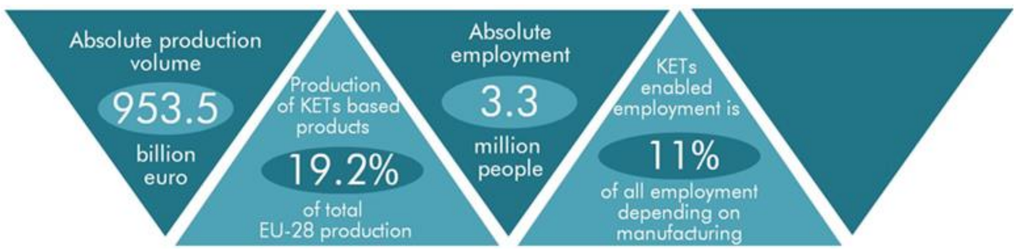
3.2 The economic importance of KETs

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.[22]

In 2013 (the latest year for which data are available), KETs-based products represented 19 % of total EU-28 production (EUR 950 billion), as 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[23]. Approximately 10 000 SMEs based their business on the development and commercialisation of KETs.

For instance, by the end of 2015 the EU photonics industry employed 290 000 people, compared to 235 000 people in 2005 (+23 %). 42 000 new jobs could be created in photonics by 2020.[24] European photonics production has grown by 5 % a year on average since 2005 and the European photonics market is estimated at EUR 69 billion.

Figure 3: Value created by the deployment of KETs in industry



Source: KETs Observatory, 2013 Eurostat data

The Regional Innovation Scoreboard (2016) also shows that regions which specialise in KETs report a positive and significant effect on economic performance. Specialisation in other fast-growing technologies does not have the same impact.[25] This is also valid for regions characterised as 'modest' or 'moderate' innovators (Figure 4). The potential for regions in the process of catching-up is even higher: the lower the technological advancement of a region, the higher the impact of specialisation in KETs on its growth.

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22 COM(2017) 479 final, 13.9.2017.

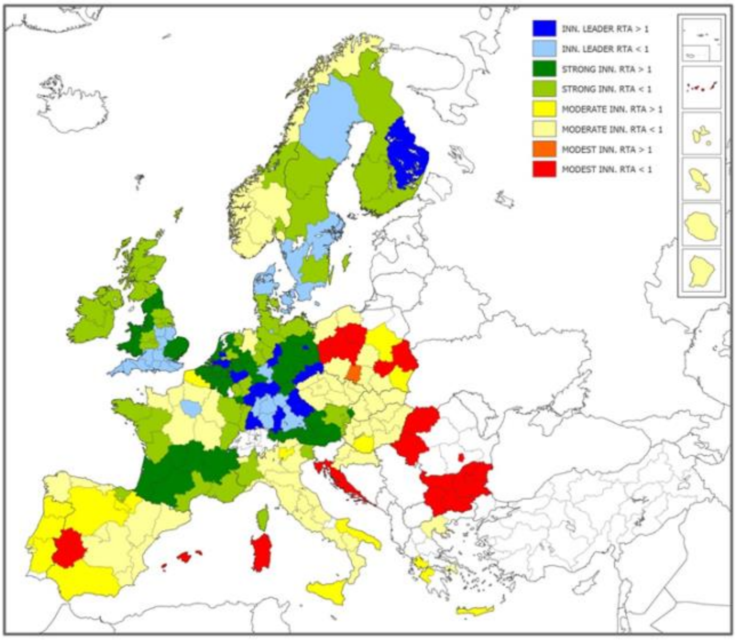
23 Van de Velde, E. / Debergh, P. / Wydra, S. / Som, O. / de Heide, M. (2015). Key Enabling Technologies (KETs) Observatory: Second report: European Commission, DG GROW.

24 Photonics21 (2017). PPP Impact Report 2017. Jobs and growth in Europe — Realising the Potential of Photonics.

25 Ibidem.

Figure 4: Regional Innovation Scoreboard 2016 ©

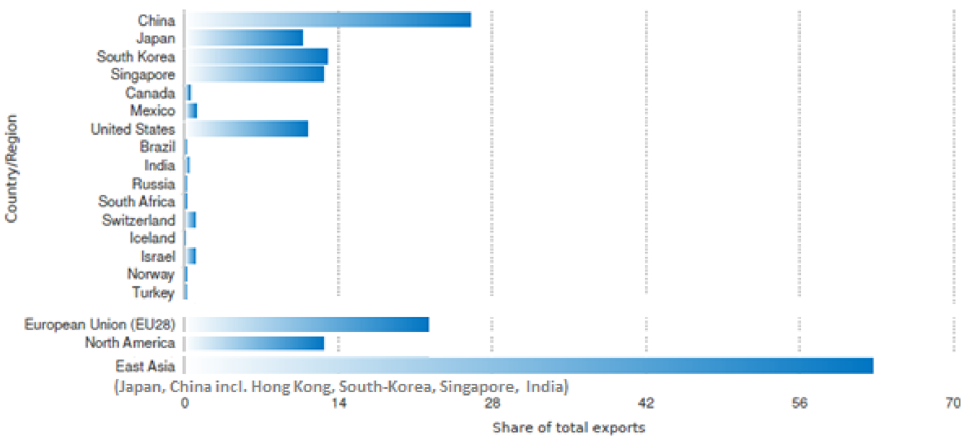
Regions with a positive specialisation in KETs are located everywhere in the EU



EU KETs-related exports grew from 2007 to 2015, with the exception of micro- and nano-electronics, which faced increasing competition from the US and Asia. Available data for 2010 and 2015 suggest that while Europe increased its KETs-related exports, East Asia (Japan, China, South Korea, Singapore and India) registered a considerably higher increase, with China's performance being particularly strong. Starting from 2015, the EU-28 has outperformed North America (US, Canada and Mexico) by approximately 30 % in shares of total exports for technology generation and exploitation by (Figure 5).

Figure 5: Technology generation and exploitation, share of total exports

Comparison by countries/regions for all KETs in 2015



Source: European Commission, KETs Observatory, 2017

While the EU runs an overall trade surplus for manufactured goods[26], a closer look at exports of high-tech products and KETs-based products reveals a deficit for these sectors. In 2015, the EU showed an overall deficit of EUR 63.5 billion in trade in high-tech products with the group of 20 leading trade partners. The largest deficit for high-tech products was with China. Among the top 20 partners, the EU had a trade deficit in the high-tech sector with eight other countries: Vietnam, Malaysia, United States, Thailand, Switzerland, South Korea, Japan, and Singapore.

[26] EUR 224 billion between January and October 2017.

4 The key enabling technologies for the future– "KETs 4.0"

4.1 The main underlying challenges

In addition to broader economic and social challenges, such as rapid population ageing, slowing growth in labour productivity, rising inequality, protracted unemployment, and climate change, there are three main challenges for Europe's industry:

- Increasingly knowledge-intensive production;
- Digitisation, which is closely linked to the first challenge; and
- Globalisation, and in particular competition from a number of emerging market economies, of which China is the most significant.

Throughout history, progress has been associated with knowledge. In feudal societies, value came from the production factors 'land' and 'labour', in industrial societies value depended on the production factors of 'capital' (i.e. machines and equipment) and 'labour'. In the knowledge society, the classic production factors of land, capital and labour are added to and amplified by 'knowledge'. Knowledge has become the most important resource of our time. In distinction to land, capital and work, knowledge increases when shared with others. And, fundamentally, knowledge is now generated and disseminated at greater speed than at any time in the past, owing to digital technologies. Knowledge is also the new social question of the 21st century, as equal access to knowledge is crucial to reduce disparities.

The knowledge society will be accelerated by the widespread digitisation of the economy and society, leading many to call this process the 'digital revolution'. It is a process comparable in its scope and impacts to the industrial revolution of some 200 years ago.

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.[27] This paradigm shift requires new policies for infrastructure, research and development, industrial value chains, education and training, regulation and standards, data protection and co-creation.

While international cooperation and trade has been going on for a long time, the scale and speed of widespread globalisation is unprecedented. The globalisation of the economy changes the world and is also part of a changed world. In recent decades, millions of people have been able to escape poverty thanks in part to globalisation. At the same time, ever more people fear that their jobs are at risk, that research and production will be relocated abroad and that their countries could be drained of capital and investments. Others fear the loss of national power, native cultures and traditions.

[27] COM(2016) 180 final.

4.2 Technology foresight

The ongoing revolution in industrial production – Industry 4.0 - results from a confluence of fast-developing technologies. These range from a variety of digital technologies (such as 3D printing, the Internet of Things, advanced robotics) and new materials (bio- and nano-based) to 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. They have been identified as strategic technologies by China in its Made in China 2015 strategy, by South Korea under a USD 1.5 billion initiative and by the US as part of a strategic programme run by the US National Science Foundation.

As regards future technologies, several foresight studies have 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). The six KETs figure prominently in that list.[28] Foresight studies conducted or commissioned by national authorities show that KETs will continue to play a very important role in the future.[29] European Commission studies on future technologies also indicate that the existing KETs remain essential in addressing the major challenges that society will face in years to come.[30] The KETs Observatory also analysed eight promising value chains based on KETs, which match several regional thematic partnerships for industrial modernisation.[31]

4.3 The next generation of key enabling technologies

Europe's competitiveness lies in our capacity to create balanced, cohesive, well educated, healthy and protected societies. Therefore, KETs must contribute to improving peoples' lives, fighting poverty and correcting inequalities.

Against this background, we suggest a new, broader definition of KETs, based on the following four criteria: impact, relevance, key capacity, and enabling power.

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28 OECD (2016). Science, Technology and Innovation Outlook 2016.

29 Technologies clés 2020: préparer l'industrie du futur 2020. Etude conduite par le ministère de l'Economie, de l'Industrie et du Numérique (2016).
Fraunhofer ISI (2014). BMBF Foresight Cycle 2. Study conducted for the Federal Ministry of Education and Research (BMBF, Germany).
Russia 2030: Science and Technology Foresight (2016)
Forschungs- und Technologieperspektiven 2030 (2015)
100 opportunities for Finland and the world, Parliament of Finland, Committee for the Future (2015).)

30 EC [European Commission] (2015). Preparing the Commission for future opportunities – Foresight network fiches 2030. EC [European Commission], DG RTD (2015). The Junction of Health, Environment and the Bioeconomy: Foresight and implications for European Research & Innovation Policies.

31 http://s3platform.jrc.ec.europa.eu/thematic-areas

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

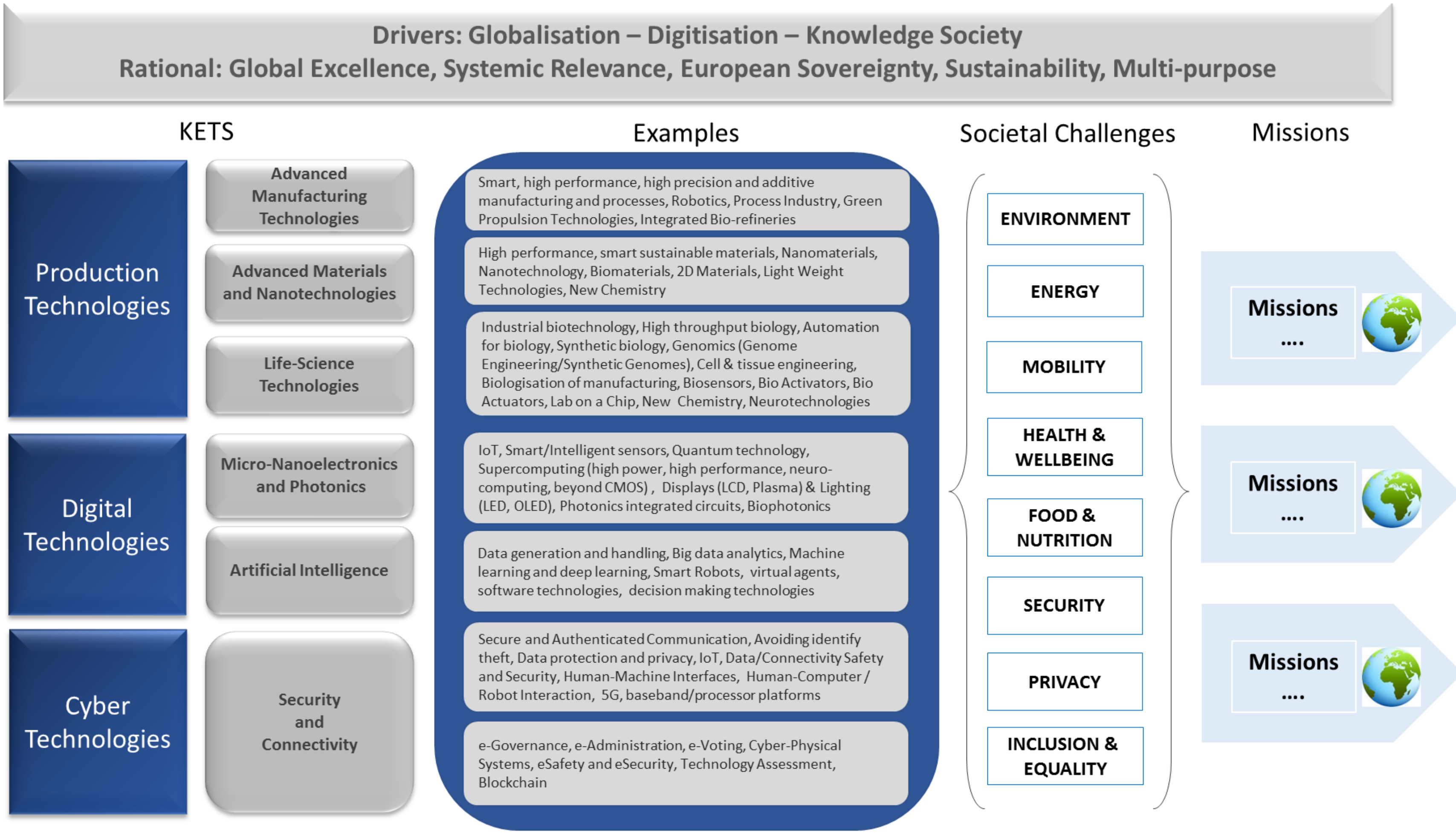
KETs have systemic relevance for all phases of product development, ensuring Europe remains a leader across industrial value chains. This also includes societal participation to support democratic engagement.

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, we recommend:

- 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:
    i. artificial intelligence,
    ii. 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
Advanced Manufacturing Technologies
Advanced Materials and Nanotechnologies
Life-Science Technologies
Digital Technologies
Micro-Nanoelectronics and Photonics
Artificial Intelligence
Cyber Technologies
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 ....

4.4 Implementation

The six KETs identified in 2009 have been receiving priority-support under EU research and innovation programmes. Some EUR 6.6 billion, or 8.5 % of the total Horizon 2020 budget, was allocated to these six KETs. Given the crucial role of KETs for the economy and the society described in section 3, and the need to use public and private investments in R&I to boost the competitiveness of EU industry, an adequate level of support should be earmarked in the next EU budget. We fully support the first recommendation of the Lab-FAB-APP report, known as the 'Lamy report'[32] to prioritise research and innovation in EU and national budgets, notably to double the budget of the post-2020 EU research and innovation programme.

In addition, support in the next EU research and innovation framework programme must also adequately reflect the two additional KETs as well as the wide scope of the 'life sciences technologies'. For instance, the global market for artificial intelligence in 2022 is estimated at some USD 20–24 billon[33], with a compound annual growth rate of more than 45 % from 2016 to 2022. This market growth calls for a commensurate additional allocation in the future EU budget, with an appropriate balance between physical and non-physical technologies. By harnessing non-physical technologies, such as security, connectivity, and AI, European industries can enhance productivity and performance, and strengthen their competitive advantage, while enhancing resilience.

Access to infrastructures for new technology and products testing and validation is essential to accelerate technology transfer and enter emerging markets. At the national level (notably in Sweden, Germany, and the Netherlands) and at the international level (notably in the USA and China), specific strategies have been formulated to support access to those infrastructures and make them open, shared and accessible. Now is the time for a jointed-up approach at EU level to upgrade and build industrial infrastructure in key areas across the Union and to make them fully accessible.

Moreover, directly engaging industrial players in collaborative research has proven to be critical for strategic planning and technology uptake. Contractual public private partnerships have been shown to be important in mobilising private investment in research and improving technology diffusion.

The Expert Group intends to present a second memorandum on the initiatives needed to create an excellent innovative system and future-proof infrastructure, again in view of the forthcoming research and innovation programme.

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32 http://ec.europa.eu/research/evaluations/pdf/archive/other_reports_studies_and_documents/hlg_2017_report.pdf

33 https://www.statista.com/statistics/607716/worldwide-artificial-intelligence-market-revenues/
https://www.alliedmarketresearch.com/artificial-intelligence-market

5 Mission-oriented policy

A mission-oriented policy approach has emerged as key element of the new industrial policy. To help create inclusive growth and new jobs, industrial policy needs to be built around missions that fully encompass key enabling technologies. Doing this will help provide the best possible conditions for the European economy to be social and sustainable, while also being internationally competitive."

Only in this way will the European economy continue to be social and sustainable, while maintaining its international competitiveness.

The missions are developed within the framework of an innovation system comprising private and public agents, researchers and educators, producers and innovators and, of course, civil society. Civil society has a central role in identifying the main challenges, and must be actively involved in the development of missions and projects. The role of society in the missions and projects is not only in the execution phase, but also in most phases of the public policy cycle. Civil society must also take part in the identification of the problem itself, in setting the agenda for solutions, in the policy making and evaluation. Communication with society should aim to share the results of these missions and also to raise awareness of the impact of innovation activities, the need to share risks and benefits and the need to develop a pro-innovation culture.

This means that the societal effects of innovation must be closely monitored, and strategies developed to address new problems, making sure that the ensuing social changes as well as the effects on the environment correspond to the expectations of EU citizens.

The new mission-oriented policy should aim to promote re-industrialisation through higher and more widespread productivity growth, new jobs, new company creation, relocating outsourced work places, and strengthening the European knowledge base through world-leading education and training.

Mission-oriented policy should focus on multi- and cross-sectional technologies and multilateral efforts.

Our proposals for missions are based on the following criteria:

- Missions should have clear goals, be understandable to the public, and be specific while not covering many issues.
- Missions should be defined not in terms of impact but in terms of a viable solution that can be applied and replicated. Impact is important but comes after the result is obtained, when it needs scaling up.
- Missions should not be limited to sectors having a public client; their scope needs to cover many sectors and involve a range of public and private actors.
- Missions should generate expectations and encourage participation from the public, including young people.

Missions should also consider the global 'megatrends' of the coming decades which will affect all continents and all parts of society, as identified by the European Investment Bank, notably:

i. population growth and food shortage in developing countries,
ii. population ageing in advanced economies,
iii. urbanisation, and
iv. sustainability.

On this basis, we have identified the following exemplary missions as a contribution to the debate on the direction of future EU research and innovation investments:

1) An inclusive democratic society
2) Industry renewal
3) Digitalisation as a European jobs engine
4) Transforming thoughts into action – the new internet
5) Circular economy – shift to de-production and re-production
6) Clean and safe mobility - re-founding car industries
7) Carbon re-use - from climate killer to industry asset
8) Energy independence - affordable renewables
9) European healthcare networks - breakthrough in disease prevention and treatment
10) Bio manufacturing – bringing life to manufacturing
11) Re-inventing food production - sustainability and traceability
12) Biodiversity – saving bees and other pollinators
13) Oceans of drinking water – starting with affordable desalination
14) Bouncing back – making Europe's society more resilient

1) AN INCLUSIVE DEMOCRATIC SOCIETY

Goals: Digital technologies should be used to enhance a democratic and secure Europe and thus to overcome societal divisions, populism and radicalisation. The digitisation of society presents a risk of social exclusion. However, if used properly, the potential exists of creating a unified democratic, transparent digital Europe; a Europe where citizens can voice their views and take a more active role in decision-making processes. This mission aims to build a connected and secure Europe that generates social and economic equality.

Impact and relevance: Connectivity is an essential prerequisite and right for all citizens to participate on equal terms in our democracy. Broad groups of users can be connected via the internet, practice e-learning and e-voting, participate remotely in democratic processes and exercise online activism while preserving privacy and safeguarding anonymity. At the same time, technologies are being exploited to undermine democracy, for example via the spread of 'fake news', including from foreign entities. Europe has to take the path of using technology to drive equality, democracy, unity and security for citizens. Technologies that support e-government, e-voting, e-health platforms, a secure internet for information, a connected society with the right to be digitally connected, no matter where a person lives, can enhance democratic participation, security, and equality and help build a united Europe. Moreover, enhanced forms of participation will allow European societies to become more resilient, while building the capacity to provide flexible answers to increasingly frequent and severe climate-related disasters and hazardous events.

Solutions: The EU needs to develop a core principle in the human rights and freedoms charter to recognise access to fast and secure internet as a key enabler for democratic participation, the rule of law, societal inclusion and equality. De facto, monopolies by technology giants need to be avoided and, where other continents favour total tapping of personal data or total surveillance, Europe's path will be characterized by the full protection of private data. Programmes, funds and regulations need to be dedicated to eradicate digital exclusion and enhance participation. Additional funding is needed to drive connectivity, assist technology adoption and ensure no EU citizen is left behind. Programmes in the national education system, health, e-government processes and social assistance programmes need to be coordinated and work together across Europe to realise their full potential.

2) INDUSTRY RENEWAL

Goals: The goal is to generate industrial renewal in Europe, such that the continent becomes the global leader in producing and using the key technologies of the next industrial revolution, with leadership capabilities becoming widely diffused. This means achieving a substantial increase of productivity and production, an increased share of global industrial exports, more persons employed in manufacturing, a doubling of overall industrial resource efficiency and the share of firms using advanced (digital and other) production processes, as well as halving dependency on fossil fuel resources and, industrial waste released to air, water and soil.

Impact and relevance: Future European industry has to combine high and widespread productivity with a high level of environmental sustainability. This will mean moving from local optimisation – for individual factories or clusters of firms - to complex system optimisation, with major impacts on the way factories are designed, the technologies factories use, infrastructure and wider government policies (for instance in education, research and infrastructure). Regions and countries with highly productive industrial capacities will generate skilled jobs with decent salaries, thus contributing to European social cohesion.

Solution: The introduction and wide diffusion of new production technologies and processes (including in traditional industries) such as advanced connectivity solutions, flexible automation and robotics, additive manufacturing, zero-defect manufacturing, combined and hybrid technologies together with holistic resource-efficient approaches, will help ensure the industrial leadership of Europe. More sustainable vertical factories and mini-factories in cities, direct and reverse logistics in cities (for the reuse of products and materials), production of personalised products close to customers, human robot cooperation, modular and transportable factories, and innovative production equipment are just some of the technical solutions that need to be developed. Diffusion must occur across and within countries and across firms of different size. The development of co-creation design, manufacturing and service platforms will significantly reduce the time to market, while boosting Europe’s competitiveness.

3) DIGITALISATION AS A EUROPEAN JOBS ENGINE

Goals: Europe has the opportunity to capitalize on its knowledge base and highly educated workforce to develop a "Smart Growth" approach establishing digitalisation as European jobs engine.

Impact and relevance: Digitalisation is a global trend of major transformative character, comprising all areas of daily and professional life. Businesses, consumers and industry are increasingly using digital technology to grow, overhaul workflows and generate efficiencies and to develop new products and services.

As digitalisation is driven primarily by knowledge and know-how, it presents a huge opportunity to build on Europe's strengths and compete on the market. As such, digitisation, and accompanying social and economic policies, can become a job opportunity for Europe to establish itself as a global leader and main hub for expertise, while sustaining and improving Europe's societal and economic model.

Solutions: There are three main types of digitalisation to open up new opportunities for growth and to generate new jobs:

Efficiency-driven: Increased efficiency and scale from digitalisation will impact production chains and potentially make certain layers redundant. This will clearly have disruptive effects on the labour market: a future-oriented and lifelong-learning employment and education strategy will be essential to re-train and upskill people for the new jobs created by digitisation. It is important to recall that increased efficiency will give more people access to products at lower costs and therefore support standards of living and well-being. An example is the application of automation in the logistics sector.

Evolution-driven: With respect to the evolution of new products and services, the resources and number of jobs are more or less stable, although higher-quality jobs will emerge. An example is the development of new smart phone generations with new technology/service features that enable new types of business and activities.

Market-growth oriented: With respect to applying digitalisation to open/access new markets and developing new business models, new job profiles will develop and the number of jobs will increase. Examples are the various data-based approaches using digitalisation technologies that open up new business models and innovation.

4) TRANSFORMING THOUGHTS INTO ACTIONS - THE NEW INTERNET

Goal: To enable people to act at a distance while still being in control of the process. The dream of mankind has always been to transform thoughts into actions. We are at the beginning of a new era in which by means of sensors, actuators, communication and big data processing, it is becoming possible to act on reality in a pervasive way. Applications cover many fields, from healthcare (e.g. surgery) to industry applications (e.g. remote operation of production), from home applications to security, from inspection to exploration and, in general, all the fields of application which enlarge the capabilities of human beings to act in distant, harsh, dangerous, and small-scale environments but also, more simply, standard environments where an individual cannot be present.

Impact and relevance: Up to now, the US has been dominating the internet and its applications. With the new internet era, there is a great opportunity for Europe to gain a central position. Indeed, Europe is well advanced in robotic platforms, mechatronics and automation which is at the core of the new transformation. Europe has a long tradition in this field, with many innovative companies which are very agile in creating new devices and applications tailored to different needs. Therefore, Europe has the potential of being the first mover in the creation of the new domain of the internet. This in turn has the potential to open the way to new products and services that we never dreamed of. With its strong democratic tradition, Europe can develop this new revolution taking into account the rights of people faster than others, and with the human being at the centre of the new developments.

Solutions: To develop new sensors and wearable devices that enable personal interaction with reality without being physically present. Physical devices should be able to guarantee reliability, safety and robustness, taking into account the impact of physical laws, the interaction with human beings, interaction with nature, and interaction with other devices. This requires high performance computing, quantum computing, ultrafast communication, optical fiber, optical communication and networks, system connectivity, power electronics, printed/flexible electronics, memory and storage, analogue and mixed signal devices, heterogeneous integration/embedded systems, optical components and systems, robotics, mechatronics, sensor technologies, smart manufacturing, human-machine interaction, virtual reality, intelligent/sensor-based equipment, electronic and optical functional materials, energy storage and generation, surface engineering and coatings, monitoring and control, connectivity standards, big data analytics, and sensor fusion.

5) CIRCULAR ECONOMY: SHIFT TO DE-PRODUCTION AND RE-PRODUCTION

Goal: Rather than reusing only the material or the energy they contain, products should be turned into competitive multi-life products. Products are developed in order to provide certain functions that are of interest to the user. Once the product reaches the end of life, instead of scrapping the product, most of the functions should be reused in new products. This is highly efficient since most of the value of the product can be regained in this way. Therefore, if appropriate solutions are developed, second life products can become more competitive than products produced from scratch. Since the growing needs of the society cannot be met even with 100% reuse of raw materials, new substitute materials are needed as well as sustainable methods for societally accepted exploration, mining and mineral processing in Europe.

Impact and relevance: The introduction of a circular economy has the potential impact of updating the whole of European industry and Europe can become the biggest market in the world based on circular economy. The circular economy not only is respectful of the environment, but it can create more competitive products since it allows the reuse of existing functions. Potentially, all the production systems will eventually be modified to incorporate de-production and reproduction technologies, logistic and reverse logistics will be integrated, and business models completely changed. The renovation of infrastructures, industry, and related services has the potential of mobilizing a tremendous volume of new investments and create new jobs. Also, new technologies and new machines will be created and exported to other regions of the world. A marked reduction of end-of-life products polluting the environment could be attained. As of today, many new environmentally and climate friendly technologies and products require resources that are scarce or inexistent in Europe. Full recyclability will therefore secure European sovereignty in raw materials supply for de-production and re-production.

Solutions: To develop new product design methods and tools that consider the many lives of products. Collect, monitor and analyse information over the life of the product, inspect products to identify the possibility of regaining functions, separate product modules without jeopardizing their functions, automatically repair the functions, upgrade existing functions, integrate production with de-production and re-production to define new business models based on the loyalty of the client through multiple use of the product, create new product functions for the continuous interaction with the user, develop material substitutions of critical elements and scarce materials, substitute non-renewable by renewable materials wherever possible, design new methods and technology for collecting, dismantling, shredding, separating, and recycling, apply new bio-materials as engineering material, develop resource efficient manufacturing processes to reduce scrap and swarf, develop new methods and technologies for sustainable exploration, mining and mineral processing.. This all requires robotics, advanced manufacturing, Smart manufacturing, optoelectronics, X-ray vision, mechatronics, Internet of Things (IoT), Intelligent/ sensor-based equipment, Intelligent/ sensor-based equipment, Big data, forecast models, Product design, Life Cycle Assessment, system design, supply chain design. In addition, using biobased manufacturing and products facilitates biodegradation and reuse as well as carbon recycling as feedstocks for new products.

6) CLEAN AND SAFE MOBILITY - RE-FOUNDING CAR INDUSTRIES

Goals: Europe should become the global leader in emission-free vehicles and autonomous mobility (electric/hybrid and autonomous/partially-autonomous). This will reduce by half traffic fatalities and lead to sustainable autonomous mobility systems, emission free, ready for practical use, and at affordable costs.

Impact and relevance: Employing about 3 million people in manufacturing and another 11 million in services, the transportation system is of high socio-economic relevance for Europe. Road transportation accounts for 21% of Europe's fossil fuel consumption, and 60% of its oil consumption. CO2 emission gases are increasing global warming, and gases emitted by conventional vehicles as NOx are toxic. The roll-out of connected car technologies, the development of low CO2 and NOx propulsion systems, together with intelligent traffic management technologies, will reduce pollution particularly in urban environments. Increasingly autonomous behaviour, the ability to collaborate with other machines and humans, and to learn from experience will mark the shift to a secure connected, cooperative and automated mobility.

Solutions: Policy making needs to target decoupling economic growth and transport, providing the right framework and incentives. The technology solutions should be focused on: a) new energy efficient system and architectural concepts; b) filling/charging and energy and power management;

c) control strategies and predictive health management; d) smart sensors; e) smart actuators and motors in transport systems, f) environment recognition; g) localisation, maps, and positioning; h) control strategies; i) artificial intelligence in automated mobility and transportation; j) communication inside and outside vehicle; k) testing and dependability; l) functional safety and fail-operational architecture and functions; m) swarm data collection and continuous updating; and n) predictive health monitoring for connected and automated mobility.

7) CARBON RE-USE – FROM CLIMATE KILLER TO INDUSTRY ASSET

Goal: To develop economically viable methods to capture and reuse carbon.

Carbon emissions are produced in every activity both industrial and non-industrial. Even if carbon emissions can be reduced, they cannot be completely eliminated. Since CO2 is responsible for greenhouse effects, which can have a tremendous impact on the planet, it is necessary to find ways to remove the excess CO2 from the air once it has been generated.

Impact and relevance: Solutions generated under this mission could have a tremendous impact on the quality of the atmosphere and could be critical to saving the planet. Also, completely new devices and a new infrastructure coupled with energy generation infrastructure could be developed in Europe. New devices could be also exported in other countries since all the regions of the world have the same problem.

Solutions: Capture of carbon at point sources is already possible now, but the challenge is to develop new physical and chemical principles, new technologies and devices that allow capture to be done cheaply and on a large scale. Once captured, CO2 could be stored underground, but more appealing solutions are to use it as feedstock, as fuel or as a basic raw material. One option would be to capture CO2 in the form of biomass e.g. bubbling it through tanks of microbes or algae that utilise the CO2 as carbon for growth and thereby produce value added products. This biomass can then be used as a feedstock for fuels or materials production.

8) ENERGY INDEPENDENCE - AFFORDABLE RENEWABLES

Goals: A united energy market allowing all partners to participate without location-related restrictions.

Impact and relevance: better efficiency and a more transparent system. For instance, renewables production would be located where it is inherently most efficient, instead of following national incentives. Harmonisation would also allow formation of new energy service providers, such as aggregators, operating in multiple countries within same regulatory framework. This would accelerate the greening of the energy systems.

Solutions: Affordable renewable technologies for energy independence and improved energy storage technologies and systems require research in new strategies for controlling generators, and for the improvement of the existing algorithms for the optimal use of the obtained power; new concepts for generators; development of cross-border connections, power measurement units, phase-shifting transformer technologies: high and low voltage converters, new Maximum Power Point Tracking algorithms, interfaces for network connection involving new quality and grid management; development of software applications and tools for the observability and the flexibility of the whole power system; as well as new materials and components to improve both energy storage costs and performance.

9) EUROPEAN HEALTHCARE NETWORKS – BREAKTHROUGH IN DISEASE PREVENTION AND TREATMENT

Goals: To make Europe the world leader in disease prevention and treatment.

Impact and Relevance: Breakthroughs in cutting edge technologies such as genomics, bioinformatics, genome editing, cell engineering and synthetic biology in combination with data management, analysis and sharing will deliver new developments in disease prevention, diagnosis and treatment. This will make Europe an excellent place for health research as well as catalysing the emergence of new industries enhancing the future health, security and wealth of all European citizens.

Solutions: Becoming the best place in the world for disease prevention and medical treatment will be enabled by the combination and convergence of state of the art life science advances and digital health technologies. Each citizen is an individual, and individual healthcare and personalised approaches will be the future medicine in Europe. In recent years, there have been great strides in the underpinning technologies for DNA sequencing (e.g. the ability to read the human genome) and the ability to write DNA (DNA synthesis). These have been key drivers for advances in our ability to diagnose and treat disease. New developments in genomics, genome editing, cell engineering and synthetic biology will speed up drug development while decreasing costs, reduce our dependency on animal testing, and increase our ability to respond more rapidly to pandemics or biosecurity threats. They provide opportunities to tackle antimicrobial resistance, neurodegenerative diseases, rapidly develop new vaccines and target specific cell types such as cancer cells. Data management, analysis and sharing are absolutely crucial for the future of European healthcare. There is the opportunity to develop new electronic healthcare structures and share data such as cancer genomics, epidemiological studies, data from large-scale drug discovery and testing programmes and also the results of public health initiatives. This data sharing and analysis will inform the way we understand and develop treatments for disease. Secure networks and high-quality digital infrastructure and connectivity will be essential to ensure standardised and interoperable electronic patient and personal health records (strong control by the citizen/patient). Such networks, for instance in the form of a European bio-informatic system for cancer treatment, will allow remote consultations, participative and preventive healthcare solutions, and an equality of access to the highest quality of healthcare. Such advanced and integrated healthcare networks will enhance efficacy and contribute to lower public healthcare costs. This combination of emerging technologies provides enormous opportunities for the emergence of new industries in Europe not just based on life sciences but also coupled to other developments in informatics (big data, AI, software).

10) BIO MANUFACTURING – BRINGING LIFE TO MANUFACTURING

Goals: Europe will become the global leader in biomanufacturing. Europe with its distinct landscapes and agriculture will develop varied location specific feedstocks and processes for the production of diverse commercially important molecules, decreasing reliance on fossil fuels and stimulating new environmentally friendly economic activity. An enhanced bioeconomy offers the opportunity of a future in which economic growth can be coupled with environmental responsibility.

Impact and Relevance: Biomanufacturing is a form of manufacturing that uses biological systems (e.g. microbial cells, animal or plant cells, enzymes) to produce commercially important molecules for use in the chemical, energy, pharmaceutical, materials, food and agricultural industries. It can produce an incredibly diverse range of complex chemistries and products including fuels, medicines, fragrances and flavours, crop protectants and new materials with uses ranging from medicine to fashion. Biomanufacturing can utilise simple sugars or waste from agriculture, forestry or even landfill. Another benefit is that because biomanufacturing uses biological systems, the conditions used for the manufacturing processes are relatively mild - not requiring high temperatures, high pressures and harsh or toxic substances - which means that energy inputs are reduced and it is relatively environmentally benign.

Solutions: Europe produces a lot of diverse biomass that can act as feedstocks for biomanufacturing. This diversity can be exploited to develop new processes at local levels using different agricultural wastes, forestry wastes or municipal wastes depending on availability and scale. This provides an opportunity for EU communities to tailor new biomanufacturing industries to their own local context and feedstock supply developing a network of distributed biomanufacturing facilities. This distributed manufacturing approach would also benefit from reduced transport costs. The scale of biomanufacturing can vary enormously from individual farmers utilising waste for biodiesel production to very large-scale biorefinaries for platform chemicals to high tech pharmaceutical manufacture. Europe is well placed to take advantage of this opportunity that would rely on the development of new biological processes and facilities, new production organisms and cell lines (including those genetically engineered for optimum performance) and the development of new value chains. The new cutting edge technologies of synthetic biology, genomics, genome engineering and high throughput biology will contribute enormously to the future of biomanufacturing in Europe.

11) RE-INVENTING FOOD PRODUCTION – SUSTAINABILITY AND TRACEABILITY

Goal: Europe to be a global leader in securing a viable, sustainable, and transparent food value chain.

Impact and relevance: The EU's food sector is a major player in the Union's well-being and future. The food and drinks industry is the EU's biggest manufacturing sector in terms of jobs and value added. Europe is also one of the largest manufacturers of food processing equipment. Farming, food processing and food-related retail and services, for example, provide around 44 million jobs in Europe. However, the food value chain is increasingly threatened by climate change, natural disasters, pests, diseases, and volatile prices. There is an urgent need to innovate along the food value chain to be more efficient, organic and sustainable, while meeting consumers' increasing demand for more transparency, including plant and animal farming practices and provenance information. Europe's ability to innovate in this sector will secure its leading role as a resilient provider for safe, healthy and sustainable food.

Solutions: By leveraging technological innovation in manufacturing, life sciences technologies, precision farming, artificial intelligence, security, and connectivity, Europe can make better use of resources (e.g. land, water, energy, pesticides, antibiotics) along the food value chain, thereby improving production and distribution efficiency while bettering food quality. For example, new genome editing technologies can provide a step change in crop and animal health, resilience and productivity.

Europe should aim to be a global leader in: reducing greenhouse gas emissions associated with the food value chain, reducing food and packaging waste along the production and value chain. In addition, the development of new biotechnology processes can turn agricultural waste into valuable products such as commodity chemicals and fibres providing new income streams for farmers and enhancing the green economy.

Europe should strive to increase food transparency and traceability. Europe can be a pioneer in facilitating citizen access to information on food provenance, allergenics, processing, distribution and related labour practices by leveraging digital tools such as sensors, artificial intelligence, security and connectivity. Further, Europe should be a leader in data-driven planning along the food supply chain, taking into account forecast information on food production and demand, thereby reducing wastes while meeting demand. Also, Europe should strive to lead the change towards personalized food supply chains to precisely meet citizen's nutritional and allergenic requirements under guaranteed conditions.

12) BIODIVERSITY – SAVING THE BEES AND OTHER POLLINATORS

Goal: Stop pollinator decline to enable food security.

Impact and relevance: The decline of wild bees and other pollinators – almost one in 10 bees and butterfly species is facing extinction - has wide-ranging consequences for our society. Around 78% of temperate wild flowers in Europe need animal pollination and 84% of crops benefit, at least in part, from animal pollination. Pollinators strongly affect both the quantity and the quality of crops: an estimated EUR 15 billion of annual EU agricultural output is directly attributed to pollinators. The diversity of crops which depend on pollinators is an important part of a healthy diet. Animal pollination also plays an essential role in the functioning of ecosystems and is, therefore, important for biodiversity conservation, especially where specific plant-pollinator cooperation has developed.

Solutions: There is no one single driver of pollinator decline. Direct threats to pollinators include land-use change, intensive agricultural management and pesticide use, environmental pollution, invasive alien species, pathogens and climate change. Therefore, in addition to assessing the full extent of pollinators' decline and getting a better understanding of the main drivers, solutions will include providing alternatives to harmful pesticides, adopting ecosystem-based approaches and nature-based solutions for safe food production and promoting green infrastructure for wider habitat and ecosystem services availability, facilitated by technologies such as precision farming, big data generation and analytics, machine learning, and DNA barcoding.

13) OCEANS OF CLEAN WATER – STARTING WITH AFFORDABLE DESALINATION

Goal: Securing clean and safe water ecosystems, supplies and management.

Impact and relevance: Water is crucial for people's health, nutrition, and for the ecology: clean water is crucial not just for health but also for growing crops and raising fish and livestock. For a variety of reasons, the supply of clean (drinking) water is increasingly a problem around the globe: ever growing cities need more water, climate change reduces the supply in some regions which rapidly become more arid, and irrigation projects drain water from rivers upstream. In addition, groundwater supplies are being depleted and some large harbour cities around the globe are under threat as pumping has led to lower fresh groundwater level, and increased groundwater salinity.

Solutions: Developing cheap desalination methods and technology to secure clean water supplies for large coastal cities. Moreover, as desalination is only part of the answer, water conservation methods for residential areas as well as industrial processes need to be developed as well as energy efficient or energy producing waste-water treatment plants.

14) BOUNCING BACK – MAKING EUROPE'S SOCIETY MORE RESILIENT

Goal: Europe able to combine the highest resiliency with the lowest life cycle costs.

Impact and relevance: Over the past few decades the frequency and severity of climate-related disasters and hazards, as well as terrorist attacks, has progressively increased. This requires building our capacity – social, technical and organisational - to prevent and provide flexible responses to actual dangers.

Solutions: High quality preventive measures and early warning systems need to be developed, such as: weak signal analysis and early detection of shocks and stresses; buffer capacity of urban, transport and other critical systems; speedier communication between cities and citizens during major events like disasters or terrorist attacks; new materials and technologies (such as those based on biomimicry); increasingly resilient infrastructure (including water/energy supply); new tools allowing for the detection of stress and preventing the collapse of critical ecosystems; and, new digital networks generating new solutions and community engagement through the combined efforts of local communities, technologists and social activists. This will also support the agenda of other EU policies such as the digital agenda, migration policy and Europe as a stronger global actor.

Members of the High Level Strategy Group on Industrial Technologies

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- German Federal Minister for Education, Science, Research and Technology from 1994 to 1998, Member of the German Bundestag from 1987 until 2000.
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- Cleantech lead in the Caixa Capital venture capital team, previously an engineer and consultant in water-focused cleantech projects.
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