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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

"Preparing for our future: Developing a common strategy for key enabling technologies in the EU"

Current situation of key enabling technologies in Europe

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Current situation of key enabling technologies in Europe

1. THE IMPORTANCE OF ENABLING TECHNOLOGIES

Currently there has been no shared understanding within the EU on exactly what should be considered as key enabling technologies (KETs). As a result there is no coherent strategy on European level on how these technologies can be better brought to industrial deployment at a European level. The Communication on key enabling technologies develops a common strategy for KETs in the EU and proposes a set of measures to improve the related framework conditions[1].

KETs are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment. They enable 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 efforts.

Several Member States have started to identify enabling technologies that are relevant to their future competitiveness and prosperity and targeted their R&D spending accordingly (see Table 1). Individual Member State technology policies, while similarly focused, often lack the synergies and benefits of economies of scale and scope that arise from more coordinated joint actions. Discussions have been also taken place at European level, but have so far not led to a shared understanding on which of these technologies a more strategic cooperation is needed to improve industrial competitiveness[2]. The fragmentation of EU efforts is often caused by a lack of a long-term vision and of coordination. Better division of work is needed to improve conditions for industrial exploitation in the EU.

2. OVERVIEW OF KEY ENABLING TECHNOLOGIES

The following section provides a brief description of the multidisciplinary characteristics of some KETs in the EU and explains why advanced materials, nanotechnology, micro- and

[1] COM(2009) 512.

[2] Synthesis report of the key technologies expert group (2005); Creative system disruption: towards a research strategy beyond Lisbon.

nano-electronics, industrial biotech and photonics have been identified as priority to improve European industrial competitiveness.

2.1. Advanced materials

Advanced materials technologies lead both to new reduced cost substitutes to existing materials and to new higher added-value products and services. This will reduce resource dependency and environmental waste and hazards at the same time. Besides the costs of capital, expenditure on materials is the most important cost factor in high-technology related industries. They are of key importance for the competitiveness of EU industry especially since Europe is not well endowed with natural resources. Overall, advanced materials markets are expected to offer an additional annual volume within the EU of €55bn over the next 5 to 7 years[3]. There is considerable potential in the area of energy €19bn (e.g. catalysts and batteries), environment €12bn (e.g. polymers and smart packaging), health (e.g. tissue engineering), transport (e.g. lightweight materials) and ICT (e.g. optical fibres and semiconductors).

Material innovations can be used in practically all manufacturing industries and form an important element in the supply chain of many high value manufacturing businesses. They have the potential to lead to innovations in key industries such as energy, aeronautics and space, automotive, engineering, textiles, electronics and consumer goods. With a world-class research base and major strengths in both producer and user industries, the EU is a world leader in advanced materials. R&D in the key materials producing/using sectors[4] is over € 44bn per year in the EU compared to €25bn in the US and €23.5bn in Japan. Maintaining competitive strength will require an increase in the added-value of the materials produced and the "knowledge embedded" in them, as well as the productivity of industrial processes while reducing energy and material consumption. The EU Framework Programmes for Research and Technological Development provide funding for new and advanced materials. The National Science Foundation in the US allocated $257m of funding in the area of Materials Research in 2007[5]. As part of the FP7 an annual average of €120m of EU funding (excluding support at national level) has been allocated for materials research with increasing synergy thanks to FP7 and increasing EU-wide networking[6].

2.2. Nanotechnology

Nanotechnology is an umbrella term that covers the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale.

The global market for nanotechnology has been estimated to amount to $147bn in 2007 and to grow to in most optimistic assessments to $1 trillion[7] and possibly to over $3 trillion by 2015[8]. The United States (40%) constitutes the biggest market for nanotechnology, followed by Europe (31%). Both regions are expected to amount to 35% of the worldwide market in

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3 European Technology Platform on Sustainable Chemistry (2008).

4 Defined as chemicals industry (excluding pharmaceuticals), industrial metals, aerospace, and automotive.

5 National Science Foundation (2009).

6 The European Multifunctional Materials Institute was created in the framework of the FP6 Network of Excellence. It serves as a European platform to create and conduct projects in research and education in the field of multifunctional materials science.

7 National Science Foundation estimates, see Red Herring (2001): "The Biotech Boom: the view from here".

8 LuxResearch (2009): "Nanomaterials of the Market Q1 2009: Cleantech's Dollar Investments, Penny Returns".

2015. Like today, the majority of global sales will be attributed to manufacturing and materials (over 55%), followed by electronics and IT (over 23%).

Advanced and novel materials can greatly benefit from the integration of biotechnology and nanotechnology, e.g. for coating/surface engineering. The nanotechnology research base is well established in Europe (particularly in nanomaterials, nanophotonics and nanobiotechnology). In 2008, EU research spending on nanotechnology from public sources was $2.6bn (some 30% of the world total) compared with $1.9bn in the US and some $2.8bn in Asia[9]. In Europe, over 240 research centres and 800 companies dedicated to the R&D of nanotechnology have been identified[10].

However, commercialising these research efforts is proving difficult in Europe[11]. Private R&D investments amounts to only $1.7bn in Europe compared to $2.7 in the US and $2.8bn in Asia[12]. Moreover EU nanotech patenting lags well behind the US where most of the significant developments in the creation and activity of nanotech companies and related jobs can be observed. Despite the potential interest from key EU industries such as aeronautics and space or automotive, a lack of engineering expertise seems to have held back adoption[13]. The EU market is fragmented, resulting in a lack of critical mass that reduces the effectiveness of the commercialisation of nanotechnology. Considering the state of technology maturity, issues related to environmental, health and safety (EHS) concerns, standardisation and public opinion needs to be addressed to ensure market acceptance and the deployment of nanotechnology[14].

European SMEs using nanomaterials are mostly present in the automotive and medical and healthcare sectors followed by energy[15]. Within medical and healthcare, implants (44%), molecular diagnostics (28%) and drug delivery (27%) are the most important fields of application. Applications in the energy field are mostly related to energy conversion or production (66%) followed by energy saving (38%) and energy storage (28%).

2.3. Micro– and nanoelectronics

Micro- and nanoelectronics deal with semiconductor components and highly miniaturised electronic subsystems and their integration in larger products and systems.

The worldwide microelectronics market is valued at $261bn in 2008 (up from $200bn in 2000)[16]. Electronic data processing and the telecom sector are the largest markets for microelectronics. However, semiconductor components are rapidly penetrating in automotive, medical, industrial or consumer markets. The automotive sector for instance accounts for a larger proportion of microelectronics sales in Europe (19% in 2008) than it does in the world as a whole (8%)[17] and Europe can further develop its strengths in the automotive sector with excellent customer access and highly specialised applications. Microelectronic components,

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[9] LuxResearch (2009).

[10] Conseil Economique et Social – France (2008) : "Les nanotechnologies" and AFSSET (2008):"Les nanomatériaux: sécurité au travail".

[11] 26% of nanotech related patents are filed by the EU25, 40% by the US (Source: OECD patent database 2007).

[12] LuxResearch (2009).

[13] Federal Ministry of Education and Research “The High Tech Strategy for Germany”.

[14] The European Commission adopted in February 2008 the Code of Conduct for Responsible Nanosciences and Nanotechnologies Research.

[15] Steinbeis Europa Zentrum (2005): “nanoroad SME“:http://www.nanoroad.net/download/sme_survey.pdf.

[16] OECD (2009): “OECD Information Technology Outlook 2008“.

[17] Future Horizons (2009): “Semiconductor Market Overview”.

such as designer-customised integrated circuits are also essential and major constituents of spacecraft. To qualify this technology for space, substantial efforts are needed to meet the harsh environment and reliability requirements (e.g. related to radiation, temperature fluctuation, impossibility of repair, etc). Due to the required quality control, rigorous qualification and detailed analysis, the know-how gained has the potential to be used in other high reliability sectors (e.g. aeronautics, automotive or defence), as well as green technologies (e.g. low energy consumption). Microelectronics applications are present in many industries such as for industrial equipment or for consumer products (cameras, TV), automotive (safety management, fuel efficiency, engine controls), computing and communications (e.g. wireless, smartcards). Microelectronics enables greater energy efficiency in devices and control systems in many end-user applications.

Europe has a declining share of worldwide investment in microelectronics. From a total investment of €28bn in microelectronics in 2007, only 10% was made in the EU compared to 48% in Asia. Europe's semiconductor market share has declined from 21% to 16% since 2000[18]. Nonetheless, total direct employment in microelectronics in Europe is over 110 000 plus 105 000 in equipment manufacturers. Nevertheless, Europe has a number of dedicated regions with critical mass and particular semiconductor competencies which are recognised world-wide. These clusters, which address all application fields and have access to the most advanced technologies are key assets for European industrial competiveness.

2.4. Industrial biotechnology

Industrial biotech is the application of biotechnology for the industrial processing and production of chemicals, materials and fuels. It includes the practice of using micro-organisms or components of micro-organisms like enzymes to generate industrially useful products, substances and chemical building blocks with specific capabilities that conventional petrochemical processes can not provide. There are many examples of such bio-based products already on the market. The most mature applications are related to enzymes used in the food, feed and detergents sectors. More recent applications include the production of biochemicals, biopolymers and biofuels from agricultural or forest wastes.

The contribution of industrial biotech to EU economic performance is currently modest, but growing rapidly. In a recent OECD study, it is estimated that biotechnology's share of chemical production will increase from under 2% in 2005 to between 9 and 13% in 2010, accounting for $130-180 billion in value[19]. This implies annual growth rates in the range of 40-50% for bio based chemicals compared to 3% for overall chemical production.

Europe is the world leader in key industrial biotechnologies such as enzyme technologies and fermentation. The most important enzyme producers are located in Europe with a total of about 80 in Europe compared to 20 in the US[20]. Nearly 70% of the estimated $313bn spent in 2006 on R&D of relevance to biotechnology by leading companies in industrial applications, was spent by European firms[21].

The global industrial enzyme market was worth about €2.1 billion in 2008. Approximately a third of that figure was accounted for by detergent enzyme sales and another third by food and feed enzymes. The detergent enzymes market is growing by about 4.5% per year, mainly for dishwasher and liquid detergents. Enzymes for food manufacturing have an estimated annual

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18 OECD (2009): "OECD Information Technology Outlook 2008".
19 The Bioeconomy to 2030, Designing a Policy Agenda, OECD 2009.
20 The Bio4EU Analysis report (European Communities 2008).
21 The Bioeconomy to 2030, Designing a Policy Agenda, OECD 2009.

growth rate of 2-3%.In biofuels, large quantities of biodiesel and bioethanol are being produced, largely driven by government support and high energy costs. While this is mostly produced using conventional technologies, improved industrial biotech processes that facilitate the conversion of biomass into fuel are being developed. For example, pilot plants are producing bioethanol from lignocellulosic biomass such as wood or agricultural waste and full-scale commercialisation is conceivable in 2011–2012[22].

2.5. Photonics

Photonics is a multidisciplinary domain dealing with the science and technology of light, encompassing its generation, detection and management. The EU has strong positions in many photonics applications such as solid state lighting (including LEDs), solar cells, and laser assisted manufacturing. The Optoelectronics Industry Development Association estimates that the global optoelectronics market reached a value of $565 billion in 2006[23]. The global market for optoelectronic components was worth $356 billion in 2008 and is expected to grow at an annual rate of 3.1% up to 2020. In particular, the green photonics (e.g. solar/photovoltaics, LEDs, solid-state lighting, and displays) share of this market is expected to grow from some 8% to over 50% in 2020. The $200bn global market for optoelectronic-enabled products (including consumer display/TV and computing/processing) and is expected to double in size by 2020. The European photonics industry accounted for revenues of about €49 billion in 2006 and is growing rapidly.

Photonics is a good example of an enabling technology, as there are around 5 000 photonics manufacturers in Europe employing around 246 000 persons (excluding subcontractors) directly. In addition, the jobs of over 2 million more employees in the EU´s manufacturing sector depend directly on photonic products. Germany accounts for 39% of European production volume, followed by France and UK (12% each), the Netherlands (10%) and Italy (8%). Private R&D investment by the European photonics industry amounts to €3.3 billion annually, which represents 9% of turnover[24]. The European production made up some 19% of the world market in 2005[25]. However, production is dominated by Asia, notably Japan (32%), Korea (12%) and Taiwan (11%). North America has some 15% of the worldwide production volume.

The potential of these technologies is largely untapped. Increasingly systemic solutions will be needed and evolve in order to address major societal challenges, such as ensuring high-speed communication, preserving food production, the environment, finding appropriate transport solutions, ensuring high levels of health care for an ageing population, unlocking the potential of services, ensuring internal and external security and addressing the energy question. Low carbon technologies and applications will play a vital role in reaching European energy and climate change targets. For instance, CCS and CO_2-related transport grids will be needed to reduce CO_2 emission in countries that will continue to rely heavily on fossil energy sources. KETs, such as new materials for energy production, transportation and storage play an essential role. They could lead to better resource and energy efficiency and

[22] Novozymes 2008 report and The Bio4EU Analysis report (European Communities 2008).

[23] The “Photonics in Europe” study by Photonics21 presents a smaller figure for the world market for photonics products (€228 billion in 2005). This figure does not include accessories, parts and service, retail sales cost, optical fibres and fibre cables for communication purposes.

[24] Towards a Bright Future for Europe, Strategic Research Agenda in Photonics, Photonics21, 2006.

[25] Photonics in Europe, Economic Impact, Photonics21 and Optech Consulting, December 2007.

their environmental impact need to be assessed in a life-cycle perspective, taking advantage of the related initiatives promoted at EU level in this context[26].

In the supply chain of KETs ***advanced manufacturing systems*** denote the range of high-technologies involved in manufacturing, leading to improvements in terms of new product properties, production speed, cost, energy and materials consumption, operating precision, waste and pollution management. This is especially relevant in capital intensive industries with complex assembly methods. They are needed to help create marketable knowledge-based goods and the related services (e.g. modern robotics). For example, the production and assembly of modern aircraft involves the whole spectrum of manufacturing technologies from the simulation and programming of robotic assembly lines to reducing energy and materials consumption. Other examples include intelligent control systems, automation for modelling and production. They can be applied in all manufacturing industries and form an important element in the supply chain of many high value manufacturing businesses. They make up some 10.5% of EU industrial productions and provide some 2.2 million jobs and account for 19% of EU exports and over 40% of EU private sector R&D expenditure[27].

Given the rapid development in science and research the above technologies may rapidly become global in the years to come and other technologies may emerge.

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26 See the Integrated Product Policy Communication COM (2003) 302; The Strategic Energy Technology Plan COM (2007) 723 has the main objective to accelerate the development of key technologies such as CCS and renewable technologies; The European Energy Research Alliance (EERA) launched within the framework of the SET-Plan will set up joint programmes, including basic energy science, enabling and breakthrough technologies.

27 ManuFuture Platform “Strategic Research Agenda”, http://www.manufuture.org/.

Table 1: Key enabling high technologies identified by Member States and the Commission's Key Technologies expert group

Germany:	**United Kingdom:**	**France:**	**European Commission:**
Nanotechnology	Nanotechnology		Nanotechnology
Biotechnology	Bioscience		Biotechnology
Microsystems technology	Electronics, photonics and electrical systems	• Micro- and nanocomponents for Microsystems	
Optical technologies		• Monitoring of image analysis processes • Photonic systems and processes • Intelligent sensors and signal processing	
Materials technologies	Advanced materials	• Advanced materials • Assembly of multi materials • New processes for surface processing	Materials science and engineering
Production technologies	High value manufacturing: • Products • Processes • Service systems • Value systems	• System engineering	Manufacturing: • Adaptable manufacturing systems • ICT • modelling/simulation
	ICT	• Computing & software tools and methods for collaboration	ICT
	High value services	• Knowledge transfer framework for technology	

Sources: Synthesis report of the key technologies expert group (2005); Creative system disruption: towards a research strategy beyond Lisbon; German Federal Ministry of Education and Research: The High-Tech Strategy for Germany (2006); French Ministry of Economy, Finance and Industry: Technologies clés 2010 (2006); UK Technology Strategy Board: Connect and Catalyse, a strategy for business innovation 2008-2011 (May 2008).