High-Level Expert Group on
Key Enabling Technologies

HLG KET WORKING DOCUMENT

Mastering and deploying Key Enabling Technologies (KETs): building the bridge to pass across the KETs "Valley of death" for future European innovation and competitiveness.

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INTRODUCTION

In 2009, European Member States and the European Commission identified Key Enabling Technologies (KETs) for their potential impact in strengthening Europe's industrial and innovation capacity[1]. In particular, KETs[2] were recognized as playing an increasingly vital role in developing the required industrial and technological base indispensable for the delivery of smart, sustainable and inclusive European growth. It was proposed to create a High Level Expert Group (HLG) on KETs tasked with the elaboration of a coherent European strategy to develop six KETs[3] - nanotechnology, micro and nanoelectronics, advanced materials, photonics, industrial biotechnology and advanced manufacturing systems[4], and bring them most effectively to industrial deployment.

> Box 1. Definition of Key Enabling Technologies (KETs):
> KETs are knowledge and capital-intensive technologies associated with high research and development (R&D) intensity, rapid and integrated innovation cycles, high capital expenditure and highly-skilled employment. Their influence is pervasive, enabling process, product and service innovation throughout the economy. They are of systemic relevance, multidisciplinary and trans-sectorial, cutting across many technology areas with a trend towards convergence, technology integration and the potential to induce structural change. KETs can assist technological leaders in other fields to capitalise on their research efforts.

This HLG KET was launched on the 13th of July 2010 in the presence of Vice-President and Commissioner for Industry and Enterprise, Mr. Tajani, Vice-President and Commissioner for the Digital Agenda, Ms. Kroes, Commissioner for Research and Innovation, Ms. Geoghegan-Quinn, the HLG President, Mr. Therme[5], along with the twenty-six HLG Members[6] consisting of representatives from European Union (EU) Member States, relevant European industry including small and medium enterprises, research technology organisations academia and the European Investment Bank. The remit of the HLG is to:

- Assess the competitive situation of the relevant technologies in the EU with a particular focus on industrial deployment and their contribution to address major societal challenges;
- Analyse the available public and private R&D and innovation capacities for KETs in the EU;
- Propose specific policy recommendations for a more effective industrial deployment of KETs in the EU.

This HLG KET has since gathered extra momentum with the publication of Commission communications on the EU 2020 Strategy[7] and related Flagship Initiatives including An Integrated Industrial Policy for the Globalisation Era[8], the Innovation Union[9], and the Digital Agenda for Europe[10], along with the Regional Policy contributing to smart growth in Europe 2020[11], with all communications making explicit reference to the importance of KETs for Europe.

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1 *Preparing for our future: Developing a common strategy for key enabling technologies in the EU*, Brussels, 30.09.2009, COM(2009) 512 final.
2 *European Competitiveness Report 2010*, Brussels, 28.10.2010, SEC(2010) 1276 final, Commission Staff working document accompanying the communication *An integrated Industrial Policy for the Globalisation Era –Putting Competitiveness and Sustainability at Front Sta*ge, Brussels, COM(2010) 614
3 Idem.
4 Advanced Manufacturing Systems (AMS) comprise production systems and associated services, processes, plants and equipment.
5 M. Therme, Director of the Atomic and Renewable Energies Commission (CEA), Grenoble, France.
6 A list of the HLG KET members is available on the HLG KET website: http://ec.europa.eu/enterprise/sectors/ict/key_technologies/kets_high_level_group_en.htm
7 *EU smart, sustainable and inclusive growth: the European 2020 strategy*, Brussels, 3.3.2010 , COM(2010) 2020
8 *An Integrated Industrial Policy for the Globalisation Era, Putting Competitiveness and Sustainability at Centre Stage*, Brussels, COM(2010) 614
9 *Europe 2020 Flagship Initiative*, *Innovation Union*, Brussels, 6.10.2010, COM(2010) 546 final
10 *A Digital Agenda for Europe*, Brussels, 26.8.2010, COM(2010) 245 final/2
11 *Regional Policy contributing to smart growth in Europe 2020,* Brussels 6.10.2010, COM(2010) 553 final

By eroding years of economic and social progress in Europe, the current economic crisis has reinforced the need to further pursue and strengthen Europe's competitive position in KETs and their deployment. This latter was also confirmed during a public consultation process involving European Industry and innovation stakeholders through a series of KET Open Days[12] and an Internet Forum.

This HLG KET Working Document outlines the potential impact of KETs on grand societal challenges and the competitiveness of European industry, presents a SWOT analysis of KETs and current challenges for KET value chains in the EU and beyond, in the context of global competition, along with an initial vision of the way forward. This vision recognises that those nations and regions mastering KETs will be at the forefront of future advanced and sustainable economies integrating cutting-edge technologies into their manufacturing and service industries and managing the shift to a low carbon, knowledge-based economy, and ensuring the welfare, prosperity and security of their citizens.

12 For more information on KETs Open Days, consult the HLG KET Website.
http://ec.europa.eu/enterprise/sectors/ict/key_technologies/kets_high_level_group_en.htm

1. CONTRIBUTION OF KETs TO GRAND CHALLENGES:

The EU 2020 Strategy has identified key priorities indispensable to deliver smart, sustainable and inclusive growth: employment, research and innovation, climate change mitigation, education, and reduction of poverty. Europe is now engaged to provide a coordinated response to grand societal challenges such as globalisation, pressure on resources and an ageing population.

In this context, KETs are attracting strong interest, as they are seen as the route to new products, processes and services capable of generating economic growth and employment, and contribute to strengthen and rejuvenate strong existing European sectors that will enable sustainable, smart and inclusive growth in Europe. In addition, KETs' follow-through applications will create the substantial jobs, growth and wealth required in our future economies to remain competitive at global level.

In particular, as leading-edge technologies of the 21st century, KETs underpin innovation in many strategic sectors and play a key role in making new products and services affordable for the population at large. They contribute to the development of disruptive technologies across sectors such as energy (e.g. renewable energies; bio-fuel, solar energy etc.), transport (e.g. lighter, safer and energy efficient transport vehicles), manufacturing (e.g. reduced material and process rates, energy saving), chemistry (e.g. green processing) and environment (e.g. sensors for environmental monitoring), information and communication (e.g. chips for nomadic, multimedia convergence and cloud computing), medicine (e.g. gene therapy and genetic testing) and consumer goods (e.g. cell phones, lighting). They also contribute to the build-out of a more productive, competitive energy, and resource-efficient economy. Products with enhanced features have the potential to bear high economic value as well as ensure a more comfortable, healthy and safe life for European consumers and workers in a clean environment.

KETs are expected to provide significant economic benefits, offering a widening variety of uses in an increasing number of application areas and industries, as well as contributing to energy and resource efficiency, through innovative materials, processes, technologies and applications.

The mastering and deployment of KETs in the EU represent a genuine opportunity; failure to maintain and develop KET-related activities in the EU would result in subsequent difficulties for Europe to keep up with international competition and master its own future.

1.1. Economic impact

The macroeconomic importance of KETs is that they can open up entirely new markets or underpin and enhance existing markets through accelerating technological progress with trickle-down effects on productivity and concurrent leaps in efficiency levels. In addition to feeding the full value chain, products based on KETs often serve as inputs of great value added that are integrated into more complex products. It is these subsequent applications that drive economic growth and competitiveness. Two examples of this underpinning nature in feeding full value chains are the micro-nanoelectronics and photonics ecosystems shown in Figure 1. It also illustrates the interdependence of the KETs themselves, as shown in this example, where advanced materials and manufacturing equipment are central to the sustainability of the two KETs value chains insofar as they provide solutions for resource efficiency (energy, waste, water, etc.) and are also the roots for the development of other technologies.

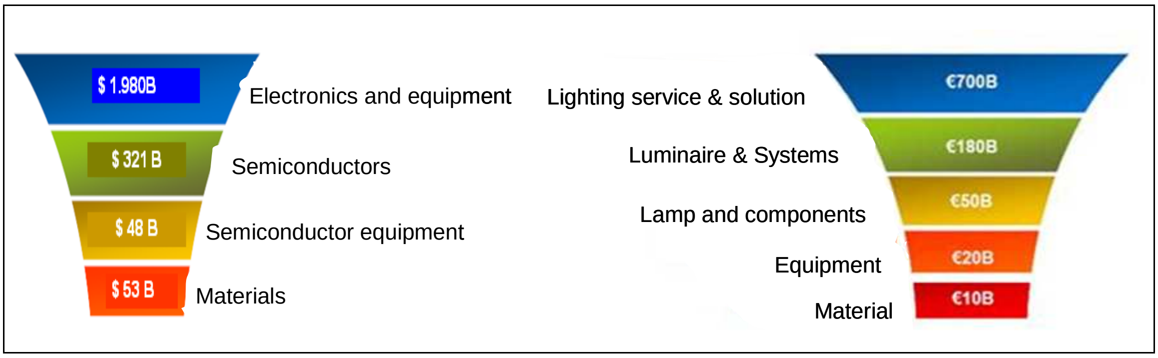

Figure 1: Example of value chains: micro nanoelectronics and photonics

The market potential for specific KETs is shown below.

	Current market size (around 2006/08; USD)	Expected size in 2015 (around 2012/15; USD)	Expected compound Annual growth rate
Nanotechnology	12 bn	27 bn	16%
Micro and nanoelectronics	250 bn	300 bn	13%
Industrial biotechnology	90 bn	125 bn	6%
Photonics	230 bn	480 bn	8%
Advanced Materials	100 bn	150 bn	6%
Advanced Manufacturing systems	150 bn	200 bn	5%
TOTAL	832 bn	1282 bn	

Source: Background study; Confindustria (2009)

Table 1: Estimated global market potentials of Key Enabling Technologies

The above data in table 1 represent an average across entire market sectors. Within specific KETs, the annual growth rate of the industries that they support varies dramatically with very significant niche opportunities. For example, the average annual growth rate of the global photovoltaic industry exceeds 40%. Likewise, products underpinned by nanotechnology are forecast to grow from a volume of $254 billion in 2009 to $2.5 trillion by 2015[13][14]. In the industrial biotechnologies sector, the value of biochemicals (other than pharmaceuticals) could increase from 1.8% of all chemical production in 2005 to between 12% and 20% by 2015[15]. A recent report by the World Economic Forum (WEF)[16] concluded that converting biomass into fuels, energy, and chemicals has the potential to generate upwards of $230 billion to the global economy by 2020. Factories have been a focal point of value creation for society for centuries. Manufacturing industries contributed to some 17.1% of GDP and accounted for some 22 million jobs in the EU in 2007.

These sizable markets sustain significant employment in the EU. For example, in the micro-nanoelectronics industry (materials, equipments and semiconductors) there are approximately 500 companies in Europe employing directly 200,000 people and around 1 million indirect jobs. These numbers do not include the electronics systems and services industry. Direct employment has remained substantially stable during the last ten years with major growth in employment generated in the related services industry.

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[13] According to Ireland's Nanotechnology Commercialisation Framework 2010 – 2014, Forfas, (Aug.2010) http://www.forfas.ie/media/forfas310810-nanotech_commercialisation_framework_2010-2014.pdf. http://ec.europa.eu/enterprise/sectors/ict/key_technologies/kets_high_level_group_en.htm

[14] According to OECD, "Nanotechnology: an overview based on indicators and statistics" (2009), based on Roco, MC and WS Bainbridge, *Societal Implications of Nanoscience and Nanotechnology*, *Kluwer Academic Publ*, (2001)

[15] OECD (2009) – *The Bioeconomy to 2030: Designing a Policy Agenda*

[16] World Economic Forum (2010) – *The Future of Industrial Biorefineries.* See http://www3.weforum.org/docs/WEF_FutureIndustrialBiorefineries_Report_2010.pdf

There are approximately 5000 photonics companies in the EU, mostly SMEs, employing 300,000 people directly. In addition, the jobs of more than 2 million employees in the EU manufacturing sector depend directly on photonics products. Similarly, employment statistics show a 25% increase in employment in specific nano-related businesses between 2000 and 2008 globally. Extrapolating this trend, by 2015 one can forecast 400,000 nanotechnology related jobs in the EU, in sectors (e.g. process and manufacturing, automotive, ICT, medical) in which the EU is amongst the world leaders. In addition, it is estimated that by 2015 approximately 2 million nanotechnology related workers will be needed worldwide of which 300,000 to 400,000 million in Europe[17].

1.2 Societal impact:

KETs contribution to society as a whole is particularly significant in terms of employment stabilization, creation and improvement of productivity and income levels, reduction of poverty through "smart specialisation", and better quality of life.

One such example is the societal benefits for elderly people. It is predicted that by 2050 the number of people in the EU aged 65 or more will have grown by 70%, and for those in the 80+ age group by 170%. As aging people are more prone to illness, keeping people healthy and active, while managing healthcare costs, is an important societal challenge which KETs address[18]. Early diagnosis using photonic technologies will help prevent severe illness, and may also provide effective new treatments leading to early stage cures. The combination of photonics and microelectronics in healthcare has been estimated to offer potential cost reductions of 20%. Nanotechnology combined with biotechnology provides optimised formulation and delivery of drugs. Sensing, interacting, destroying, monitoring and tracking biomolecules involved in pathological processes is of paramount importance for diagnosing, curing and monitoring human illnesses that mostly start at the molecular level.

Remote health care monitoring will allow citizens to age longer and more safely at home and avoid hospital overcrowding. Nanotechnology and advanced materials continuously improve orthopædic implants (bio-resorbable scaffolds, fillers, pins, biocompatible coatings, etc.) and computer assisted surgery permits key-hold surgery reducing recovery time. Biochips combining advanced materials, nanotechnologies, nanoelectronics, and biotechnologies will allow rapid diagnosis of, for example, bird flu, and ICT based mental health management can provide therapy with 80% savings in therapist time compared to conventional therapy. Semiconductors offer automatic blood-pressure monitors and pain-management devices. By doing so, KETs will contribute to lower the costs of public health systems.

1.3 Environmental and energy impact

In a resource-scarce and knowledge-rich Europe, new products must have high knowledge content and low material/energy resource needs. As stated in the EU 2020 Strategy, “Europe must promote technologies and production methods that reduce natural resource use, and increase investment in the EU's existing natural assets”.

Key Enabling Technologies can play an important role in this context. By developing and implementing technological solutions along three parallel approaches, Europe’s vulnerability to materials scarcity can be mitigated within the following timescales:

- short term : improve access, enhance recycling and develop recycling technologies;
- medium term : design for recycling;
- long term : develop substitution materials;

Advances in materials technologies and other KETs will be required to meet the challenging requirements, but these are within the reach of European development capabilities. The progress on short and medium terms goals can be achieved within a 2020-horizon. Europe is leading the world in recycling technologies and industry, this position should be further strengthened; the conceptual stage of a “design for recycling” initiative for selected products can be rapidly set up, industry and technological research organizations have already

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[17] According to OECD Nanotechnology: an overview based on indicators and statistics (2009), based on Roco, MC and WS Bainbridge Societal Implications of Nanoscience and Nanotechnology, Kluwer Academic Pub., (2001

[18] World Economic Forum (2010) – The future of Industrial Biorefineries
See http://www3.weforum.org/docs/WEF_FutureIndustrialBiorefineries_Report_2010.pdf

declared their interest.

One of Europe's main challenges is to produce knowledge intensive goods that require small quantities of materials. KETs allow us to make this transition and in so doing, save energy, reduce raw materials and other costs, reduce pollution and increase competitiveness.

KETs are crucial in the battle to combat climate change and mitigate the effects of the mounting price and scarcity of oil and other essential raw materials. European energy needs are predicted to continue their inexorable increase, with most energy uses switching to electrical (transportation, heating, cooling).

Electric energy production, distribution, storage, and the efficient use of electricity are striking examples: over two thirds of global installed photovoltaic capacity is found in the EU and PV generation costs could continue to fall by 8% a year[19]. The application of smart grids and smart meter technology will enable consumers to make real-time power saving decisions.. Low consumption lights and LEDs will also save significant energy. Organic Light Emitting Diodes for lighting have a potential to use less energy than fluorescent lamps[20] and less resources too. Efficient new battery advanced materials can assist in making the most of renewable energy technologies, advanced materials for rotor blades can make more efficient wind turbines and breakthroughs are likely in the realisation of high efficiency fuel cells, direct hydrogen generation and new energy storage solutions such as super capacitors[21]. In addition, many innovative technologies are either significantly less damaging to the environment or directly applied to environmental protection. Industrial biotechnologies, based on renewable resources, can save energy in production processes. Reports on the potential of industrial biotechnology to cut CO_2 emissions conclude that the full climate change mitigation potential of biotechnology processes and bio-based products ranges from between 1 billion and 2.5 billion tons CO_2 equivalent per year by 2030[22].

16. SET for 2020, report, EPIA, 2009
20 http://www.bmbf.de/de/7045.php
21 http://www.suschem.org/upl/3/default/doc/Suschem_SRA_final.pdf
22 WWF (2009) – Industrial biotechnology: More than green fuel in a dirty economy?

2. SECTORIAL KET SWOT ANALYSIS

2.1 Sectorial KET SWOT Analysis:

Key Enabling Technologies play a crucial role in accelerating technical progress and are essential components of advanced products, processes and services. As seen from the previous economic impact analysis, KETs will be the enablers of future economic growth in sectors of key strategic importance to Europe such as energy, transport, health, and telecommunications. It is therefore essential that Europe puts in place a comprehensive, coherent and coordinated policy covering all aspects from knowledge and patent generation through product development and industrial deployment, with a short time-to-market, sufficient investment and fast feed-back-loops between science and industry as well as within industries to allow for a quick and efficient transition from scientific knowledge to industrial competence in Europe. To do this, it is essential to build on European strengths and exploit European opportunities. This section presents a KET strengths, weaknesses, opportunities and threats (SWOT) analysis as a necessary input to the development of a comprehensive European KET policy.

This SWOT analysis is not intended to be exhaustive but rather to highlight key issues as perceived by KET European leadership that will be addressed in detail during the next working phase of the HLG.

KET	Strength	Weakness	Opportunity	Threat
Nano-technologies	➢ High employment potential ➢ Strong basic research ➢ Elaborate research landscape Good industrial base of SMEs and large companies ➢ Skilled workforce to deal with complexity ➢ Good climate for innovation	➢ Utilisation shortfall ➢ Uncertain economic climate ➢ Limited cross border and inter-institutional cooperation ➢ Insufficient start-up risk capital ➢ Commerce information deficits ➢ "Mature" world leading industry sectors as primary clients ➢ Lack of long term investments and demonstration ➢ Lack of skilled work force for large scale deployment ➢ IP and patenting European regulations	➢ Deployment along value chain ➢ Diverse, more efficient materials ➢ Diversity of applications ➢ Investor interest ➢ Rejuvenation of industry sectors	➢ Risk discussion as priority instead of risk benefit (no nano-vision) ➢ Speed of conversion of research into products ➢ Speed of policy implementation and new business models ➢ Lack of critical mass for deployment ➢ Uncertainty and non harmonised scientific risk assessment ➢ Lack of safe, responsible handling protocols of nanotechnology along value chain ➢ Absence of coherent strategy in EU ➢ Lack of public-private risk capital fund
Advanced materials	➢ Strong basic research ➢ Skilled workforce ➢ Technology leadership in many domains ➢ Market leadership in many domains ➢ Broad application range	➢ Pilot plant / large demonstrator gap ➢ Loss of operational excellence leadership ➢ Complex and bureaucratic legislation ➢ Lack of EU strategy	➢ Instrumental in addressing green and societal challenges ➢ Exciting new applications	➢ Material scarcity ➢ Not enough young people making science/technology choice ➢ Further loss of manufacturing
Micro-electronics	➢ Industrial Base. Presence in the EU of leaders in the top ten of most major semiconductor sectors along with world leading equipment suppliers, world class advanced manufacturing facilities with highly skilled and experienced employees. ➢ Clusters. Number of successful clusters (e.g. Dresden, Grenoble, Dublin, Eindhoven, and other EU locations ➢ Industry Leadership. Global leadership in More than Moore technologies and applications, with the presence in Europe of the complete value chain up to the system. ➢ R&D Network. Existing strong network of R&D capability, capacity in industry, institutes and academia ➢ Education and Innovation. Strong innovative expertise (over 135,000 patents filed in 2009, more than 10 European universities in the global top-50) ➢ Adaptability. Flexibility and agility of semiconductor sector to adapt to fast-moving environment	➢ Lack of Strategy. Insufficient alignment of member states on a European semiconductor strategy. ➢ Lack of European industry policy. Inadequate economical framework conditions No Cluster Policy at European level. ➢ Weak R&D supports. 60-70% of R&D is not eligible for funding due to interpretation of the eligibility criteria. ➢ Incentives policy: Incentives are limited by State Aid regulation for instance, geographic restrictions. ➢ Lack of financial ecosystem and dedicated stock markets for high tech industries to enable SME's to grow. Inadequate venture capital for commercialisation of inventions and R&D results. Lack of homogeneous tax credit system across Europe for R&D activities. ➢ Low Investment in Manufacturing Capability. An ecosystem of large scale foundry & large scale assembly & testing service providers is absent in Europe. Lack of dedicated educational facilities. Weak education in Manufacturing Sciences and Industrial Engineering Only few ICT dedicated faculties.	➢ Develop New Markets and business models ➢ Strengthening clusters ➢ Lab fab creation (common lines between R&D and Industry) ➢ Increased public procurement for stimulation of new markets. Creation and steering of Lead Markets by setting standards and regulations ➢ Cross-Border Opportunities. ➢ Exploit Leadership Position in specialised application areas such as Analog/mixed signal space, modular design approaches, system architectures & integration capabilities ➢ Competitiveness not dependant on salaries of employees	➢ Lack of a global level playing field (unfavourable EU framework conditions). ➢ Fragmented regulatory framework prevents economy of scale exploitation ➢ Prohibitive costs of IP Protection. ➢ Falling behind in manufacturing. Where manufacturing goes, R&D will follow. ➢ Loss of Competitiveness in production cost (labour, energy, imposed environmental conditions) ➢ Missing some Value Chain. ➢ Education Deficit
Photonics	➢ Established technology leadership ➢ Strong European research ecosystem ➢ World market leaders in core industry areas Established links with application and user industries ➢ Highly diversified SME driven industry ➢ Highly educated workforce ➢ Wide applications space	➢ Fragmented and uncoordinated EU development strategy along the value chain ➢ Lack of significantly sized demonstration and commercialization actions ➢ Constrained access to Private Equity money to finance innovative SMEs ➢ Limited public (pre-competitive) procurement ➢ Unfavourable IPR conditions and European State Aid Rules in the EU ➢ Lack of skilled engineers ➢ Lack of investment funds to compete with aggressive capacity expansion in other parts of the world	➢ Photonics provides competitive advantages to vital manufacturing industries in Europe ➢ Demands for greener technology and carbon neutral energy generation ➢ High demand and fast growing markets in safety and security for greater data bandwidths	➢ Low-cost off-shore manufacture ➢ Increasing competition ➢ Massive investments abroad in core areas of Photonics to improve competitiveness
Industrial bio-technologies	➢ Strong chemical industry as drivers for IB ➢ Competence in R&D, highest regional R&D density ➢ Availability and flexibility of renewable feedstock sources	➢ No relevant technology provider in Bioenergy ➢ Weak start-up generation ➢ GMOs and transgenic plants not accepted ➢ Fragmented and non coordinated research funding ➢ Access to renewable raw material at competitive price	➢ Feedstock flexibility ➢ Growing acceptance for GMO and transgenic plants for non-food applications ➢ Special plant-based precursors for niche markets	➢ Lack of investments in early technologies Resistance against modern biotechnology and genetics, such as transgenic plants, synthetic biology, metabolic engineering, etc.
Advanced Manufacturing systems	➢ Strong engineering tradition, expertise and know-how ➢ Broad technology basis ➢ Strong technological and manufacturing clusters	➢ Complex and bureaucratic R&D support structures ➢ High Investment risks ➢ Growing deficit of skilled staff and low labour mobility ➢ Costly up-scaling of processes ➢ Public innovation policies focused on end of the value chains ➢ Barriers to commercialization ➢ Access to finance in capital markets ➢ Fragmented European markets	➢ To tap the potential of new (e.g. green industries) for growth and jobs creation ➢ To pioneer development for all industry and enhance technological leadership	➢ Globalisation ➢ Asymmetric conditions for trade ➢ Lack of skilled ➢ Workforce ➢ Non-smart regulation ➢ Investment outside Europe

2.2 General observations

With regard to KETs' strengths, one can firstly observe that from research and industrial perspectives, Europe's assets consist of a strong research base, as well as world market leaders in several KET application sectors (automotive, aeronautics, health, and energy) relying, for most of them, on strong technological and manufacturing competences in large and small companies, and in production and competence networks along established and highly diverse new value chains. KETs development and deployment represent significant opportunities, in terms of opening and developing new markets (for instance new green industries).

In parallel with this SWOT study, an analysis of EPO/PCT patent applications (European Competitiveness Report 2010) shows that Europe is neither losing nor gaining ground in the six technologies, judging by its share of patent applications. In all cases Europe is confronted with increasing competition from Asia, which in the past decade has made considerable progress, whereas North America’s share in global technology output has gradually diminished.

In addition, the SWOT analysis has highlighted that innovative SMEs are an essential element of the European economy. Europe should therefore apply the “Think Small First” principle which has been proposed and accepted in the “Small Business Act”. Europe should also develop the potential of production and innovation networks that typically tie small and large companies together along the value chain in European manufacturing and services industries: combining specialized competences and skills with the investment and marketing resources of international reach.

The SWOT analysis has clearly shown that KETs development and deployment may be threatened if Europe does not implement successful conditions to create a global level playing field, reduce the fragmentation of its regulatory framework and Member States' policies, take appropriate measures to stimulate and anchor globally competitive manufacturing in Europe, and reduce trade barriers.

This analysis shows the need to further reflect on the lack of appropriate financial ecosystems, along with limited financial instruments to address KET issues, risk taking in funding large-scale capacity expansions in KET production technologies, and public strategic procurement and the current absence of a European IP patent.

3. AN INTEGRATED ANALYSIS of KETs

3.1 KETs value chain: a great opportunity for Europe

From the perspective of a KET value chain analysis, one can identify the opportunities for Europe to create value along the whole value chain; from materials, through equipment and devices, to products and services responding to grand societal challenges. Given that by definition KETs are enabling, and of systemic relevance, KETs feed into many different value chains in very heterogeneous ways. This is shown in Figure 2 for three specific examples in automotive, lighting and electronics value chains. It is observed that KETs are necessary at all levels of the value chain to product development and manufacturing.

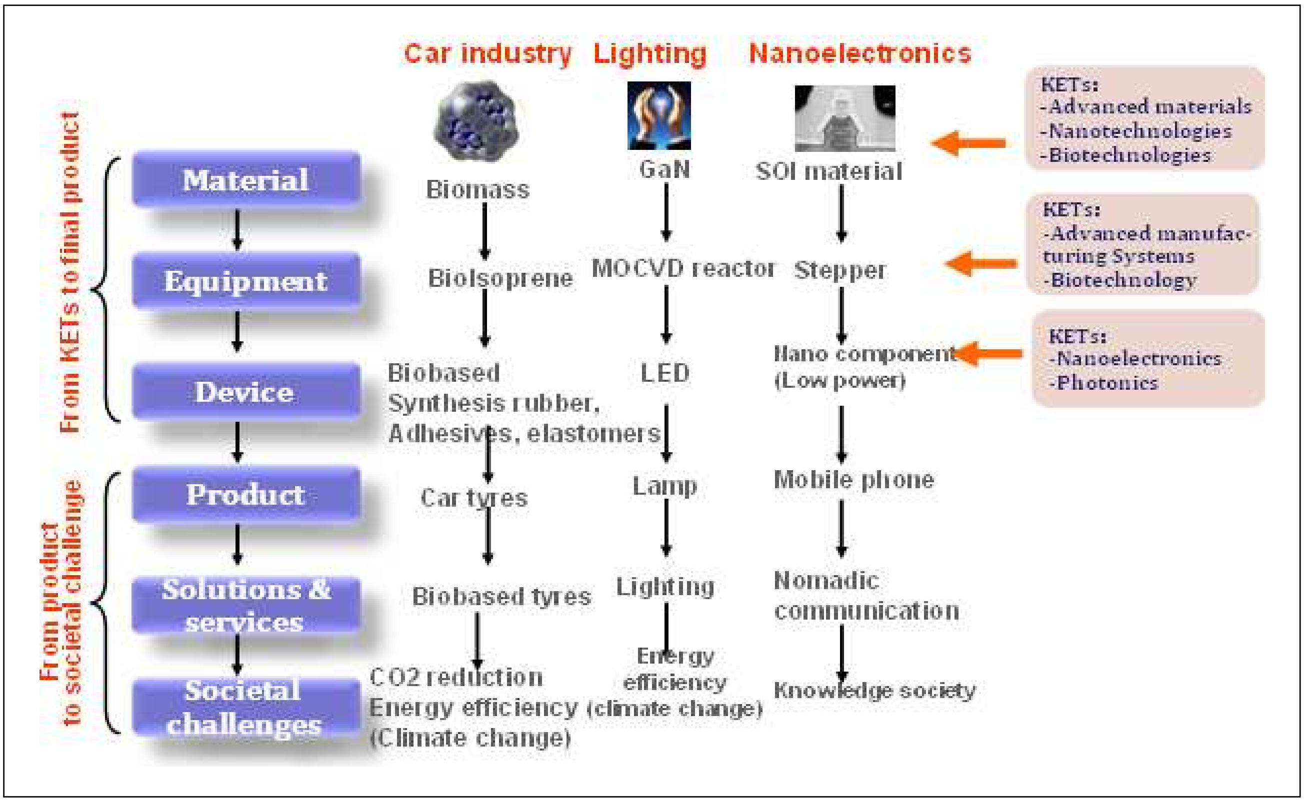

Figure 2: value chain approach: examples on KETs vertical integration

To exemplify the points made, four representative cases were studied with respect to their value chains, solid-state lighting, nanoelectronics, advanced batteries and automotive, with the intention of identifying the strength of their foothold in Europe, and in particular, which segments of these value chains were mastered and operated in Europe.

Case 1: Solid State Lighting

Solid state lighting (SSL) is a major potential contributor to energy saving and addressing European energy and climate challenges. Several advanced KETs are used in the solid state lighting value chain as shown above.

Europe has been at the forefront of SSL technology development: until recently, two out of three main SSL producers were European and had substantial manufacturing activities in Europe. The current manufacturing shift to Asia has heavily impacted this industry. Explosive growth in China is reinforcing this trend with Asian companies now threatening to overtake former European market leaders.

Whereas the European manufacturing base is strong in the downstream segments of the value chain close to the application, with more than 40% of general lighting manufacturing in Europe, it is weaker in the upstream segments, with 11% of Light Emitting Diode (LED) packaging and approximately 10% of global production of devices (LED chips) and advanced materials (compound semiconductor ingots and wafers). However, it is noted that the majority of key MOCVD (Metal-Organic Chemical Vapour Deposition) equipment for LED chip production is still manufactured in Europe.

One may conclude that although significant initial technology development and industrialisation for all lighting value chain segments originated in Europe less than 10 years ago, the manufacturing fabric upstream from the "lighting solutions" level is weak. In the case of this value chain, one notes that the technology development competences are available in Europe but face a significant threat of relocation to Asian manufacturing locations with favourable costs, a higher growth potential in nearby markets and quickly improving technological competence associated with increasing manufacturing experience, the successful agglomeration of critical complementary industries and services and a decidedly pro-active strategy to improve R&D capabilities and their industrial use. A significant obstacle for the realization of large-scale manufacturing capacity increases in SSL is the limited availability of funding caused by the risk aversity in the European banking sector

Case 2: Nanoelectronics

As clearly demonstrated in Figure 2, micro- and nano-electronic KETs are used at several levels of the value chain in the development of advanced products. Europe has a strong position in microelectronics KETs and related KETs. Three European companies are leaders in microelectronic substrates and related advanced equipment, amongst whom the world leader in lithography equipment, a key element in future microelectronics processing technologies. Europe has three major companies who master production of the most advanced semiconductors based in France, Germany and Ireland. Europe is a global leader in embedded systems and mobile phone platforms. Europe has one of the only three companies world-wide able to propose LTE platforms (Long-Term-Evolution). At the level of nomadics, Europe has two leaders. At the level of telecom networks, Europe has one of the global leaders. Europe is already engaged in the deployment of future LTE infrastructures after largely contributed to the definition of this world standard.

Another example is the transportation sector which is a key sector for energy challenges. Europe already has a leading position in this sector and can have great ambitions to be a home to world class equipment and system manufacturers. Europe can leverage its automotive micro and nanoelectronics sector to increase its competitiveness. This sector is currently in a period of rapid evolution and technological advancement with initiatives such as electrical or hybrid cars, smart roads where cars interact with their surroundings, and in-vehicle entertainment, Electronics are contributing significantly to bringing innovative solutions to these applications. In the automotive component and power module market alone, demand is expected to increase twenty-fold over the next decade, giving the market a value of over $5 billion in 2020. In order to illustrate the strength of European semiconductor industry in this sector, it should be mentioned that four enterprises headquartered in Germany, Switzerland and the Netherlands are within the top ten globally, other US and Japan headquartered companies have a strong R&D base in Europe. All these companies serve Tier1 enterprises headquartered and producing in Europe for European OEMs. For this reason, Europe is well positioned in the electrical and electronic components for the development of future all electric cars and the respective infrastructure like the smart grid. As far as electro-technical systems are concerned, Europe can provide the full value chain with leading edge technology. Europe can get the powerhouse for future individual transport systems.

Case 3: Advanced Batteries

With application domains in PV/smart grid and electro-mobility it is clear that advanced batteries are key to responding to climate and environmental challenges. Europe has traditionally been strong in developing this technology and was the cradle of most major breakthroughs during the last three decades. These technological strengths have not materialised into strong Europe-based manufacturing. The industrial production in Europe is below 5% of the global production for cathode materials, anode materials, separators, electrolytes, foils, cells and packs.

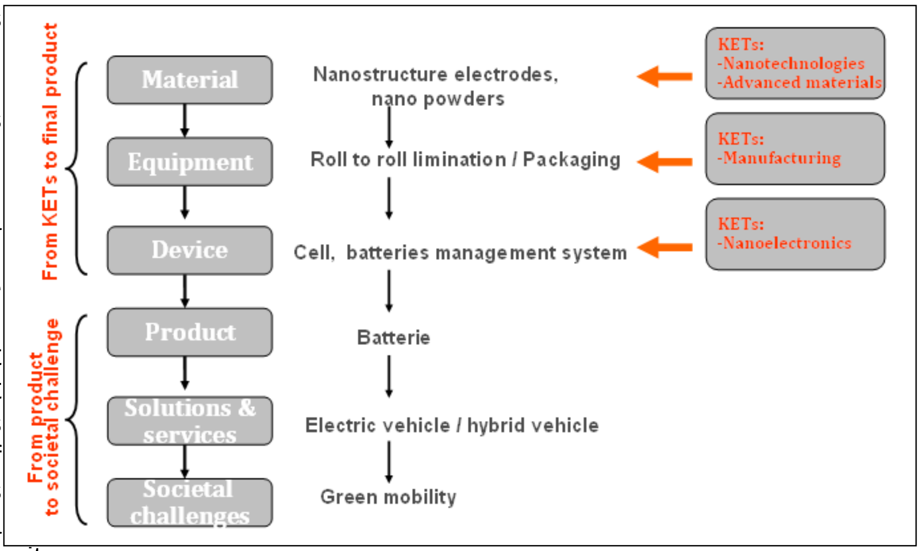

Figure 3: Battery value chain

The vast majority of this industry is today located in Asia (primarily Japan, with Korea and China catching up). For certain segments of the value chain, European companies are amongst the world leaders, but their production plants are located outside of Europe. The US has recently launched a major action[23] to increase its production capacity up to 40% of the world market in this important industry sector: in order to reach this goal, more than $1 billion USD has recently been awarded by U.S. Federal Agencies to build U.S. industrial capability and capacity in battery materials and batteries (9 battery manufacturing projects, 4 of which will be operational in early 2011, along with 11 component manufacturing facilities). European companies have already benefited from this US public funding and are establishing plants in the US.

To achieve a similar goal, Europe would have to mobilise its capabilities in order to bring large parts of the advanced batteries value chain within its borders. State-of-the-art technology remains in Europe, but European companies active in this domain have located their industrial activities in the vicinity of their main customers. There is a trend that in the coming years large parts of R&D and technology development will also move to the manufacturing sites outside of Europe drying-up resources in mainline innovation, scientific knowledge, R&D-infrastructure, technological and entrepreneurial stimuli and seed-money for knowledge-based start-ups along with the ability to link manufacturing experience and scientific progress vital for fast innovation cycles.

Case 4: Industrial Biotechnology in the Automotive Industry

Two companies recently started a collaboration to develop a biobased process to produce isoprene from renewable raw materials. The development of a BioIsoprene™ platform represents a major achievement for industrial biotechnology because it has the potential to enable production of isoprene from renewable raw materials to deliver commercial quantities of a basic C5 hydrocarbon that can be used as a feedstock for a large number of value-added products. The Bioisoprene product has many commercial applications, not only in rubber, adhesives and specialty elastomers, but also as biochemical or as biobased

[23] See Reuter's news 5 August 2010, press release from President Obama, USA: "We are also creating an entire advanced battery manufacturing industry in the United States. We used to have 2 percent of that market. By 2015, we expect to have up to 40 percent of that market".

hydrocarbon fuel for the gasoline, diesel and aviation markets. Through use of renewable feedstocks, the production of the BioIsoprene™ product is expected to be advantageous compared to petroleum-based processes for producing isoprene relative to reductions in non-renewable energy demand and global warming potential based on greenhouse gas (GHG) emissions. An expanded supply of low cost, high purity isoprene is expected to have a market potential of up to 11 billion pounds per year by 2012 as a replacement for petroleum-derived isoprene, natural rubber and other monomers used in a wide range of commercial applications. Although the innovative process as well as its commercialisation plan is being led by a European company, and there are several European tyre companies that probably share the same need for an alternative resource to oil, yet, the research collaboration phase is happening with a US tyre company, with the deployment of the technology, manufacturing, and commercialisation of the BioIsoprene product intended for the US market in the first phase.

GHG emissions resulting from transport account for more than one fifth of total GHG emissions in the EU[24]. Cellulosic ethanol, bio-ethanol made from agricultural residues such as straw or corn stover, has a huge economic and environmental potential. Biotechnological processes using highly specific biocatalysts and fermentation organisms can produce cellulosic ethanol in high yield. GHG emission reductions of almost 95% compared to fossil fuels can be achieved, and first generation problems like competition between food or feed and fuel or additional land use are overcome. In the EU27, more than 294 million tons of crop straw is produced annually[25], and using 60% of this amount would be sufficient to substitute up to 20% of EU gasoline consumption[26]. The potential is even higher if other residues like corn stover or energy plants are considered. Cellulosic ethanol can play an important role as platform compound in the production of chemicals such as ethylene which is the source for one of the most commonly used plastics polyethylene (PE). In Brazil, bio-polyethylene is already being made from bio-ethanol made from sugar cane. Both, the cellulosic ethanol as well as green polyethylene have applications in the car industry: cellulosic ethanol is one of the most climate-friendly fuels and bio-polyethylene can be used in many plastic parts of the automotive.

In the EU, an estimated 1.000 to 2.000 cellulosic ethanol plants would be needed only to exhaust the straw potential. This would result in the creation of several 100,000 new green jobs and would reduce the oil dependence of the EU by roughly 5%. Three European companies are building or operating first demonstration plants, and the technology to sustainably and cost-effectively produce cellulosic ethanol is ready and available in the EU now. But there is a lack of incentives for investment into first production plants which are more expensive because of the uncertainty in scale up. Political frameworks are needed to unlock the total economic potential and ensure Europe’s leading position in the field. In the US, where such frameworks are in place, first commercial production plants are already being built.

Other similar cases can be made for nanotechnology and advanced materials.

Where value chains are not as coherent and KETs are used in other industrial sectors they typically constitute a high-value part of the value chain such as sensors, energy storage, intelligent materials, or process and production technologies; often provided by small and medium-size specialized companies that supply a global niche market. It is crucial that they too develop and retain their technology leadership by cooperating with demanding European customers, leading scientists and highly qualified employees and have access to the latest in

[24] http://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-7
[25] EUROSTAT, Cereals production 2009
[26] Corn : straw ratio = 1.0; conversion rate ethanol : straw = 0.225; fuel value ethanol : gasoline = 0.65

technological advances, industrial competence and market vision.

3.2 The "valley of death": a key European weakness

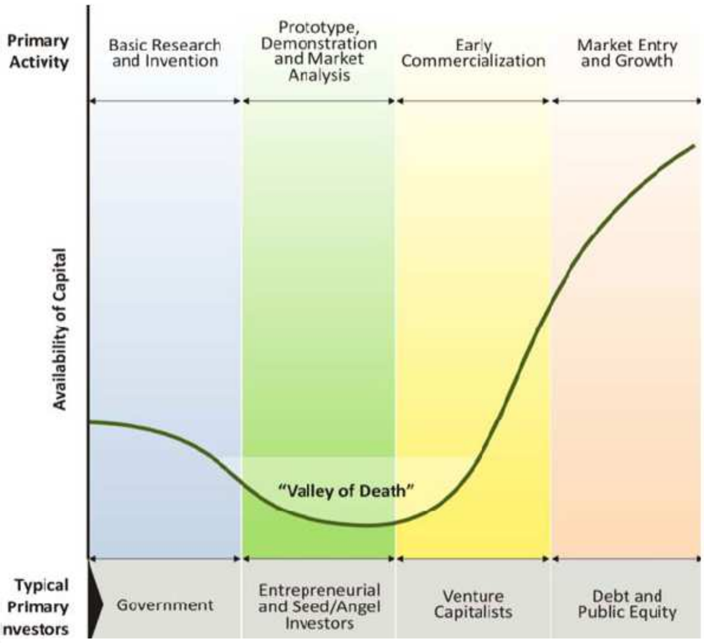

Figure 4: "Valley of death"

The above value chain analysis highlights significant challenges in current European industry translation of R&D into commercial products within an EU footprint. Whilst European R&D is generally strong in new technologies, it is observed that the transition from device to product and scale-up demonstration is crucial, and is the weakest stage in European KET enabled value chains. In particular in KET commercialisation, there are very large initial investment costs in new plant and processes which may lead to short-term lack of competitiveness. There is now an acknowledged growing problem with escalating competition from emerging economies. The relocation of manufacturing tends to be followed by relocation of R&D. This situation has been commonly identified across the KETs and is known in broad terms as the "valley of death" issue. Its effects can include not only relocation of manufacturing and R&D, but also the disruption of the entire value chains with their ultimate consequences on the sustainability of various strategic sectors in Europe.

This "valley of death" is demonstrated graphically in figure 4, for financial hurdles. However, the "valley of death" is not only due to financial issues, but also due to other factors, such as lack of political support, the absence of smart regulation and entrepreneurship, etc.

This issue has been identified in many competing countries, including USA, China and Taiwan, where they have established coordinated programmes in strategically important areas that cover the full innovation chain addressing basic and applied research, standardization measures, deployment and market access, all at the same time and, significantly, in a logical joined-up manner. Deployment is aided by targeted instruments addressing all technology readiness levels of competing technology approaches, from basic science through proof-of-concept and prototypes, to large-scale demonstration actions and public procurements.

One example is the US Department of Energy's 'Solid State Lighting' (SSL) programme, for which it has "developed a comprehensive national strategy that encompasses Basic Energy Science, Core Technology Research, Product Development, Manufacturing Research and Development Initiative, Commercialization Support, SSL Partnerships, and Standards Development"[27].

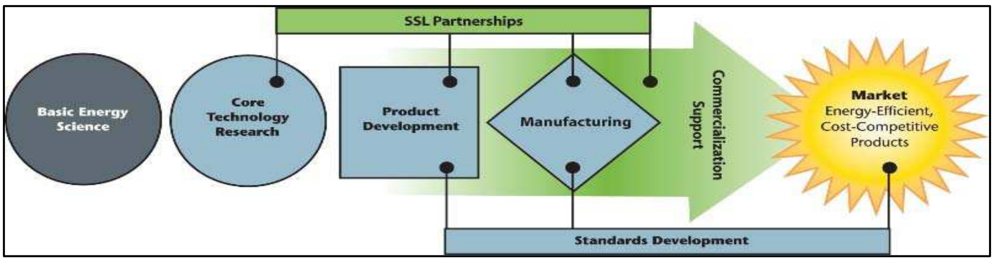

Figure 5: US Dept of Energy SSL funding initiative

27 US Dept of Energy SSL Initiative, http://www1.eere.energy.gov/buildings/ssl/about.html

As illustrated in Figure 5, this initiative provides coordinated support throughout the whole innovation chain of the technology from 'laboratory to marketplace', and, crucially, is open to all comers and not just the established stakeholders.

The EU has a lack of market-oriented public-private partnerships and programmes that combine transnational research through coordinated action specifically aimed at shortening time to market even if there are some successful examples. Factors that lead to success include: securing a significant size of the action; ensuring the early involvement of relevant value chain partners (SMEs, spin-offs, suppliers and end-user industry); and providing access to flexible manufacturing capabilities. Public and long term (beyond 5 years) funding via entities such as the European Investment Bank can go hand in hand with venture capital private funds. However for venture capital funding, the usual requirement for a relatively short exit horizon (say three years) from their investment is often too short. This means that hybrid public–private financing models are needed to fill a potential investment shortfall.

Developing new policy and financial issues to support KETs will be meaningless if the critical "valley of death" problem cannot be solved. Possible enablers suggested include smart market-pull measures and significant support for large scale demonstrators.

3.3 The need for an integrated strategy for KETs development

The KETs sectorial SWOT and value chain analysis highlight the need for an integrated KET approach.

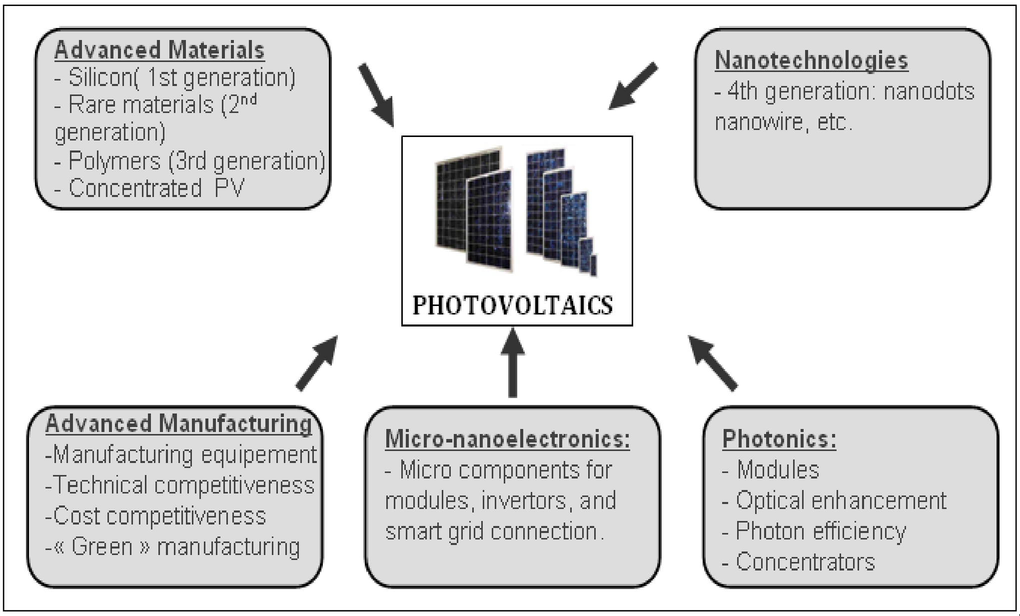

Figure 6: KETs interdisciplinary approach: example of photonics

Owing to the interdependency of KETs in the development of advanced products, it is essential to propose an integrated KET approach covering the spectrum of all the KETs. This will provide significant added value to strengthen their development and deployment in and from Europe.

The photonics example shown above demonstrates that a number of KETs are required to develop photovoltaics based products. In fact, for each subsequent PV generation, the number of KETs to be combined increases. The third generation of PV products will include nanotechnology, advanced materials along with microelectronic devices.

Due to the different degree of KETs maturity, it is essential to propose an integrated KET approach covering the different development phases as previously illustrated by the SSL funding initiative. The HLG vertical sector analysis has been mapped to this architecture, and will be presented in detail in part 4 "The way forward".

The KETs sectorial SWOT and value chain analysis has identified a double condition for sustainability: technology capability and manufacturing capacity:

To be world competitive requires both a technology capability and manufacturing capacity.

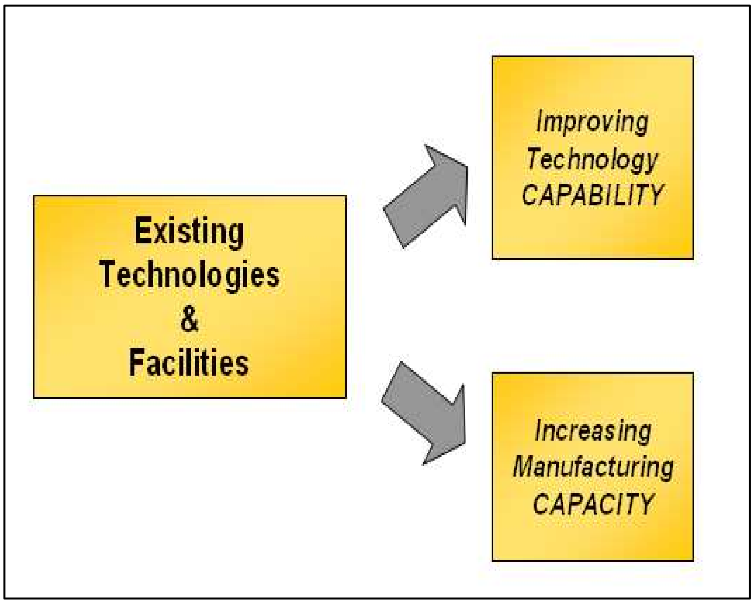

Figure 7: How to improve the competitiveness of European KETs

Therefore, KETs competitiveness improvement must follow two combined routes within the overall KETs integrated strategy:

- improving technology capability mainly supported by public investment
- improving manufacturing capacity primarily supported by private investment.

Returns on investment in Europe due to the increasing manufacturing capacity of existing companies and the attraction of international investment, will ensure the sustainability of the actions.

4. The Way Forward

4.1 An integrated initiative on KETs

An integrated approach to KETs will provide an added value for Europe, also in terms of visibility and readability of the action. Otherwise there is a risk of dispersion of effort and loss of efficiency in the ongoing KET initiative.

The different contributions arising from phase 1 of the analysis by the HLG clearly showed that it is the same key stages that determine the development of all KETs. The KETs challenges being similar, it follows that their solutions, practices and the financial requirements will be broadly similar. An integrated approach to KETs is therefore perfectly possible and enables common solutions and actions, each of which can then achieve a more significant critical mass, effectiveness, visibility and impact.

The degree of maturity along the development process of each KET differentiates each of them. This variable degree of maturity depends mainly on their order in the history of emergence of technologies, with two extremities, that of microelectronics which emerged in the 1950's and nanotechnology which emerged in the 1980's, which represent the most and least mature respectively of those KETs currently considered. The knowledge acquired throughout the maturation process of a KET enables innovation ecosystems and industries to accelerate the development of new KETs. An integrated approach to KETs will therefore allow the use of the know-how and feedback of experience of the more mature KETs to accelerate the development of more recent and therefore less mature KETs. Such an integrated approach would therefore benefit from an overall "pull-along" effect for all KETs.

In addition, it is evident that the most innovative products incorporate not only a single KET but several KETS simultaneously. Each KET brings a part of the technological innovation but the accumulated benefit from a number of KETs constitutes a significantly more important technological leap-forward. All the more so, as mastering the development of different KETs all along the chain enables one to be innovative in the way to integrate them and develop new products. This holistic approach assures greater product competitiveness and in turn a significantly higher barrier to copying. To propose a global approach to the development of KETs therefore makes particular sense given their highly interdisciplinary nature.

The HLG thus decided to conclude phase 1 of its work by proposing an integrated industrial and political approach to the development of KETs in Europe. This proposal is described in the following sections of this report and will constitute the framework of reflections to be launched during the second phase of the HLG-KET in early 2011.

4.2 From basic science to the global market

The US built their economic development on the logical sequence from the creative idea of a new company to the market, accompanied by appropriate stages of financing by major US Federal Departments and agencies and subsequently by massive availability of venture capital, private equity and risk-bearing investment vehicles. The presence in the US of a very powerful and large home market served as a significant growth accelerator of numerous KET based companies. Whilst the US has lost technological leadership in some fields, its innovation capacity is still considerable but has tended to weaken in the face of an Asian dynamic.

The Asian model, on the other hand, has been so far based on a technological "catch-up" financed at the lowest cost and realized by a systematic absorption of existing advanced western know-how. Their significant reactivity and capacity to master very rapidly the latest technologies has allowed several Asian countries to achieve parity with, if not surpass, the level of most advanced western economies. Japan was the first to master KETs in a quasi-systematic manner before finding itself in difficulty faced with crucial investment going abroad to resurgent Taiwanese and Korean economies. China is demonstrating its capacity to master and deploy KETs in a competitive manner and increasingly represents a major risk for Europe. Asian countries are placing significant emphasis on the mastering of key technologies, to the level of mass production at very low cost. They are convinced that starting from such a mastery of key technologies they can rapidly climb the value chain and thus restrict European industry to only the very high value added end of this chain. In the future, there is little chance that there will remain space at the top of value chains reserved for western economies. It is most likely that those who master key technologies, like a number of Asian countries, will subsequently impose their standards on those that use them in their high value added products, thus forcing them from their historic markets.

KETs are “embedded” in these products but their contribution to the quality of the final product and service is more important than one would imagine. Considering that KETs will become a commodity would be a serious strategic error for Europe.

4.3 The KETs “valley of death”

Europe has fundamental research in the different KET domains at world-class level. However, beyond this foundational innovation creation stage, Europe encounters major difficulties to commercially exploit its ideas, transform them into technologies, subsequently into products and finally produce them competitively at world level.

Europe finds itself incapable of crossing in a systematic and efficient manner the "valley of death” which separates the creative idea from the global market. Whilst the Americans excel in this crossing and Asians commit their energy and finances to ensure a rapid and unencumbered crossing, this “valley of death” constitutes a major hurdle for Europe. Europe thus often losing first-mover-advantages that establish whole industries, and subsequently being surpassed on the way to the marketplace by more nimble competitors.

Therefore, the successful deployment of KETs in Europe necessarily implies focusing future actions on this “valley of death” challenge and putting in place the means necessary to cross it as well as US and Asian competitor nations.

4.4 A European “three-pillar bridge” to pass across the "valley of death"

Crossing the “valley of death” in the key enabling technologies in Europe requires the delivery of solutions to the three successive stages implicit in this crossing.

- **The first stage, called “Technological research”** consists of taking best advantage of European scientific excellence in transforming the ideas arising from fundamental research into technologies competitive at world level. These should be both shown through proofs of concept and be proprietary, that is protected by patents. It is the patents that will guarantee both the future freedom to exploit these technologies by European industry and their capacity to resist counterfeits and copying. From a more general perspective, an IPR strategy for global markets along with a single and efficient European system for IP protection and enforcement are urgently needed.

- **The second stage, called “Product demonstration”** allows the use and exploitation of these KETs on European soil to make innovative and performing products competitive at world level. This requires firstly putting in place pilot lines having the technologies and prototyping facilities to enable the fabrication of a significant quantity of innovative products arising from these KETs. Secondly, the product validation in terms of its user performance requires deployment operations at a significant scale, on European sites protecting the technological advance achieved. In both cases, the objective is to make a demonstration at real scale of the relevance in terms of user value and the competitiveness of new products containing one or several KETs.

- **The third stage, called "Competitive manufacturing"** should allow, starting from products duly validated during the demonstration phase to create and maintain in Europe attractive economic environments in EU regions based on strong eco-systems and globally competitive industries. In particular, production facilities competitive with their US and Asian equivalents in terms of production volumes and therefore price of products. This will allow to further strengthen the capabilities of EU industry to more successfully deploy KETs-based products, face international competition and master solutions to tackle grand societal challenges. In fact, in KETs where economies of scale are of importance, only advanced manufacturing based on the latest technologies and at a significant level will allow:
    - The acceleration of the learning curve on new manufacturing technologies and products in order to arrive amongst the first on non-mature markets with a high probability of penetration.
    - To absorb the enormous fixed costs of quality production on a volume sufficiently important to attain production costs in line with those of international competitors, notably Asian.
    - To retain the production know-how at the top level, this is the only guarantee of a complete mastery of all these crucial KETs steps on European soil.
    - To develop an industry for equipment and advanced manufacturing systems generating a source of export revenues, and support the downstream producers of machinery capable to produce the most advanced manufacturing technologies in Europe (machinery, software, services, etc.), as well as the development and improvement of manufacturing systems (technology and processes) in order to build efficient, modern and high technology manufacturing facilities in Europe.
    - To master the whole product life cycle, from resource efficient and energy saving production to recycling processes.

The role of globally competitive fabrication facilities at large volumes where economy of scale is required is therefore very important to nourish the economic eco-system, in particular with regard to SMEs, which act as sub-contractors and suppliers to downstream industry users. Only significant fabrication facilities will have the integrated capacity of technologies and product development to be able to react to the international competition and follow the rapid renewal dynamics in the field of KETs-based products. The improvement of framework conditions for KETs will also encourage dynamic markets for KETs.

The crossing of "valley of death" in the KETs could therefore be imagined in the following manner in constructing a European bridge comprising three pillars:

- The pillar of technological research focused on the technology
- The pillar of product demonstration arising from the technologies focused on the products
- The pillar of production, competitive at world level, focused on advanced manufacturing.

This bridge, illustrated in figure 8, would be supported at one end by the European knowledge reservoir and would arrive at the other end on worldwide global markets, therefore becoming the bridge between knowledge and the market.

This crossing of the "valley of death" presupposes appropriate framework conditions; in particular that the financial, legal and commercial support measures would be adapted in order that European technologies could be successfully developed, deployed and protected, that enterprise and especially SME's could develop, that local innovation ecosystems could be born and grow, that the products could benefit from standardization activities, that emerging markets could be privileged and that the rules of international commercial engagement could guarantee a fair competition between producing nations at world level. It is therefore a complete political and regulatory environment which would need to be put in place in order that the efforts made across the three pillars would be crowned by success.

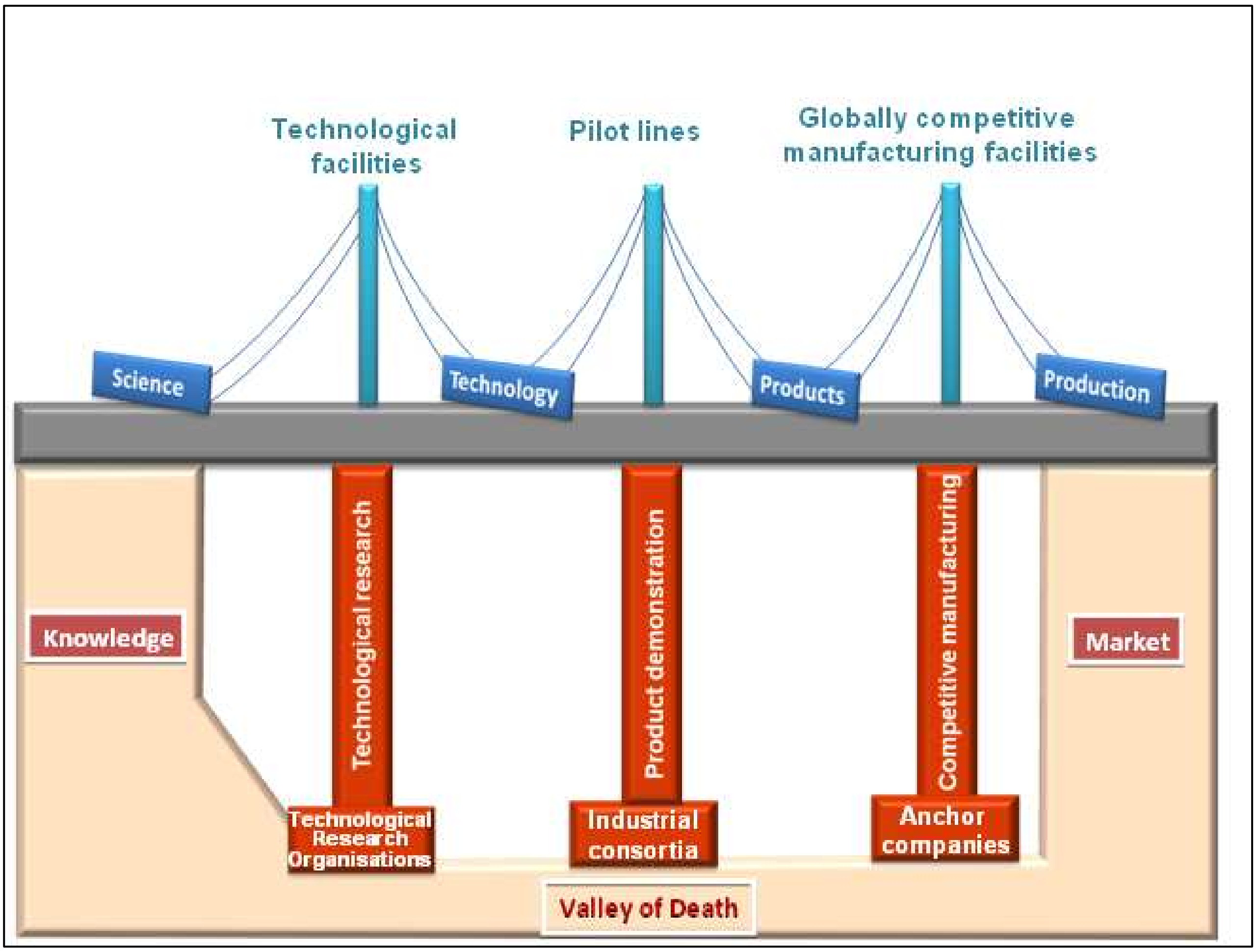

Figure 8: A European integrated initiative to pass through the KETs valley of death

4.5 Triggering a virtuous cycle

From knowledge generation to market flow

This flow enables companies to successively pass:
- From basic science to technology by the technological research stage;
- From technology to product by the demonstration stage;
- From products to large scale production stage by competitive manufacturing to have access to global competitive markets.

From the market to knowledge generation "return flow"

The return flow from market to knowledge generation closes a virtuous cycle leading to a competitive growth.

- It is only based on market experience feedback that one can acquire a true understanding of user needs and therefore the relevant specifications of future products. It is also this large volume production that ensures a significant return on investment for Europe in terms of orders, employment and taxes, thus enabling a harmonious societal development.
- From this feedback loop, products arising from the demonstration phase will have been correctly specified, they will naturally find an optimal usage value which will in turn lead to a relevant demonstration. The return on investment of this stage is therefore de-facto guaranteed.
- The product evolution expected by consumers having been identified, it is therefore easier to identify the technologies in gestation or to initiate the technological developments required to address the technological breakthrough needed. The level of relevance of the technology is in turn improved significantly along with its chances of future exploitation.
- Finally the technological developers can, in turn, identify the most relevant ideas in the knowledge reservoir arising from the European fundamental research. This research base will therefore become more “useable” and more “useful” thereby ensuring a return on investment at its proper level.
- At the same time, early feedback from the equipment and manufacturing community will allow to understand and identify new possible product specifications. This is only possible if these communities remain in Europe.

Such a virtuous cycle constitutes a solid bridge which links the basic science to the global market.

4.6 The first pillar: KETs technological research

In order to develop KETs, gain and retain a leading industrial capability and create new potential for growth, Europe must react in the face of Asian competitors, who have rapidly made a technological catch-up at minimum cost by exploiting the results of scientific work realized by western countries and who are now developing a formidable fundamental research base through a focused, well funded and well coordinated effort.

Fundamental research has as its principal objective the progress of human knowledge and therefore publishes its research in a world reservoir to the benefit of whole mankind. This approach necessitates a considerable initial investment without guarantee of any return on investment to the societal stakeholders who support this effort.

In effect, with the simultaneous development and extreme rapidity of ubiquitous information along with a global knowledge marketplace, this knowledge has become accessible to all, everywhere and at every moment. It is not therefore evident that the countries which developed this knowledge are those that exploit it economically themselves but rather the countries which know how to rapidly pick-up this knowledge base and transform it into technologies and innovative products with the consequent economic exploitation on their own territory. A significant decoupling between the production of knowledge and its economic exploitation has therefore occurred.

It is therefore vital for Europe which massively produces knowledge but which has not translated this capacity into internal economic and societal development, to reverse this tendency. Europe must therefore first focus its attention and action on the rapid transformation of its knowledge base into know-how protected by patents, moving up the learning curve ahead of its competitors and enforcing IP where necessary.

To develop innovative technologies starting from new knowledge, arising from fundamental research, and subsequently demonstrate its feasibility in innovative products, is the role of

Europe's technology research organizations. By providing a linkage between fundamental research and industry, these organizations play a major role in Europe. Asia is in the process of copying this model and is now developing technology research organizations in several countries (Japan, Korea, Taiwan etc.). In Europe, advanced technological research infrastructures have been established by these organizations. In the nanoelectronics and photonics domains, considerable infrastructures open to both industry as well as academia have been operated by such organizations. The first alliances between technology research organizations, created to facilitate shared access to technological infrastructures, occurred over ten years ago. There is now an imperative to accelerate such technological cooperation amongst these organizations and for industry to be actors in international industry alliances in order to share the extremely high cost of generic development.

The majority of European technology research organizations are engaged since a considerable time in the development of KETs; certain of them specialized in one or more KETs, others covering a spectrum significantly larger addressing all the KETs mentioned previously in an interdisciplinary approach. This group of European technology research organizations therefore cover all the thematic KETs at the stage of technological development, a key stage in the assembly of an intellectual property portfolio for Europe.

4.7 The second pillar: KETs product demonstration

The different HLG KET working groups along with the different propositions made by key European actors have clearly highlighted the deficit of member state and European initiatives to demonstrate the capacity to make innovative products with embedded KETs, but equally the validation of the real value of these products through deployment operations at a sufficiently important scale to be relevant and have impact.

It is therefore indispensible to conduct a vigorous action in these two directions in order to reestablish this situation in particular vis-à-vis Asian countries that systematically practice this approach. In fact, it is only by providing itself with this type of capacity to demonstrate new products embedding one or more KETs that Europe will demonstrate mastery of its KETs in a competitive manner.

To pass from the feasibility demonstration of a technology by one or more technological research organizations, to the competitive production of products requires Europe to have pilot lines which comprise:

- A tool to allow the fabrication of products in a reproducible manner thereby demonstrating the "feasibility" of the KETs.
- A tool sufficiently flexible to rapidly diversify the products according to the different applications targeted but also to absorb new KETs technologies which are continually renewed.

This pilot line concept could perhaps be explained as a hybrid unit simultaneously capable of having the mastery of technologies like a "Fab" whilst also able to act like a "Lab" to introduce new generations of technologies before competitors. The combination of these two objectives, a priori paradoxical, gives rise to a need for resources that cannot be absorbed in their totality by industry. Only appropriate financial support can lower this threshold and make possible the existence in Europe of such pilot lines for the different KET domains.

The diverse HLG inputs to-date have highlighted several suggestions for KET pilot line projects:

- In the domains of microelectronics and photonics, it involves pilot lines allowing the fabrication of miniaturized innovative components addressing primarily rapidly growing markets such as energy, health, security and ICT.

- o In the domains of advanced materials or nanotechnology, it involves pilot installations allowing the production of materials or innovative components whose properties are profoundly revolutionized by the progress made within these KETs, as well as in the areas of batteries for decarbonised mobility, photovoltaic's, organic electronics, etc.
- o In the domain of industrial biotechnologies, the objective is to install in Europe pilot installations allowing the production of chemical molecules from vegetal or animal species, for applications in energy and chemistry.

To have, in advance of competitors, innovative KET based products in small series does not signify that these products have found a niche market. That is the reason for which innovative technological countries accompany this stage of product development with large scale deployment of these products in the form of demonstrators. These demonstrators target several objectives at the same time:

- o Create a seed market which will turn the production lines concerned, thus showing the feasibility of the innovative KETs in production terms.
- o Have a significant scale demonstration of the innovative products to evaluate the difficulties of the operation but also and above all to evaluate the end user value of these innovative products and this in a limited liability environment
- o This real experience feedback will allow the fine-tuning of the products to improve their performance and thus to start significant volume production in a secure and optimal manner to address relevant markets.

Countries such as Japan have developed in a systematic manner such demonstrations with significant success. Thus, for example, large scale photovoltaics demonstrations at city level have allowed the development of a world-class Japanese industry, the reduction of prices and the retention of significant profits which are today subsequently reinvested into a new technology for energy, that of fuel cells which now follows the same virtuous cycle.

Pioneer deployments in Europe could include the deployment of very high speed wiring communication networks based on the combination of photonics and nanoelectronics devices, in order to create the appropriate infrastructure for new e-services; deployment of photonics based diagnosis systems, that offer valuable solutions for predictive medicine at reasonable cost.

4.8 The third pillar: KETs Competitive Manufacturing

The deployment of KET is key for Europe to strengthen its manufacturing capacities while addressing societal challenges, through a rejuvenation of production capacities as well as through creation of new plants. Development of new products will require new unit operations as well as the clever combination of new and existing manufacturing technologies. Introduction of innovative materials in a value chain can have high impact on the manufacturing technologies of downstream industries. For some KET process integration down in the value chains or multipurpose plants will have to be considered. For advanced materials which are the roots of many other KETs, manufacturing does not start with engineering of the materials, but essentially has to include the earlier value chain of manufacturing the new materials itself, which is the role of the process industries. A specific challenge for the process industry is up-scaling which is critical in the development of any new process. Larger demonstration at industrial scale, rejuvenation of existing plants should therefore be supported through relevant instruments such as Public-Private-Partnerships (PPP). PPPs involving all key partners and supporting the collaboration with and within different value chains should enable sustainable (incl. competitive) manufacturing of KETs in Europe.

This third pillar is, in a general manner, what Europe lacks most. To really take conscience of what is involved, it suffices to use an analogy with the world of the automobile, despite the fact that the automotive industry is a sector and the KETs are generic.

Imagine that our European industry did not have fabrication plants for large volume production of automobiles and that the only fabrication units installed in Europe were limited to small and medium series fabricated in these pilot plants. This would in essence translate to massive importations of automobiles produced in the US or Asia and to no European exportations towards these geographic zones or indeed towards emerging countries. After a few years would Europe be sure to have within its borders the mastery of advanced manufacturing technologies for automobiles? To still have on European soil the network of sub-contractor enterprises and equipment makers along with advanced production systems? Then, if one cannot imagine a Europe without its automotive industry, why can one imagine a future Europe without powerful industries in the domain of KETs, these technologies at the base of most future products which will appear?

The different discussions arising from the open HLG consultations and those of its working groups have demonstrated that KETs-based products manufacturing in Europe is under intense pressure from world competitors for example:

- In microelectronics, three European sites Dresden, Dublin and Grenoble are still engaged in the manufacture of advanced 300mm wafer technology semiconductor products. All suffer from an inability to attain the critical mass indispensible to their medium term stability. In contrast, INTEL in the US, Samsung in Korea and TSMC in Taiwan already have giga-fabs and invest continually in new ones. A further major site, Eindhoven / Leuven is engaged in semiconductor equipment development and validation.
- In photonics, Europe, which has two of the world giants in the field of lighting, still does not possess production facilities of a size competitive with those in Asia.
- In the field of advanced materials, the European photovoltaics market is by far the largest market in the world and nevertheless, European industries are increasingly losing competitiveness especially with respect to their Chinese counterparts who already built huge and efficient factories with high end equipment leading to a rapid fall in their cost base, a fall which most European industries cannot follow. In the case of batteries, lithium ion based technology is at the heart of future energy applications. Whilst Europe was the prime initiator of these battery technologies, it has never succeeded in passing the level of pilot plants and now even sees its new factories redeploying to the US.

It is of course evident that production capacity must follow rapid growth markets however it is also indispensible that they exist in Europe; on the one hand to supply European markets and on the other to export towards other regions of the world. To ignore this fact is to accept the slow erosion of the European industry base. To not do so would be to definitively renounce the position which Europe should regain in the mass production of goods.

These globally competitive manufacturing facilities should preferentially be installed in Europe in sites which are already significant both in terms of technology and fabrication. They will naturally benefit from the emergence of local innovation ecosystems pulling in their wake a whole stream of enterprises, notably SMEs, equipment makers, start-ups, laboratories, research centers and training centers.

These globally competitive manufacturing facilities should be at leading world-class technological standard, they should equally integrate on their site a pilot line as described previously, which will allow them to mature technologies in advance of phase and to subsequently, efficiently implant these technologies on their volume production lines. The geographic co-location of pilot lines and a globally competitive manufacturing facility would allow each to support each other to optimize installations, resources, competences along with the rapid and efficient transfer of new technologies.

In order to successfully install in Europe KETs globally competitive manufacturing facilities, it finally appears necessary to ensure that appropriate mechanisms are in place to ensure a level playing field with respect to large-scale investments on KETs. Only large volume production allows significant cost savings. This is now routinely achieved by new facilities in Asia, such as GW-scale PV production facilities in China. In those instances, the key advantage of the Chinese competition is not lower salaries, which represent typically less than 10% of the operational costs of such highly automated production, but easy access to investment capital at very low interest rates. In order to address this obstacle for European manufacturing in vital KETs, new investment guarantee financial instruments should be considered.

To act to reverse this tendency is to promote the implantation in Europe of a certain number of globally competitive manufacturing facilities on strategic KET technologies. To do so will require Europe to have the courage to confront the structural difficulties currently hampering such action. Today, large R&D domains where significant European added value is created and where the competitiveness of European industry is guaranteed are not eligible for adequate support. Europe must check and guarantee a global competitive playing field versus the rest of the world for R&D and manufacturing. This requires first of all framework conditions that are attractive for large scale and risky investments, e.g. easy access to finance, appropriate regulatory and fiscal conditions, protection of IPR, advanced infrastructures, highly educated workforce, standardization, strong internal market, etc; Europe already possesses some strengths with regard to such framework conditions, even if improvement is necessary to ensure a level playing field with global competitors aligned with international best practices. To not do so is to let Europe become ineluctably overtaken by international competition, in particular from East Asia.

4.9 Potential pillars actions

On the basis of the HLG KET Working Document observations obtained by European wide open consultation and from specific HLG KET working groups during the first phase of its work, and in keeping with the decisions agreed by the HLG KET during its kick-off meeting on the 13th of July 2010, the HLG KET will enter into its second phase of work during the first semester of 2011**.** This second phase shall deepen priority paths identified during the first HLG phase, and shall elaborate a series of recommendations for implementation.

During its kick-off meeting, the HLG KET agreed that conversely to the phase 1, dedicated to the vertical analysis of each KET, phase 2 would be dedicated to a transversal analysis of the whole KETs, in order to deliver comprehensive proposals and measures implementable for all KETs. For all the priority paths identified during phase 1, the second phase shall then be focused on the analysis and identification of the policy measures required to implement a single industrial and political approach to KETs.

The HLG KET proposes therefore to implement the same methodology successfully used during the first phase of work, in order to carry out the transversal analysis of phase 2, including in particular; the organisation of KETs Policy Workshops with appropriate invited outside expertise and the establishment of new HLG working groups focused on each priority path and related policy issues.

5. Closing remarks:

This working document presents the current state of reflection of the HLG with regard to the industrial deployment and commercialisation of Key Enabling Technologies in Europe. It is based on a European wide consultation of relevant stakeholders including industry, technological research organisations, academia along with national & regional authorities. The report represents a diagnosis by non public policy makers to prepare the recommendations to be transmitted to policy makers. The development of appropriate policy recommendations will be the goal of the second phase of this HLG KET initiative, which will look at how existing instruments at EU and national level can be better aligned and utilised for the deployment of KETs." To accomplish this work, seven working groups have already been identified with their remit as outlined in Appendix A. A full report will be delivered by the HLG KET President and Board in July 2011.

APPENDIX A: HLG KET PHASE 2 ORGANISATION

It is the overarching task of all working groups to identify and propose improvements for policies in their respective mandate, within the time pressure context for these rapid and integrated innovation cycles technologies.

WG 1: KETs transdisciplinarity. Most innovative products combine several KETs simultaneously, each KET bringing a piece of innovation resulting in a more innovative product as a whole. It is therefore important to assess the value-added of an interdisciplinary KETs approach, and to deliver proposals likely to facilitate such interdisciplinarity. Particular attention should be paid to the development of skills, education and training systems compatible with such interdisciplinarity as well as formats for disseminating current technological knowledge to industry. In addition, this interdisciplinarity inevitably leads to the converging of technologies, which raise societal questions, deserving a structured response. In this respect, WG1 shall also focus on the key issue of societal acceptance of KETs and on the benefits-risks analysis for society.

WG2: KETs Value chain and vertical integration. Innovation has to start simultaneously at various stages of the value chain: in order to speed up innovation in Europe, the traditional modus operandi needs to be complemented with an approach that brings together and stimulates innovation at key stages of the value chain simultaneously, in order to create competition and breakthrough for comprehensive solutions. The various contributions received during phase 1 of the HLG clearly identified the necessity to assess the KETs value chain from KETs to final product to identify and follow-through on opportunities for KETs integration in other established or new value chains as well as KETs contribution to addressing grand societal challenges. A particular emphasis was given to the vertical integration between product suppliers including these KETs and users of the same products. The working group shall clarify the key elements of the different value chains from KETs to grand societal challenges, and elaborate proposals to reinforce the links between the various parts of this value chain at a European level by considering for instance the contribution of KETs to future European Innovation Partnerships, along with the appropriate measures to reinforce these links.

WG 3: KETs Technological Research enhancement. This working group shall focus on the first pillar of the KETs bridge to pass through the "valley of death"; the development of core technologies by European technology research organizations, in close collaboration with industry speeding up feedback loops aimed at shortening time-to-market. It shall work on key measures to reinforce technology research in Europe through technology transfer and intellectual property measures, the strengthening and launching of flexible public private partnerships involving innovative multinational companies, SMEs, academia, government research agencies and government sectors, as well as joint strategic programming activities. It shall also work on key measures in order to promote technology research organizations' alliances in Europe by facilitating access to complementary facilities, compatibility of their simulation and modeling tools for KETs design, and to strenghten their links with upstream basic research and downstream industry directly involved in the two remaining pillars, being KETs demonstrators and KETs Globally competitive manufacturing facilities, to create and maintain interdisciplinary KETs centers.

WG4: KETs Product Development launch. This working group will define the various demonstration activities required in Europe to further deploy KETs. It will include focusing both on pilot lines, scale up and large scale deployment demonstrators for KETs open to small and large companies in a variety of applications. The main objective will be to create the success conditions for Europe to remain competitive with respect to American and Asian competitors. The working group will then be tasked with the identification of the key measures required to succeed in the launching of such activities.

WG5: KETs Globally competitive manufacturing facilities installation. This working group will address policy and other issues concerning the conditions for establishing competitive production capacities in Europe, able to compete with international facilities, in particular those in East Asia. The high level of investment required, coming mainly from the private sector, will naturally lead to a selection of globally competitive manufacturing facilities, covering all the KETs, according to their level of maturity. The working group will be tasked with the elaboration of proposals on potential European globally competitive manufacturing facilities, as well as the identification of a policy framework to create the successful conditions for an equal global level playing field.

WG6: Policy benchmark and options. European industrials willing to strengthen and / or install pilot lines or production plants always face various options for their localisation throughout the world. One strategic issue for Europe is to make Europe the obvious place for such investments. To improve current framework conditions, it is essential to benchmark positive deployment policy frameworks and strategies across the world and within Europe on issues such as European internal market, competition and trade policies, support of investments, state aid policies, R&D activities, tax incentives, public procurement, skills development and training activities, trade, market pull (e.g. lead markets), skills and public-private engagements. This is essential for new production facilities as well as for the rejuvenation of existing plants in order to integrate KETs into all production processes and products. This WG will focus mainly on the 3rd pillar and propose needed actions.

WG7: KETs Financial instruments. Launching European initiatives to recover a leading role at a global level will imply a considerable financial effort from the public and private sectors. The public sector will have to combine several horizontal sources of EU funding reflecting the recognition given to the role of KETs in the framework of Europe 2020 Agenda, together with several sources of vertical funding provided by regions and Member States. This public support will subsequently leverage private funds, with the total combination of investments enabling Europe to address in parallel the two major KETs challenges, the continuous improvement of technological capabilities and the improvement of production capacities in Europe. In return, Public Authorities will require precise commitments from industry leading to clearly identifiable wider economic benefits for Europe. The working group will focus on financial aspects and deliver recommendations such as proposals for public-private funding schemes decisive for the establishment of pilot lines and globally competitive manufacturing facilities as required by KETs industrials in Europe, access to long term investment funds as well as venture capital funding, risk mitigation, along with the definition of potential new financial instruments for KETs.

These working groups' tasks, along with the consultative workshop process of phase 2, shall be finalised at the end of May 2011, so that the final HLG KET report will be validated during the HLG KET closing meeting of June 2011.