HLG KETs

Transdisciplinarity, Societal Acceptance and Innovative Regions

Working Group 1 Report

0 - Executive summary

Key Enabling Technologies open a whole range of opportunities for future growth and their potential may be pivotal to enable the EU to solve societal challenges. The six KETs, micro/nano electronics, photonics, advanced materials, nanotechnology, biotechnology and advanced manufacturing share common scientific grounds that make them interdisciplinary. KETS synergies and transdiciplinarity should lead to new high value-added products as well as to contribute to solve societal challenges by means of more sustainable new applications and services.

KETs require a common approach given their characteristics, even if their degree of maturity might be different, since they all have to face their valley of death and the three pillar bridge represents a common solution to get across it.

The exploitation of KETs, taking advantage of their synergies and transdisciplinarity, requires new competences and skills that have to be sought at different levels. Research and engineering skills will have to adapt to satisfy KETs needs, in particular to satisfy the buildup of pillars 1 and 2. They will have to correspond also to industrial needs in order to satisfy the request of industrial jobs and to participate in building up pillar 3. In fact, the interdisciplinarity mind is not only necessary to work on KETs, but it is also a must for the assessment of projects from the side of the evaluation and funding organizations.

Interdisciplinarity means bringing together expertise from different solid disciplines to work on common ground. In this sense the skills requirements for engineers, apart from their technical competences will include project management, innovation management, understanding customers and suppliers, communication abilities, team work and problem solving as the most relevant. In order to fill all these demands action needs to be taken at different levels. Promotion of Maths and S&T should be made at secondary education level in order to assure a flow of engineering students in European Universities. Universities and research organizations should devise training programmes adapted to KETs, and University-Industry partnerships should look at education mechanisms that foster the development of the required skills and the requirement of industrial needs. At present several general European initiatives and instruments are being or have been implemented that could be useful to this end.

Risk assessment has played a pivotal role in the control of technological and industrial environment. An integrated risk/benefit assessment, where as much attention is given to benefit assessment as it has been given in the past to risk assessment, would be strongly recommended. EU regulation on nanomaterials is a good example of best practices in safety. In fact, nanosafety from knowledge to market includes three main steps as it has been shown in the case of France: ethic concerns, safety concerns and regulation and standardization concerns. Acceptance or distrust of the benefit/risk analysis depends strongly on the communication abilities. Communication should be transparent and visibility as wide as possible. The credibility of the source can only be preserved in this way and requires anticipation about information on risks and safety.

A European strategy supporting the development of KETs should rely strongly on leading multi-KETs ecosystems, able to maximise spill over effects in Europe thanks to their concentrator and integrator role. “Smart KET cities” could be the cornerstones of the KET community in Europe. Among the criteria to identify the multi-KET ecosystems the following could be mentioned: the presence of universities providing skills and training in KETs, a history of investment in KETs technologic, a history of investment in KETs technological research, an industrial environment in KETs including R&D, pilot lines and global manufacturing facilities, a continuous and sustainable support of public authorities and finally a favourable urban environment.

At present the results of European research effort are not applied quickly enough or sufficiently widely. The guidelines and rules should be changed so that regions would make far more use than now of the Structural Funds and other financial instruments for the innovative application of the results of the Framework Programme and other research activity. Economic and operational support should be allocated particularly for the development of open innovation activity in the regions so that they can help to create the necessary conditions for a reform of public administration and for entrepreneurial activity aimed at generating growth and new jobs.

Recommendations:

1. A distinct KET skills box needs to be included in the EU Flagship Initiative “New Skills and New Jobs”
2. Competitive advantage through KETs value chain integration
3. A robust benefits-risks assessment for KETs applications
4. Communication strategies
5. Transdisciplinary technological platforms and physical environments
6. Creation of a “Smart KET Cities” label

1 – Introduction

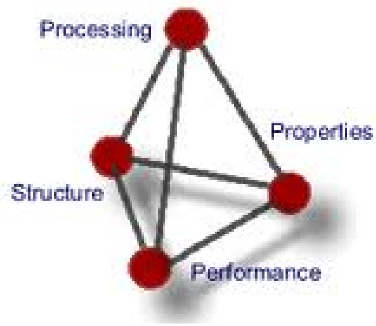
Key Enabling Technologies (KETs) are defined by the European Commission as "*knowledge and capital intensive and associated with research & development (R&D) intensity, rapid or integrated innovation cycles, high capital expenditure and highly-skilled employment. Their influence is pervasive, enabling process, goods and service innovation throughout the economy and they are of systemic relevance. They are multidisciplinary and trans-sectoral, cutting across many technology areas with a trend towards convergence and integration. KETs can assist technological leaders in other fields to capitalise on their research efforts*".

After analysing the competitive position of the EU in each KET area, the opportunities for future growth in the sectors that use each KET, and the potential impact each could have in enabling the EU to solve societal challenges, the aim at the present stage is to work in the development of specific policy recommendations for the EU and Member States based on this analysis. This working group focuses mainly its attention to the development of skills, education and training systems compatible with transdisciplinarity of KETs as well as formats for disseminating technological knowledge to industry. Moreover, societal acceptance of KETs and benefits-risks analysis for society and innovative regions are particularly addressed.

2 – Key Enabling Technologies (KETs)

2.1 - Scope, boundaries and transdisciplinarity

Within the present strategy, six KETs have been considered and chosen as the most relevant in order to boost EU technological potential impact and its competitive position. The six KETs are micro/nano electronics, photonics, advanced materials, nanotechnology, biotechnology and advanced manufacturing. All these technologies share common grounds: they take advantage of the intelligent manipulation of mater to develop materials with finely tuned properties able to enter and play a leading role in different value chains. In this sense the tetrahedron currently used to explain materials behavior may be of great use:



The performance or the behavior in service of a given material will depend on its properties, whether mechanical, electrical, optical or thermal. But these properties will depend on the structure of the material at different levels: chemical, crystallographic, or aggregation order. But at the end what governs the structure, the properties and eventually the performance is the processing method used: the effects of melt and casting are completely different from rolling, drawing, surface coating, etc. It is this interdisciplinarity which is at the base of KETs. Electronic and optical properties depend on chemistry, crystallographic structure, processing technology, etc. At the nano level, surface properties become more important than bulk ones. Biological materials have very specific chemistry, structure and properties. The development of advanced materials for improved performance requires mastering all the previous factors. Finally in order to produce devices and products, advanced manufacturing technologies require knowing, respecting and eventually improving the sought properties. Basic scientific and technological disciplines are at the base of KETs, which is what makes them interdisciplinary. Before going further, it would be convenient to comment about the difference between multidisciplinarity and interdisciplinarity. A case of multidisciplinarity would come from classical mechanical engineering, where for example materials for a given product (i.e. car motor components or hip prosthesis) are selected from the shelf in terms of what standards request. An example of interdisciplinarity would be to understand the physical properties of a material in terms of its structure and its chemistry, and therefore, being able to develop the processing technology, again in terms of chemistry and final structure control that will assure the physical properties sought. Since different basic disciplines are at the base of KETs, the transdiciplinarity of KETs does not seem far: it does not seem a chimera to think that advanced materials combining electronic and photonic properties can be developed or that due to their surface properties, nanomaterials with improved biological or electronic properties may appear, or that materials with a biotechnological origin exhibiting good physical properties will substitute the present ones in a certain value chains. This is exactly the transdiciplinarity of KETs. Their boundaries being diffuse, the synergies expected are very high.

2.2 – Technological fields and industrial dimension

KETS contribute and play a leading role in most innovative products and services of all classical industrial/economic sectors. In fact, it is not only their individual present role in the classical sectors, i.e. energy, health, transport, ICT, etc., which make KETs pivotal in the industrial development; it is the fact that already at present they combine multidisciplinary in different value chains. They do it either independently as different parts in the integrated product or synergistically in certain parts or along the value chain. It is easy to foresee that the transdiciplinary challenge will be fulfilled by innovative products in the midterm. KETs have become integrated into different parts of existing advanced value added products and services. In the immediate next future we should expect that technologies at the boundaries will allow the development of new parts or devices to be integrated in new products and eventually combinations of KETs will participate in the development of devices impossible today. KETs synergies and transdisciplinarity should lead to new high value-added products, providing solutions to societal challenges. An aspect that seems important is the contribution of KETs to sustainability of new applications and services.

All KETs require a common approach, given their potential, inter and transdisciplinarity. In fact all KETs have to face their valley of death, and for all of them the three pillar bridge represents the common solution to get across it. However, it should be borne in mind that their degree of maturity and industrial applicability is different. Probably micro/nano electronics, photonics and partially advanced materials and advanced manufacturing main present requirements are closer to pillar 3, whilst the main present requirements of nanotechnology and biotechnology are closer to pillar 2 and even pillar 1. This aspect can be probably understood in terms of the ways in which the different KETs enter the value chains and their infrastructural requirements. In this sense, a biorefinery is a local infrastructure, with local supply of feedstock or raw materials. Nanotechnology can be also currently implemented in the development of devices and products at a local level. Pillar 2 plays here the leading role.

Finally, a proper assessment should be made about how KETs may be relevant entering in well established mature value chains, by modifying some of their steps, i.e. the use of new materials developed from industrial biotechnology or nanomaterials, or KETs would promote ex-novo value chains requiring appropriate new environments. In other words, existing mature industrial clusters can incorporate KETs, or do KETs require new industrial environments?

2.3 – Case studies. Emerging applications. Innovation opportunities

Case 1: Photovoltaics value chain

A silicon materials provider will have to develop insights in the solar cell technology in order to learn how to adapt its overqualified micro-electronics product to the price/quality needs of the solar application. Some European companies are very good in looking beyond the value chain segment boundaries and have achieved world leadership. Advanced materials, advanced manufacturing and nanotechnologies are key in III-V photovoltaics. In cross-boundaries technology development effort products and standards have been developed, leading to long-lasting leadership for European advanced materials and equipment manufacturers.

Case 2: Smart systems technologies

Smart systems are based on interdisciplinary approach. We need to harness the benefits from nano area to micro area and put all components into macro area, and into a product. KETs are in a key role.

Case 3: Neuro-electronics

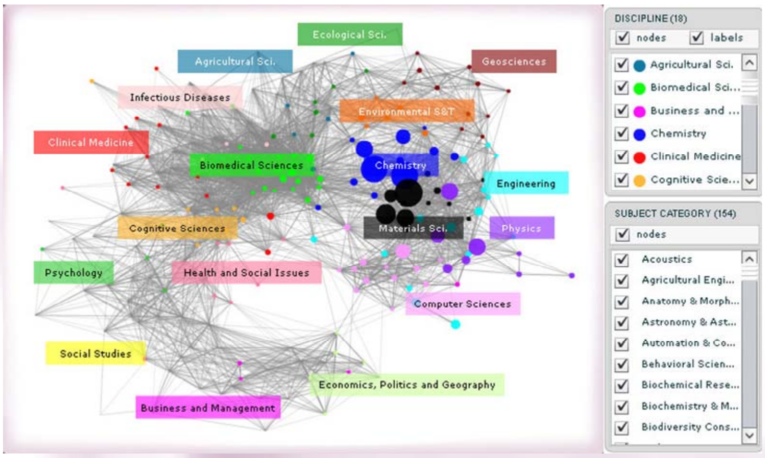
Miniaturisation is a strong trend and this can be applied for neuroelectronics, mastering smart implants, where electrical and chemical interactions take place in a single cell. We need to understand dynamics of the human brain, for example, before we can tackle Alzheimer, Parkinson and other brain disorders diseases. What is important is to understand language of different scientific disciplines in order to accomplish the heterogeneous systems integration.

2.4 – Views and requirements from evaluation and funding organizations

Multidisciplinarity / interdisciplinarity / transdisciplinarity is not only about bringing chemistry, physics and biology together, it is about bringing different industry sectors together. However, we cannot assure currently that project proposals are assessed with multidisciplinarity in mind. Interdisciplinarity needs "ownership", like in the case of NERF (Neuroelectronics Research Flanders NERF is an initiative started in 2009 by Imec, K.U. Leuven and VIB). We have a clear distance between business and policy related research and KETs related research (shown in the distance mapping picture below) – there is again the challenge of understanding each other's language:

Technology Strategy Board
Driving Innovation

Graph of transdisciplinarity



Global science map based on citing cosine similarities among ISI Subject Categories(2007), NSF funded

3 – Training and education

3.1 – New skills and competencies required for crossing boundaries and achieving synergies

In order to fulfill KETs technological fields and their industrial dimension, new skills and competencies will be necessary. Exploitation of KETs synergies and crossing the boundaries towards KETs transdisciplinarity requires competencies that present linear training and education cannot supply. These new skills have to be sought at different levels. In the first place trainers and educators should set their minds into this direction. Academia and training institutions should start to devise mechanisms to offer KETs training and education since the demands for skilled workforce at all levels will come. In the second place, research and engineering skills will have to adapt to satisfy KETs needs. In this sense, competencies to satisfy the buildup of pillars 1 and 2 will be required. Finally the third level will be to respond to what industrial jobs request in order to satisfy industrial needs. This means to understand what competencies and skills will be necessary to buildup pillar 3.

3.2 – Interdisciplinarity mindset and skills. New academic requirements and incentives. European initiatives

Working with an interdisciplinary mind requires great effort. It is in fact a totally new concept, which needs to take into account communication, language, state-of-the-art, specific methodologies, mental inertia, etc. Real interdisciplinarity means that experts coming from different disciplines should work on common grounds. This requires that they speak a common language and understand the limitations and possibilities of each technology, knowing what is possible from a given existing technology and what is not possible.

Universities and research institutions tend to intensify in certain disciplines, and in fact their structure in Departments or Institutes, even if they are multidisciplinary are meant to preserve and foster specialization and discipline. Industry keeps a much more open mind, since it responds to demand, but even though, it tends to intensify in "industrial sectors". Industries participating in different value chains, usually with high added value products require competencies and skills that align with those of KETs.

Too often, reward and promotion systems in academia fall very far away from interdisciplinariry and transdisciplinarity requests. The industrial demand of the competencies and skills commented may not be sufficient to move academia fast enough into KETs direction. A specific recommendation to the EU, Member States and Regions would be necessary. This is not an easy problem to solve since the depth of the scientific or technological disciplines needs to be preserved while it is necessary to educate the interdisciplinarity. Interdisciplinarity is by no means superficiality. Professor Bengt Holmstrom from MIT (USA) and Board Member of Aalto University (Finland) raises the question sharply: "How can you become interdisciplinary without losing the discipline?" This is then the challenge.

A recent study by Cefic looked at the skills needed to improve innovation in the European chemical industry. In addition to critical technology skills for engineers curricula should better address industrial business skills (project management, innovation management, understanding customers and suppliers) and personal skills (communication, team work, problem solving). In a similar way, scientists should be better educated in "science business skills" (IPR, innovation management, understanding customers and suppliers) and personal skills (communication, team work, creative thinking). Because innovation often happens at the interface of disciplines, scientific interdisciplinarity is key for innovation and the future of European industry.

When addressing the competencies required for each one of the three pillars, it seems that universities and research institutes and organizations should be appropriate to provide those necessary for pillar 1. Industry seems to be the most appropriate to provide the skills necessary for pillar 3, by promoting industrial internships of young undergraduates by means of university-industry agreements. Pillar 2, associated to industrialization of technological research from pillar 1 requires special attention. The coordination here between industry and universities is even more necessary than in pillar 3.

The main pillars in the EU2020 strategy are Smart Growth, Sustainable Growth and Inclusive Growth. Inclusive Growth encompasses employment & growth, especially with the agenda for new skills and jobs. Innovation is about people and there are several initiatives going on at the moment in Europe. A Commission communication on modernising higher education is underway (by end of 2011). Europe has high expectations on the EIT KICs. At the moment, important question is how the KIC (Knowledge and Innovation Communities) model develops. University-Business Forum was set up in 2008 as a partnership for the modernisation of universities. Here the big question is how the implementation is done. Developing entrepreneurial mindset in Europe is a must. From systemic perspective we need to deal with several levels / layers: people level (knowledge, skills, competences, entrepreneurial attitude), institutional level (entrepreneurial university, lifelong learning university), regional level and beyond (University-Business cooperation, the Smart Specialisation Agenda, global perspective). Knowledge Partnerships is a recent pilot action proposed by European Parliament.

4 – Societal acceptance and innovative regions

4.1 – Risk-benefit analysis

It is important to take into account public perception towards KETs. Risk assessment has played and plays a pivotal role in the control of our technological and industrial environment. It has been proved as consistent and harmonized, although with some limitations also. The final answer will have to be related with safety, which will have to be preserved by all means. Acceptable risk and adequate trade-off need to be communicated by decision makers. However, there is still wide room for a more integrated risk/benefit assessment. Benefit assessment has not attracted as much attention as risk assessment and requires further to be developed.

4.2 – Nanomaterials in EU regulation. Best practices in safety

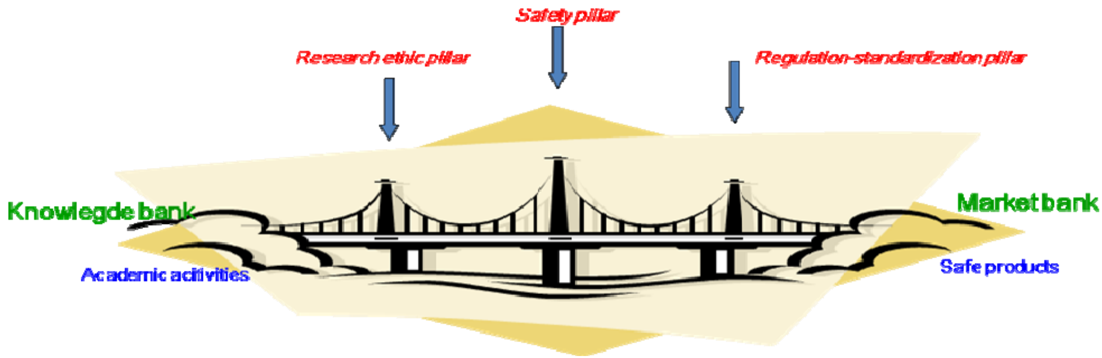
In general, European consumers are viewing nanotechnology as medium risk and moderate benefit technology. Consumer psychology has shown that when the benefits are viewed low, the consumers are more concerned about the risks than when the benefits are high. Risk assessment is not easy. Main elements in the risk assessment are hazard identification, hazard characterisation, exposure assessment and risk characterisation. We need assessment methodology, tools and data. Currently we have a number of tools and no best techniques.

Safety aspects regarding nanotechnologies are in principle covered in EU regulation, both through horizontal legislation (REACH) and product legislation (general safety of consumer products). Position of the European Parliament is that current EU legislation is considered inadequate and there is significant lack of knowledge and information on nanomaterials already on the market. More information should be provided to the public: Information on Environmental/Health/Safety (EHS) data; Labelling of products containing nanomaterials; Inventory of types and use of nanomaterials on the EU market. Examples of ongoing activities include:

- Standardisation activities: CEN TC 352 Nanotechnology and ISO TC 229 Nanotechnology
- OECD Working Party on Manufactured Nanomaterials
- Reference Nanomaterials
- Data sharing: IT Platforms and Databases
- Definition of Nanomaterial for regulatory purposes

4.3 - Best practices on nanosafety: The case of France

From knowledge to market, the three pillars bridge for societal acceptance include Pillar 1 of research ethic concerns, Pillar 2 of safety concerns, and Pillar 3 of regulation and standardisation concerns. Ethic of research is the first step of global ethic and crucial for societal acceptance. Regulation & standardization are the green light for the market access. Safety is the core of societal acceptance (« no data, no market »)… and involves KET’s (e.g. advanced materials and manufacturing). Examples of existing European initiatives are the NANOfutures ETP, the NMP Nanosafety cluster, FP6&FP7 with no less than 29 ongoing (or completed) projects (12 FP6, 17 FP7) on the overall value chain of nanosafety, and the Nanogenotox project run by the Executive Agency for Health and Consumers.



France has put specific measures on the regulation-standardisation side and on the ethic side (e.g. Grenelle 2 law is imposing the declaration, for any actor, of elaboration, importation and commercialisation of substances in the nanoparticle state - law is still under discussion). On the ethic side, several bodies are in charge of feeding the global reflection on the opportunity of developing nanomaterials (OPECST, CESE, Académie des Sciences, Conseil Général des Mines, Comité de la Prévention et de la Précaution…) and the public consultation takes place at local and national levels

4.4 – Communication abilities and strategies

Acceptance or distrust of the benefit-risk analysis will depend very strongly on the communication abilities and strategies used. Generally speaking, there is a great public interest for science and technology. However, sometimes science and technology are disseminated by media either as wacky, as breakthrough or as scary. The three scenarios are extremely negative. Recent media stories can be related with the hadron collider at CERN (the black hole campaign) or the MMR triple vaccine (vaccination as cause of autism) are clear examples of media campaigns hampering science progress and public health respectively. Since understanding technology, science and statistics is not a competence to be demanded from media communicators, it is necessary that KETs communication is carried out by experts that can address such issues. On the other hand communication should be transparent and visibility as wide as possible. Credibility of the source should be preserved by all means and this requires anticipation about information on risks and safety.

4.5 – The role of innovative cities and regions in the development of KETs

Since Lisbon Treaty the notion of *innovation* has been more than technology: we should promote innovation and citizens' needs, especially driven by Grand Societal

Challenges. We need to acknowledge the role of special territories with enough size and enough interaction between people. We need to have clusters where people are interacting with each other. Cities have the role of facilitating these interactions. There should be enough diversity in these cities. According to Porter, the model of geographical ecosystem comprises the knowledge triangle. But our model is not any more a triangle – it is a pyramid – and we are talking about “multi-KETs ecosystems”. The corners of the pyramid are universities, technology research organisations, industry and society (public administration). Europe needs to speed up this process.

A European strategy supporting the development of KETs should rely strongly on leading multi-KETs ecosystems, able to maximise spill over effects in Europe thanks to their concentrator and integrator role. “Smart KET Cities” could be the cornerstones of the KET community in Europe. This approach should be taken to the discussion on Smart Specialisation Strategy in Europe.

To keep and take leading positions in KETs at international level, these “Smart KET Cities” will need dedicated support at European level, with combined funding at local and national levels. Major investments will be needed, both in public R&D institutions and in industrial pilot lines and manufacturing facilities, in order to ensure Europe’s position at different levels of the value chains of these key sectors. Such investments will enable to create sustainable wealth and employment for all industrial sectors in Europe.

The criteria to identify such multi-KETs ecosystems could be the following:

- The presence of universities providing training in KETs, and ability to increase the level of skilled human capital, locally and more broadly in Europe, thanks to strong links at European level (EIT, Erasmus Mundus, university associations, etc.);
- A history of investments in KETs technological research, with the development of large open technology platforms and with recognised experience in strategic public-private collaborative projects;
- An industrial environment in KETs, including R&D, pilot lines and global manufacturing facilities, supported not only by large KET anchor firms, but also an important network of KET SMEs;
- A continuous and sustainable support of public authorities, which could take a new role in the development and integration of KETs by implementing KET technologies within their city and metropolitan area in real-scale demonstrators;
- And finally, a favourable urban environment, which is attractive and international.

The above criteria are based on what is experienced today in sectors having reached a certain level of maturity, with concentration of investments and actors and a need for critical mass (nanoelectronics, photonics and industrial biotech). They will need to be confronted to the other KETs, which may not be, today, at the same level of maturity (such as nanotechnologies) and / or at the same level of structuring (advanced materials and advanced manufacturing).

In addition, the emergence of new KET ecosystems in domains where Europe needs to take a leading role will also need to be accompanied. The identification of these "to-be" smart KET cities will need to be discussed, inspired by the success stories of recently developed KET ecosystems worldwide (e.g. Albany, Dresden, Singapore, etc.).

4.6 - KETs innovative ecosystems: Political will and ways ahead

In the KET value chain approach we start from the materials in different areas (car industries, lighting, nanoelectronics…) to arrive at solutions and services, and at the end, identification of the impact on societal challenges. The problem is to find the right way to identify the major societal challenges and to verify that the selected KET is improving societal needs. We have to complement this approach in going also the other way: starting from the societal needs and looking for the type of R&D to be implemented. We are confronted with the question of finding efficient mechanism to help decision making concerning the identification of areas corresponding to the needs of the society and where R&D has to be strengthened.

In addition to key characteristics of KETs, increasing number of complementary (knowledge) assets and resources - and open innovation - are needed. It is important to monitor industrial investments and understand value production from local/regional policy perspective. European regions are different and growth is not located evenly in Europe. Technology producing regions in Europe mainly focus on KETs but these knowledge producing regions in Europe are lacking in diversity, scale and scope of cluster in comparison with US or Asian knowledge producing regions. Other vulnerabilities in European city-regions come from misguided local/regional policy visions on KETs (old industry vs new knowledge production) and misguided inter-regional/inter-city (policy) competition.

For Europe to become a Global Pioneer, we need European Pioneers. Implementing EU2020 means that we put focus on regional and local level & territorial pacts. At present the results of European research effort are not applied quickly enough or sufficiently widely. The guidelines and rules should be changed so that regions would make far more use than now of the Structural Funds and other financial instruments for the innovative application of the results of the Framework Programme and other research activity.

Parallel to cluster-based innovation hubs, and in some respects even more important than these, is the need which has emerged in recent years to understand the complex workings of regional innovation ecosystems and create conditions conducive to development in the desired direction. Therefore economic and operational support should be allocated particularly for the development of open innovation activity in the regions so that they can help to create the necessary conditions for a reform of public administration and for entrepreneurial activity aimed at generating growth and new jobs.

Smart City / Smart Region European Innovation Partnerships need to be started, because prompt and effective measures are critical here in producing the new and bold solutions needed to address the economic crisis and climate change and adapting these to municipal practices; it is particularly important to step up cooperation between regions with pioneering enterprises and institutions and to provide them with the resources to effectively disseminate their findings for implementation in other regions.

5 – Recommendations

1. A distinct KET skills box needs to be included in the EU Flagship Initiative "New Skills and New Jobs"

Activities so far have focussed on best practices, and they easily remain singular approaches. Furthermore, education has so far focussed mainly on research excellence skills rather than practical skills needed for the implementation and deployment of KETs. Europe needs strong scientific skills, hands-on engineering skills, and smart workers. There is therefore a need for a systematic integration of the innovation skills requirements into higher education agendas across Europe. Master Programmes with interface technologies and foresighting curricula should be endorsed. Multidisciplinary and broad skill set base should be further developed systematically in higher curricula. Financial and business skills should be better addressed in scientific higher educational curricula. Entrepreneurial mindset (communication skills, business skills, team work skills, management skills) is a must. Moreover, focus should go for Pillar 2 training (intra-company and inter-company value chains; industry collaboration with relevant education networks and associations; Europe Practices initiative). Integrating these skills into higher education curricula and system should be a dedicated area (as a pilot) within the EU Flagship Initiative "New Skills and New Jobs".

The importance of the skills required for KETs development led to the need to proceed into a deeper analysis into this issue. A specialised workshop with participation of members of the Sherpa group and representatives of the European Commission discussed about the needs and the EC existing instruments. Three specific recommendations on skills were formulated:

1st recommendation.

There are two gaps to be filled. One is related with the need to know what are the interdisciplinary competences required for KETs in terms of industrial needs. The second one is quantitative and consists in assessing the numbers of engineers required at European Level in order to supply the European industrial needs. In both cases the gap should be filled by assessing what is required and what exists. **The Commision should define and implement the procedure to make the diagnosis and apply the appropriate therapy to fill these gaps.**

2nd recommendation.

Instruments are needed to provide the education and skills of the future KETs engineers. Within the framework of the ESF, the promotion of opportunities as KETs could be set up. **Same priorities within ESF through smart specialization given on technology could be given to skills for KETs.** The Commission could prepare guidelines for skills, or in other words, to define policies for conditionalities and promotion. Promotion of Maths and S&T should be made at secondary education level in order to assure a flow of engineering students in European Universities. **Existing instruments such as "Knowledge Partnerships" from DG EAC could be strengthened** in the next generation of EU Education and Training programme and under ERDF/ESF funding with regional focus.

3rd recommendation.

An effort from industry on partnership and organization would be most welcome in order to participate in the long term in the definition of interdisciplinary competencies required. **Public-private partnerships University-Industry should be fostered in order to fund chairs and professorships as well as education programmes.**

2. Competitive advantage through KETs value chain integration

Collaboration could be developed into a European competitive advantage, using cultural inclination and proximity to our advantage and adjusting public funding rules to support this strength. The innovation chain integration, seen in this perspective, is crucial, needing strong hand-over mechanisms along the life-cycle (+ feedback loops), as well as new training approaches. KETs value chain integration will be decisive in rejuvenating existing mature industrial sectors in-situ and does not require ex-novo creation of KETs environments. It is possible to build on existing wealth and knowledge.

3. A robust benefits-risks assessment for KETs applications

Innovation means change, and change can create uncertainty. Political, investment and consumer attitudes may become risk-averse. A careful balance needs to be struck between the benefits and the risks raised by novelty. Technologies should not be evaluated as such for their intrinsic characteristics but rather according to their specific application which has a direct impact on solving societal (e.g. energy storage) or individual (e.g. personal health) challenges. Europe needs a robust benefits-risks assessment for KETs regarding their specific application.

4. Communication strategies

It is important to understand the power of public perception and to take it into account. Public perception can shape and affect the progress of scientific activity. Transparency, proactivity and strategic foresight should be the principles for open communication. Benefits-risks assessment must be done in parallel and acceptable risk and adequate trade-offs need to be communicated by decisions makers. However, benefits assessment is still immature and needs more work. Best practices in stakeholder involvement need to be addressed: setting up stakeholder Platforms (e.g. nanosafety), shared databases and depositories at national and EU level; safe-by-design principle; common terminology and protocols; harmonised test methods and standards; international cooperation. Besides the above routine communication ("didactic-by-design"), it is important to anticipate crisis situations (either accidental or societal) and to prepare adequate communication.

5. Transdisciplinary technological platforms and physical environments

Transdisciplinary technological platforms should be created involving academia, RTOs and industry through-out the life cycle (innovation integration). We should hesitate in creating new legal entities as a sole vehicle for transdisciplinary collaborations (avoiding complex structures, non-transparent IP rulings, or large overheads). A long term effort is needed for cross-disciplinary teams to get aligned. Graduate-internships in co-development environments need to be encouraged. There is need for 'single sited' clusters as a first step: to get scientists and engineers of different origin to work together around a common vision.

6. Creation of a “Smart KET Cities” label

A European strategy supporting the development of KETs could rely strongly on leading multi-KETs ecosystems, able to maximise spill over effects in Europe thanks to their concentrator and integrator role. It is therefore proposed to create a label “Smart KET Cities”, which could be the cornerstones of the KET community in Europe. This proposal could be discussed within the Smart Specialisation Strategy on the EU2020 Agenda, Smart Growth Initiative. To keep and take leading positions in KETs at international level, these “Smart KET Cities” will need dedicated support at European level, with combined funding at local and national levels. Potential criteria to identify such multi-KETs ecosystems could be the presence of universities providing training in KETs, and able to increase the level of skilled human capital, locally and more broadly in Europe, thanks to strong links at European level (EIT, Erasmus Mundus, University associations, etc.); a history of investments in KETs technological research; an industrial environment in KETs, including R&D, pilot lines and global manufacturing facilities, supported not only by large KET anchor firms, but also an important network of KET SMEs; a continuous and sustainable support of public authorities, which could take a new role in the development and integration of KETs by implementing KET technologies within their city and metropolitan area in real-scale demonstrators; and finally, a favourable urban environment, which is attractive and international. However, Smart Specialisation should not only take account of local cluster formation or geographical proximity; contracts between EU and the regions must include a clause that requires trans-European value chain integration.