Cross-sectoral Analysis of the Impact of International Industrial Policy on Key Enabling Technologies

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1 Executive summary

1.1 Introduction

In October 2010, the European Commission DG Enterprise and Industry launched a study of the impact of international industrial policies on Key Enabling Technologies (KETs)[1].

The study was carried out by **Danish Technological Institute (DTI)** and **IDEA Consult**.

Background to the study
On the 30th of September 2009, the European Commission published its Communication *Preparing our future: Developing a common strategy for key enabling technologies in the EU*[2]. The Communication states that whilst the EU has very good research and development capacities in some key enabling technology areas, it has not been as successful in translating these results into commercialised manufactured goods and services. A common European strategy on the deployment of KETs in European industries would be needed. This approach has been re-emphasised in the Commission's most recent publications, namely the Europe 2020 flagship initiatives *An Industrial Policy for the Globalisation Era*[3], *Innovation Union*[4] and *A Digital Agenda for Europe*[5].

In July 2010, the European Commission established a High-Level Expert Group on Key Enabling Technologies (HLG). This was set up to develop a shared longer term strategy for key enabling technologies. The group shall in particular address and assess the ten policy areas which have been outlined in the Communication on Key Enabling Technologies for possible policy measures to promote the industrial deployment of KETs in the EU**.**

In the KETs Communication, the European Commission called for an intensified exchange of experiences and best practices between Member States and with other high-tech regions. The Commission announced an international comparison of high technology policies in other leading and emerging countries, such as the US, Japan, Russia, China and India, with the purpose to also explore the scope for closer cooperation.[6]

[1] Nanotechnology, Micro- and Nanoelectronics, Industrial biotechnology, Photonics, Advanced materials, and Advanced
[2] COM(2009) 512.
[3] COM(2010) 614.
[4] COM(2010) 546.
[5] COM(2010) 245.
[6] COM(2009) 512, 9.

This study of the impact of international industrial policies on Key Enabling Technologies (KETs) is a response to the Commission's announcement of an international benchmark of KETs policies and it complements the activities of the HLG. The purpose is to identify and compare high-technology policies in EU Member States as well as in leading and emerging regions/countries, in particular with regard to the different measures supporting the deployment of KETs.

The European Commission will use the findings in this study as well as the final report of the HLG in the development of a long-term European strategy for KETs.

Global focus on KETs – increased competition

Europe faces increasing competition from leading and emerging regions outside the EU. In the past few decades significant parts of the manufacturing activities have been sourced to regions outside the EU such as the US, Japan, Korea, China, Russia and India. Another BRIC country such as Brazil has also gained ground. The choice of location is based on varied factors such as cheap labour, access to emerging new markets, access to capital, tax breaks, free land access, and access to a growing number of graduates and doctoral candidates with a degree in science and engineering.[7] The combination of heavy investments in Key Enabling Technologies (KETs) in competing regions and the struggle in the EU to turn its world leading research into commercial products creates a situation in which Europe needs to take proactive measures with a view to increasing the industrial deployment of research conducted – especially relating to KETs[8].

The executive summary presents the main findings from the final report submitted in March 2011. The findings are based on:

- A literature review on each of the KETs
- More than 70 interviews (telephone and face-to-face) with experts and stakeholders from industry, academia and policy
- Six European case studies of KET clusters and eco-systems
- Innovation policy profiles for ten selected countries
- Six best practice examples
- A study visit to the US
- An analysis of European data on patent and R&D investments for the KETs[9].

Limitations

The scope of analysis is defined by the relatively short duration of the study contract, so the study provides snapshots of the challenges and policies with particular relevance to EU policy making. The study is based mainly on qualitative analysis. In some countries access to interviewees proved to be difficult due to the sensitivity of the topic of this

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[7] See for exzample National Science Foundation- Science and Enbgineering Indicators 2010http://www.nsf.gov/statistics/seind10/pdf/c03.pdf

[8] COM(2009) 512/3, Preparing for our future: Developing a common strategy for key enabling technologies in the EU

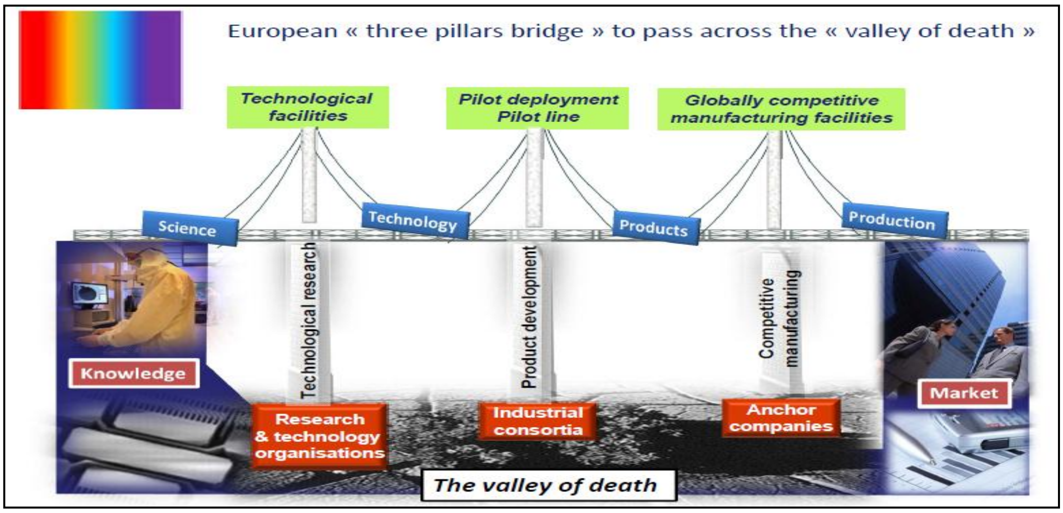
[9] The patent analysis was based on the work carried out report in report from the European Commission (2010) *European Competitiveness in Key Enabling Technologies (2010)* and only used as background information to get an overview of the patent structure in the individual KETs.

study. Insufficient data furthermore makes it difficult to quantify some statements and positions expressed by stakeholders in this report.

1.2 Understanding the innovation process for KETs

The innovation process for KETs is often considered to be a linear process in which basic research results in new products marketed through a 'value chain' of science, technological research, product development, and scaling through competitive manufacturing facilities, cf. Figure 1 below.

Figure 2.1: The KET value chain - from basic research to market



Source: High-Level Expert Group on Key Enabling Technologies (2011): Mid-Term working document

In this understanding, the key innovation challenge for Europe is to overcome the various barriers to commercial deployment of R&D base, the 'Valley of Death', by linking together the various parts of the value-chain using for instance tech transfer mechanisms, supporting demonstration projects, and creating favourable market conditions for innovative (yet often relatively expensive) products.

Interviews with experts and companies show that innovation may be a result of the creative application of existing technologies by companies - not least in SMEs. This suggests that industrial deployment of KETs is not merely a question of effective technology transfer mechanisms and demonstration projects; it is also a matter of facilitating open innovation processes involving industry and researchers with specialist knowledge so as to provide a solution to a specific industry problem (rather than first developing a solution and then starting to search for the problem).

Market demand and the creation of markets for innovative products play a vital role for driving technological innovation. But innovative products produced in small scale will have high initial prices which will make the products uncompetitive and unable to achieve mass market sales[10]. KETs also provide an opportunity of first mover advantage, and have potential to create new lead markets as KETs substitute old technologies with few or no rivals. Also, when rivals do come along the first mover will have an advantage[11]. One important aspect of KETs is that they are high-tech and require substantial R&D investments, and as a first mover this will need to be sustained in order to keep the advantage. The Polish case study provides an example where the early mover advantage is threatened by limited access to funding[12].

1.3 KET challenges for Europe

There are only minor differences in the challenges for each of the six KETs, but a number of challenges stand out for all the KETs. The challenges for each KET and the general challenges are described in detail with examples in the main report.

Alignment and prioritisation to achieve sufficent scale

Large investments in both KETs and related sectors in leading and emerging regions are starting to pose a considerable threat to Europe's competitive position in high tech industries. The interviews revealed that the prioritisation of investments in the different European programmes is not consistent and has a broad focus, which makes it difficult for Member States create synergy with EU-level prioritisation. This results in broadly focussed investments within the priority areas, and this is unlikely to create critical mass in terms of knowledge and funding. Also, there is little or no alignment of investments between Member States, so there is a risk of duplication in terms of investments made. In other words, Member States invest in the same areas instead creating larger collective investments similar to the levels seen in other leading and emerging regions.

Europe 2020 and the related flagship initiatives are providing a comprehensive vision for Europe's future. However, the range of programmes and initiatives at EU level result in a broad and rather unclear focus, and there is an inherent risk, as pointed out by multiple stakeholders, that it is so broad that it will set new requirements to ensure sufficient synergy between national strategies and with other EU programmes such as the Research Framework Programmes (FPs). Policy coordination is called for to ensure maximum synergy between programmes and instruments deployed at EU, Member State, and regional levels to ensure sufficient value added from investments made.

There are scattered albeit promising examples of coordinating efforts from both industry and policy from which important lessons may be deduced. In microelectronics, for example, the clusters in Dresden and Grenoble are collaborating, and some of Europe's leading research institutes collaborate through Heterogeneous Technology Alliance (HTA)[13] and European initiatives such as Joint Technology Initiatives (JTIs)[14].

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[10] Berlin, Kenneth (2010): The Second Valley of Death, http://tpmcafe.talkingpointsmemo.com/2010/12/08/the_second_valley_of_death_by_ken_berlin/
[11] http://www.pearsoned.co.uk/Bookshop/article.asp?item=312
[12] See Ammono case in the Polish case study
[13] http://www.hta-online.eu/uploads/media/HTA-2010_web.pdf
[14] http://cordis.europa.eu/fp7/jtis/

To further enhance the reputation of the Grenoble cluster, the European Clusters of Dresden and Grenoble announced in March 2010 the foundation for a structured and strengthened cooperation in the areas of R&D, Education, Industry, and Institutions related to Nano-Electronics and Nano-Technologies[15]. As the most important European Clusters in Nano-Electronics and Nano-Technologies, they have agreed to strengthen their collaboration in the fields of education, research and development, industrial deployment, SME coordination, and environment. An action plan defines priorities in each domain. Quoting Geneviève Fioraso, Deputy Mayor from Grenoble:
"Microelectronics is a key technology for European industry competitiveness. Dresden and Grenoble, the major poles in Europe, have agreed to work together to be competitive facing Asia & US. As public authorities we ask to support this process."

On the other hand, current research relating to KETs is so diverse that it lacks critical mass in especially knowledge, investments, and skills in order to compete with leading regions where strategies in many cases set out clear paths for future research priorities – often to address global grand challenges such as climate, energy, and clean water. There is therefore a need for increased cross-border cooperation and collaboration in the EU to create this critical mass as well as a joint EU strategy to guide future investments and initiatives in Europe as suggested by stakeholders interviewed.

In the US the issue of scale and impact is of growing concern in the national debate on energy. The National Academy of Engineering calls for a new research paradigm consisting of a national network of regionally-based, commercialisation oriented energy discovery-innovation institutes (e-DIIs) that would serve as hubs in a distributed research network linked through "spoke" relationships to other concentrations of the nation's best scientists, engineers, and facilities. The DII concept, developed by the National Academy of Engineering (NAE), is characterised by institutional partnerships, interdisciplinary research, technology commercialisation, education, and outreach.

Need for demand-side measures

Support for the creation of markets for KET-based products through regulation or pre-commercial public procurement could help drive innovation in Europe. However, policy instruments at the EU level and Member States so far only provide such support to a limited extent and primarily related to ICT. In general, EU instruments and Member States have not deployed enabling technology policies through public 'super consumers' such as the US Departments who use public procurement to test new ideas and drive innovation in various technology domains. A clear EU strategy based on addressing the grand challenges in Europe could be a first step.

Transfer and uptake of research in industry

Europe leads the rankings in terms of publications and articles – knowledge which increasingly becomes a commodity and more easily obtainable. This shows that Europe has a world leading pool of knowledge on KETs, an opportunity which should not be passed up. However, this knowledge is not sufficiently deployed at the same level as by competitors outside Europe. The European research projects, especially the Framework

[15] http://www.grenoble-isere.com/eng/News/Dresden-and-Grenoble-Nano-Electronics-Clusters-pave-the-way-for-strengthened-cooperation

Programmes (FP), often have a character of early stage technological research. Research consortia are often led by universities with more interest in patent filing and production of peer-reviewed articles. The outputs of research efforts tend to be at a low technological readiness level, which means that more investments are needed in order to commercialise the results. Evaluation criteria with emphasis on market potentials and criteria for appointment of evaluation teams to ensure industry involvement and industry expertise could be instruments that could increase the likelihood of a commercial output of the Framework Programme. In leading and emerging regions outside the EU different policy instruments are deployed to increase commercial uptake. In China, for example, major strategies are to decrease public funding for R&D over time to force research institutions to link up with industry partners and to encourage R&D institutions to set up companies to exploit commercial value.

Countries, such as the US, Korea, and Japan all have initiatives supportive of commercialisation of research results, especially support to find potential investors for the next stage of development – the stage in the innovation process called the 'Valley of Death' in Europe. Addressing the 'Valley of Death' is a key priority for the HLG as pointed out in their mid-term report[16].

> In 2000, the Korean government introduced the Technology Transfer Promotion Act. The idea behind the act was to change focus from quantity to quality of patents and technology, the advantage being that high-quality patents and technology will increase market interest. The Korean Invention Patent Association (KIPA) reviews the technology to be sold, assesses the commercial viability of the market and industry trends, and identifies potential licensees or partners. Furthermore, the KIPA offers support for legal issues and deal closing.
>
> *See Korean Innovation profile in Annex 3.*

Interviews carried out with companies, research organisations, and Technology Transfer Offices (TTOs) showed that there is a lack of incentives for researchers at universities to commercialise their research or collaborate with industry, as research careers depend on peer reviewed publication/article and the number of patent applications, rather than on the quality of those in terms of their commercial potentials.

Another barrier is that communication between industry and researchers tends to be weak. Both within Europe and outside Europe there are many examples of how a formalised facilitator function has helped to increase strategic collaboration. However, the case studies show that such structures are not yet the norm.

High tech companies in the EU in KET-related industries are concerned about their access to high-skilled labour and access to R&D facilities, and many research institutes mention difficulties in attracting PhD students in science and technology. This, combined with an increased focus and high investments in higher education in science and key technological areas in China, India, Japan, Korea, and the US, is a growing threat and a

[16] http://ec.europa.eu/enterprise/sectors/ict/files/kets/hlg-working-document_en.pdf

challenge for Europe not least due to different demographics in Europe and its competitors.

Lack of support for large scale demonstration and commercialisation activities

The interviews noted a need to create EU-wide state-of-the-art pilot test facilities located around Europe to help companies test and create prototypes quicker and without having to engage in larger R&D projects – a view shared across research institutes, policy makers, and companies interviewed in this study. Simultaneously, the exploitation of the results of R&D should be accessible to all EU countries.

The interviews with the companies and research institutes suggested that pilot test facilities can create opportunities to enhance the economies of scale for a specific product and can stimulate the manufacturing of products by creating intensive knowledge on prototypes and the scaling process. Knowledge about manufacturing is often necessary in order to exert sufficient control over the entire value chain to commercialise a technology. In the last decade, commodity production has increasingly been outsourced to Asia, leading to a lack of mass volume production in Europe. However, to influence value creation within the value-chain, it is important to encourage increased focus on clusters and networks combined with an extensive knowledge of the manufacturing capabilities. Large scale demonstrators and pilot test facilities, and the EU Technology Platforms such as Manufuture[17, 18] offer the potential to develop new competitive manufacturing strategies and innovation models, which could provide an opportunity to retain high value and flexible production in Europe[19]. Minatec in France is an example of a regional initiative providing pilot test facilities. The High Tech Building houses project teams, allowing them to continue their projects right through to the prototyping phase, and even to zero-series production.

Organisations like Minatec in France are creating critical mass by involving several industrial and academic partners in their activities. This in turn allows them to offer state-of-the-art equipment, which is often too expensive for an individual company or university to buy. Moreover, through their offering they are an important attraction factor to industry as companies gain access to the best lab facilities, knowledge, and skills on pilots and prototypes. This allows them to compete again major companies in Japan, the US and China.

However, in Europe there are only national or even regional examples of these facilities, whereas large scale demonstrators are funded and made publicly available in competing regions and leading countries, such as the US.

The US Department of Energy's Biomass Program has been awarded nearly $718 million in Recovery Act funds to accelerate the commercialization of advanced biofuels and foster the growth of a sustainable US bioindustry. €18 million of these funds has been used to build an advanced biofuels process development facility aimed at speeding the commercialization of advanced biofuels by allowing researchers and the private sector to test and integrate innovative technologies. http://newscenter.lbl.gov/news-releases/2010/03/31/advanced-biofuels-user-facility/

[17] See also http://www.manufuture.dk/ which is the Danish key technology and research platform for elaborating new approaches to maintaining high value manufacturing in Denmark through different strategic approaches.
[18] http://www.manufuture.org/manufacturing/
[19] Interview Martin Spät, ESIA

This type of large scale demonstrator project is not publicly funded in Europe, which, according to the company interviewees, is creating an uneven playing field.

Access to risk capital

Two major challenges were identified in regard to access to risk capital:

- Funding for basic or early stage research is focused on technology and not on market potential
- Banks, venture capital funds, and business angels are reluctant to invest in high-risk projects.

Limited market potential in EU research programmes

There are certain challenges accessing finance for the whole R&D process for KETs. The outcomes of the framework programmes are typically at a "technological readiness level", where the technologies cannot yet be immediately commercialised.

According to the interviewed companies, funding for basic research is relatively easy to obtain. The Framework Programmes are the most important R&D funds available in Europe, and are oriented towards basic/technological research. The projects are mostly based on development of technologies instead of addressing societal challenges or general market needs – hence there is limited market potential.

In many of the research initiatives and programmes in emerging and leading regions there is focus on market potential in the selection criteria. Many of these initiatives and programmes are based need for solutions to grand challenges.

SBIR/STTR Program (US)

The programme focuses considerably on market opportunities when selecting proposals for funding. The NSF webpage states that '*all proposals submitted must describe a compelling business opportunity to be enabled by the proposed innovation. The proposal must show scope and nature of the business opportunity. All proposals shall provide evidence of a market opportunity*'[20]. According to interviews with Mr. James Rudd and Mr. Murali Nair from NSF, approximately 25% Phase 1 and 50% of Phase 2 the selection criteria are related to market potential. *For more info, see US Innovation profile in Annex 3.*

In the European Framework Programmes there is less focus on market potential in both the design and selection criteria of the programmes. The Commercialisation Division at the ARPA-E[21] at the US Department of Energy (DoE) stress that focus on market potential and commercialisation support from the start of projects that are funded is vital to ensure commercial success.

[20] http://www.nsf.gov/eng/iip/sbir/program.jsp#PhaseI

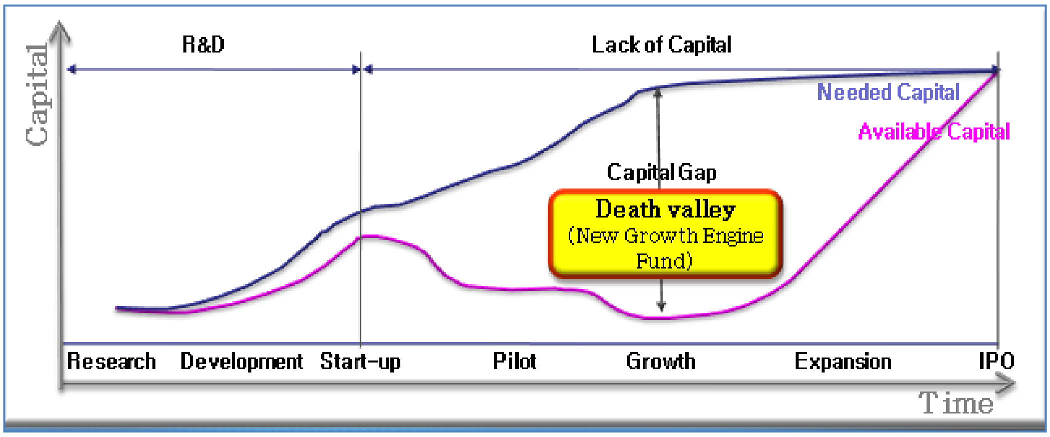
[21] Advanced Research Projects Agency – Energy

Difficult to obtain risk capital for high risk projects
Access to risk capital is a major issue in high tech companies. Firstly, it can take several years before there is a potential return of investment and therefore venture capital funds are extremely reluctant to engage in high tech companies. Secondly, high risk projects generally exclude funding from banks. However, European companies are also reluctant to approach venture capital funds, unlike companies in the US. This is a cultural challenge, which is hard to change through policy initiatives.

Lack of access to risk capital can result in relocation of high tech companies to destinations outside Europe. There are greater opportunities to obtain risk capital in for example the USA, Japan, China, and Russia. However, the precondition is often that the company has to relocate to the given country to secure funding[22].

On example where this particular funding gap has been addressed is Korea. The "New Growth Engine Fund" addresses the "Valley of Death" barrier in regards to access to risk capital. The figure below shows that the R&D stage, including the start-up phase, is well supported in Korea, as it is in Europe.

Figure 1: New Growth Engine Fund, Korea



Source: KIAT, 2011

However, the New Growth Engine Fund supports medium sized companies at the growth stage in Korea, where funding at that stage is scarce in Europe, especially for high risk projects. The fact that these types of funds are available in leading and emerging regions outside Europe and not in Europe is a challenge for Europe and especially European companies. The US innovation policy profile provides examples of funds set up because of this particular funding issue.

Due to the limited market focus in the European research projects, large European companies increasingly participate and invest in research projects outside Europe according to informants. Research projects in especially the US and China have strong commercial focus and/ or market opportunities and are well funded.

[22] See examples in main report section 5

Also in Taiwan innovation policies are designed to attract the location of R&D units from international companies

Taiwan Multinational Innovative R&D center.
The Program of Multinational Innovative R&D center in Taiwan is an important element in the International Innovation and R&D Base Plan, which forms part of the National Development Plan. The aim is to get multinational corporations collaborating with local Taiwanese firms so that Taiwan can establish itself as a regional R&D center within the Asia Pacific region. This in turn will help to support multinational production activities, thereby enhancing the role which Taiwan plays in global R&D, giving the R&D activity of Taiwanese industry greater depth and encouraging Taiwanese companies to focus on cutting-edge research.

Implementation of the plan began in 2002. So far, several leading international corporations including Intel, HP, Dell, Sony, Microsoft, IBM and Ericsson have established 43 R&D centers in Taiwan. Among these companies, many found that the industry environment and infrastructure here are much better than what they had expected, and some even expanded the scale of their R&D centers. This proves Taiwan to be an ideal location for multinational corporations to establish their R&D bases for innovative R&D activities. The introduction of key technology by these R&D centers will help Taiwan to become a valued partner to the world's multinational corporations in the area of technology, and will contribute to the further development of Taiwanese industry. Source: http://investtaiwan.nat.gov.tw/matter/show_eng.jsp?ID=433

Gaps in the continuous support to all firms in the value-chain

Manufacturing activities are an integral part of the innovation value-chain, and efforts to retain or restore the KET value-chain in Europe are vital to product, process, and market innovation. For instance, the US has launched several initiatives to re-establish manufacturing activities in various KET domains, such as *Manufacture America – Rethink, retool and rebuild,* and in Japan through the support of industrial clusters (see main report section 3).

One of the key strengths in Europe is the strong clusters and networks built up over many decades. The case studies (Annex 2) show examples of many of these strong clusters. They also provide examples of the benefits, such as easy access to knowledge (including tacit knowledge), research partners, and sub-contractors, and strong linkages to especially research organisations and universities. However, the whole value chain must be supported in order to build on these strengths.

The multinational companies have substantial funds and are likely to carry out most R&D internally, the SMEs benefit from a large range of public support opportunities at both European level and in the Member States. However, many mid-cap firms (or médiane in French), which do not come under the SME definition, face many of the same challenges encountered by SMEs, such as lack of internal means to ensure the deployment of KETs. Company representatives from the mid-cap category of firms interviewed for this study state that it is very difficult to obtain funding for deployment activities. R&D projects with a high potential may remain unexploited because national funding schemes will not allow inclusion of foreign companies[23].

Several of the large companies interviewed also mention that sub-contractors are increasingly found outside Europe and that many R&D programmes outside Europe take in the whole value-chain.

1.4 Conclusions

The study has identified a number of challenges for successful deployment of European policy initiatives in Europe and in emerging and leading regions outside Europe.

The study presents several good examples of international initiatives, but it is important to note that the study has not analysed challenges and gaps in policies in the regions outside Europe. Examples of such challenges include lack of access to qualified labour, dependence on inflow of foreign scientists, and challenges for companies in high-tech/high risk sectors to attract private funding in the US, to limited research infrastructure in China, and limited success with commercialisation of R&D results and patents taken out in Korea. In especially the US and in Korea, several measures have been launched to overcome the barriers to commercialisation.

In terms of global competitive advantage the work of the HLG shows that Europe has been holding a constant level of patent applications over the last years. However, it also stresses that Asia has accelerated its efforts and has in the meantime overtaken Europe, whereas the US has lost ground. Europe still has significant strengths in both research and industry in all KETs. Emerging regions and leading regions outside the EU are also facing challenges to overcome “the Valley of Death”.

There are several areas where the right mix of EU policy instruments could spur an increase in the industrial deployment of KETs and thereby strengthen Europe’s competitive position in a global economy with increased focus on KETs. Some of the interesting policy initiatives identified outside Europe cannot simply be transferred due to differences in framework conditions. Nevertheless these initiatives are an important source for policy learning not least because economies are increasingly inter-connected.

The findings from this study lead to a conclusion that the four areas below are important to address:

- Create critical mass in knowledge and funding through increased synergy;
- Increase market focus on R&D projects
- Large scale demonstrators and pilot test facilities; and
- Provide post-R&D commercialisation support.

[23] Interview Alfred Hoffmann, Infineon

Create critical mass in knowledge through increased synergy

As one geographical entity, Europe has the critical mass in knowledge and funding needed to compete with leading and emerging regions. However, as the EU consists of 27 Member States with different agendas, strengths and weaknesses, cultures, and funding schemes, the benefit of size is not used to its full capacity. Due to costs and technology complexity there are areas related to KETs where Europe needs to increase critical mass to keep up with its competitors investing heavily in the KET value chain. Investment strategies pursue a holistic approach comprising research, investments in demonstration and innovation activities and in education and training to stimulate the soft side of technological innovation relating to the quality of human capital.

Emerging and leading regions outside Europe have clear long-term strategies for their research programmes in the KET areas with an integration of program design from idea to commercialisation of project outcomes.

European research programmes need to be more focused to align the European initiatives and national strategies. A joint EU strategy could guide investments and initiatives within the KETs. If this strategy is focused it will result in a coherent funding framework for technological advance and innovation in Europe, it would allow for sufficient critical mass in funding and knowledge creation to fully exploit innovation opportunities stemming from KETs deployment. For Member States a coherent strategy would provide a guiding framework, whereby which Member States could prioritise and align national strategies with focus on KETs. As an added benefit it would likely also contribute to an increase in cross-border collaboration.

Increased cross-border collaboration will especially benefit small and new Member States and address the lack of critical mass in terms of access to funding, knowledge, large industrial partners, and facilities (research infrastructure).

Finally it should not be forgotten that KETs are central to solving some of the great global challenges – offering the opportunity that Europe can become a central player in driving sustainable innovation in emerging new growth regions in the world.

The European Commission should also consider how or if Structural Funds could be made available to and provide the funding basis for large-scale demonstrators and pilot test facilities in which KET-based technological solutions are deployed to address specific national/regional challenges. This could boost national/regional innovation capacity. Such measures are likely to contribute considerably to creating positive spill-over effects from European R&D to national and regional innovation priorities. Finally, this could also strengthen the clusters and value-chains in Europe operating in KETs areas, and it could spur internal innovation capacity in SMEs and increase their ability to work actively with the knowledge system.

Nationally funded projects often exclude participation of foreign companies to ensure that the taxpayers get a return on investment. For innovative companies in small Member States with lack of critical mass in a particular technology, this poses a barrier. On one hand they cannot include partners from a another country even if it would increase the research quality and likelihood of impact, on the other hand they will often not be able to participate as partner in public research funded by another Member State, where the capability relating to a specific KET might be substantially higher, and thus also accrued benefit.

Increase market focus on R&D projects

Basic research is essential stay competitive, but part of the European Research Programmes, such as the Framework Programmes, should have a clear strategy for commercialisation of results in areas where European research and innovation can contribute to the creation of new markets – also in a global context.

This could be aligned to strategies aimed at addressing the grand societal challenges in Europe and/or globally. Though there is a growing shared understanding of what constitute the grand global challenges, new challenges may develop over time. This calls for supportive instruments such as foresights to ensure a dynamic policy framework.

The speed of research advance and thus innovation potentials relating to KETs pose particular demands to the capacity of evaluator teams appointed by the European Commission. Evaluators need to have an insight in and understanding of emerging market potentials. Consequently, industry representatives or persons with global industry insights as well as insights in research and technological innovation advance need to be included in the evaluation process, and there should be increased requirements for state –of the-art pre-assessment of market potentials and commercialisation plans. One option would be to use the technological readiness levels as a tool for assessing the results and expectation of the projects.

In order to ensure results, a two-phase programme could be an option to boost commercialisation. The proposal for the first stage should provide evidence of commercial potential, whereas after the feasibility stage a new proposal should be submitted where both technological progress and commercialisation plan should be included. This is inspired by the US SBIR/STTR programme.

Enhancing the market opportunities will make highly innovative European companies more interested in participating in the Framework Programme. It will also increase the potential for industrial deployment after the end of a project.

The funding framework for European R&D projects is not coherent in terms of the project cycle from idea to pre-commercial product. R&D partners need to get funding from different European and national public funds for different steps in a project, which makes it complex and time consuming. There are examples from emerging and leading regions and countries of more integrated funding frameworks, which could function as a source of inspiration both for the European Commission and the Member States.

Large scale demonstrators and pilot test facilities

An important step in increasing technological readiness levels is to test prototypes in large-scale demonstrators and pilot test facilities.

Large scale demonstrators and pilot test facilities create opportunities to enhance the economies of scale in the exploitation of R&D and stimulate the manufacturing of products by creating intensive knowledge on prototypes and the scaling process. Currently, there is little public access to these plants in Europe. Many Member States have invested in test equipment, but this is often not on a commercial scale. Small Member States and companies without internal test facilities could benefit from European state-of-the-art large scale demonstrator and pilot test facilities available to the public in order to exploit R&D results.

Heavy public investments in large-scale demonstration and pilot testing facilities are made in competing regions. It may be necessary for Europe to go the same way. This will strengthen the clusters and encourage cross-border collaboration. In addition, this could also attract leading foreign companies to locate part of their activities in Europe if Europe could offer an advanced test infrastructure also with access to "leader users" in different application areas.

Below is an example on such as facility at a national level (see the Irish case study in Annex 2 for more examples).

Nanofab[24]

NanoFab is one of the first European laboratories applying nanotechnology to industrial production. Created to promote interaction between the nanotechnology and business communities, it offers businesses access to advanced laboratories in order to support technology and scientific expertise transfer. The Nanofabrication Facility is a 2,500 sq m R&D lab to be utilised by both universities and innovative companies. NanoFab proposes itself as a reference point for scientific consultancy through its own facilities as well as through its links with national and international academic institutions. It offers a wide variety of high tech products and services aimed at satisfying the specific demands of its clients. Companies can place orders for R&D projects stemming from the company's team of researchers or can merely use the laboratories with their own technical staff. The Nanofabrication Facility is managed by Nanofab s.c.a.r.l., a non-profit organization created by the Park of Science and Technology VEGA and by the CIVEN Association. The Region of Veneto has invested €14 million in order to create the laboratories that cover an area of 2500 sq m and employ 12 fulltime researchers.

For more info, see Italy innovation profile in Annex 3

[24] http://www.venetonanotech.it/en/industry/nanofab/,76

Provide post-R&D commercialisation support

As many of the European R&D projects are early-stage research and in a pre-commercialisation stage, it is necessary to spur continuous innovation by matching the results of R&D projects with potential investors. As shown in this study, this can be achieved in many ways.

First, matchmaking measures could ease the process of finding investors for the projects in need of further research or investment capital. This would require the outcomes of research projects to be managed and filed in a way that provides a transparent gateway for potential investors, be they large private companies or funds (venture capital, business angels, European Investment Bank). Second, some sort of brokering mechanism could make it easy for investors to identify attractive opportunities so that especially SMEs participating in the European programmes could obtain support for commercialisation. This would not require an increase in the funding for the Framework Programme (FP). The European Commission could choose to prioritise parts of the FP budget for the above-mentioned activities. This could increase the attractiveness of the research results and thus attract more investors for high-risk projects – which is currently a major challenge for European businesses working with KETs. The report provides several such examples (see for example Korean and US innovation policy profiles in Annex 3).

It is important emphasise that if the previous measures are applied, the importance of post-R&D phase commercialisation support will decrease. However, as seen in the US and Korea examples in the section on challenges, some companies or technologies may need support to be commercialised to ensure market uptake in the early phases.

2 Introduction to the study

In October 2010, the European Commission, DG Enterprise and Industry, launched a study on the impact of international industrial policies on Key Enabling Technologies (KETs). The study was carried out by Danish Technological Institute and IDEA Consult.

The process of strengthening key enabling technologies (KETs) within the EU's industrial policy and innovation framework was initiated with the adoption of the Communication "*Preparing for our future: Developing a common strategy for key enabling technologies*". In July 2010, the European Commission established the High-Level Expert Group on Key Enabling Technologies (HLG), which will support the European Commission’s efforts aimed at developing a shared long-term European strategy for key enabling technologies.

This study on the impact of industrial policies on key enabling technologies will complement the activities of the HLG by identifying and comparing high-technology policies in EU Member States as well as leading and emerging regions/countries, in particular with regard to the different measures supporting the deployment of KETs. This study and the final report of the HLG will feed into the European Commission’s development of a long-term European strategy for KETs.

Methodology
The findings are based on a literature review, an analysis of European data on patents and R&D investments, over 70 interviews (telephone and face-to-face) with experts and stakeholders from industry, academia and policy, and a study visit to the US.

Limitations
The scope of analysis is framed by short time duration for the execution of the contract, so the study provides snapshots of challenges and policy instruments from leading regions and countries outside the EU with a view to their relevance in Europe and EU policy making. In some countries access to interviewees proved to be difficult due to the sensitivity of the issues in the study.

As part of the study is to identify international examples on initiatives addressing the deployment challenges facing Europe in relation to KETs, the study will provide a rather glorified picture of the leading and emerging regions outside Europe and leave a less optimistic impression of the state of play in Europe. The study only provides scattered examples of the challenges faced by the leading and emerging regions, as this is outside the scope of this study.

The innovation policy profiles provide a snapshot of initiatives and policy framework in selected countries in relation to deployment of KETs. The country profiles are based on a limited number of interviews and a literature review and will therefore not provide a deep insight into all relevant aspects relating to KETs in these countries. The innovation policy profiles of Japan, Taiwan and India are only based on e-mail exchanges and policy reviews, where for example the Chinese innovation policy profile is based on five interviews. All profiles and case studies have been verified by the interviewees.

2.1 Structure of the draft final report

The interim report consists of six main sections:

- Section 1: Executive summary
- Section 2: Introduction to the Study
- Section 3: Key deployment challenges in Europe for the six KETs
- Section 4: Policy challenges and initiatives
- Section 5: SWOT and key lessons from the international benchmark.

To ensure a natural flow for the reader of this report, we have inserted several deliverables in annexes, including the case studies, innovation policy profiles, and best practise examples.

- Annex 1: Case studies
- Annex 2: Innovation policy profiles
- Annex 3: Best practise examples
- Annex 4: List of interviewees.

2.2 Background and objectives of the study

With the launch of Europe 2020, the European Union (EU) has presented its strategy for smart, sustainable and inclusive growth in Europe.[25] Three mutually reinforcing priorities will be guiding the activities of the EU in the coming years:

- *Smart growth:* developing an economy based on knowledge and innovation
- *Sustainable growth:* promoting a more resource efficient, greener and more competitive economy
- *Inclusive growth:* fostering a high-employment economy delivering social and territorial cohesion.

Key Enabling Technologies are one of the key factors to realise the overall policy objectives of Europe 2020, due to the importance of these technologies for the competitiveness and innovation of European enterprises as well as for the development of sustainable products and processes. The European Commission has launched a number of

[25] European Commission (2010): EUROPE 2020 A strategy for smart, sustainable and inclusive growth, COM(2010) 2020

Europe 2020 Flagships such as *Innovation Union*[26], where 10 priorities are highlighted to increase innovation, including easier access to EU programmes, modernisation of the education system, increased collaboration between academia and the business community, and key areas for improvement of industrial deployment.

Other Europe 2020 Flagships also encourage industry-led initiatives and focus on engagement in key enabling technologies, such as *A digital agenda for Europe*[27] where industry-led initiatives aiming at standards and open platforms for new products and services will be supported in EU-funded programmes. The European Commission aims to reinforce the activities bringing together stakeholders around common research agendas in areas such as the Future Internet including the Internet of Things and in key enabling technologies in ICT.

The focus on the value-chain in manufacturing and the above points are key elements in the Communication "*An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage".*[28] The Communication calls for a more effective European governance approach, with less focus on individual national sectors and industries and more focus on cross-fertilization between Member States and industry/technology sectors. This is to be achieved through better coordinated policy-making internally in the European institutions and through closer collaboration with Member States.

Finally, the Communication "*Regional Policy contributing to smart growth in Europe 2020"* highlights how initiatives at regional level can contribute to the overall growth of Europe through a three-pronged approach needed to help regions to realise their full potential. The approach consists of (i) developing world-class research and ICT infrastructure, building on existing regional scientific excellence through Structural Fund support, (ii) establishing networks of research facilities for less research-intensive countries and (iii) developing Regional Partner Facilities (RPF).

The process of strengthening key enabling technologies (KETs) within the EU's industrial policy and innovation framework was initiated with the adoption of the Communication "*Preparing for our future: Developing a common strategy for key enabling technologies*". In July 2010, the European Commission established the High-Level Expert Group on Key Enabling Technologies (HLG) to support the European Commission's efforts aimed at developing a shared long-term European strategy for key enabling technologies.

This study on the impact of industrial policies on KETs complements the activities of the HLG. It identifies and compares high-technology policies in EU Member States as well as leading and emerging regions/countries, in particular with focus on measures supporting the deployment of KETs. This study together with the reports provided by the HLG will be used by the European Commission as an important basis for the

[26] http://www.umic.pt/images/stories/publicacoes3/innovation-union-communication_en.pdf
[27] http://ec.europa.eu/information_society/digital-agenda/documents/digital-agenda-communication-en.pdf
[28]http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/10/532&format=HTML

development of a European strategy for KETs within the context of the 2020 Smart Growth Strategy.

The EU has already presented strategic approaches to promoting life sciences and biotechnology, nanosciences, nanotechnologies, and energy technologies, but there is no coherent strategy at the European level on how to support the development and deployment of KETs in European industries.[29] This study together with the reports provided by the HLG will be used by the European Commission as an important basis for the development of such a strategy.

[29] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS "Preparing for our future: Developing a common strategy for key enabling technologies in the EU", COM(2009) 512/3

3 Key deployment challenges in Europe

3.1 Introduction

The European Commission's has identified the following technologies as "Key Enabling Technologies" (KETs):

- Nanotechnology
- Micro- and nanoelectronics
- Industrial biotechnology
- Photonics
- Advanced materials
- Advanced manufacturing technologies.

There are no clear boundaries between these six technology domains due to technology convergence and integration.[30] Nanotechnology, for instance, is considered separately in this report even though this technology is also driving technology developments in other KET domains, e.g. nanoelectronics, nanomaterials, and nanobiotechnology. Technology convergence is not only a conceptual challenge, but also a challenge for industry structures and value chains as convergence is blurring the boundaries between existing industries as well as creating new industries and value chain constellations.[31]

KETs share some basic characteristics - in particular, they are characterised as *"knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment"*.[32] The different KETs, however, also differ with regard to maturity level and application areas. While some KETs such as advanced manufacturing systems, micro- and nanoelectronics, and industrial biotechnology have developed a strong industrial base, nanotechnology is still a relatively young and research-driven KET. Such differences imply that deployment challenges and the relevant policy measures addressing these challenges may also differ somewhat.

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[30] European Commission (2006): Emerging Science and Technology priorities in public research policies in the EU, the US and Japan; Roco, Mihail C. and William Sims Bainbridge (2003): Converging Technologies for Improving Human Performance, http://www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf; RAND (2001): The Global Technology Revolution. Bio/Nano/Materials Trends and Their Synergies with Information Technology by 2015

[31] Hacklin, F., C. Marxt and F. Fahrni (2010): "An evolutionary perspective on convergence: inducing a stage model of inter-industry innovation" in International Journal of Technology Management, Vol. 49, Nos. 1/2/3, pp. 220-249; Hacklin, F. (2008). Management of convergence in innovation: strategies and capabilities for value creation beyond blurring industry boundaries, Springer.

[32] European Commission (2009): Preparing for our future: Developing a common strategy for key enabling technologies in the EU, http://ec.europa.eu/enterprise/sectors/ict/files/communication_key_enabling_technologies_sec1257_en.pdf

The first section provides a discussion of cross-cutting issues and policy perspectives concerning the deployment of KETs, based on the literature review and the expert interviews. The subsequent sections present a more in-depth analysis of the deployment challenges for each KET and present a range of policy measures applied in Europe and other world regions.

Public interventions, such as industrial and /or innovation policies, are typically based on the identification of market failures such as lack of access to capital, but also on weaknesses of the industrial system or the innovation system (system failures). The analysis of the international literature on KETs points to a range of key market and system failures that constitute barriers to the deployment and commercialisation of the different KETs. These market and system failures constitute a "Valley of Death", which refers to the funding and knowledge gap that may exist between on the one side scientific discovery (invention), and on the other side the introduction of products, processes and services on the market (innovation).[33]

Recently, a distinction has been made between a 1st and 2nd Valley of Death. The 1st refers to the difficulty that technological innovators face in raising funds for the development of their products, and the 2nd refers to the difficulties in deploying new products after development.[34] The 2nd Valley of Death is determined by government regulations and market support mechanisms, which tend to differ between countries. In theory the deployment of products will take place in the countries providing the most favourable production and market conditions. If conditions are not competitive in Europe, the technologies developed in Europe (and thus often funded by European governments) may be deployed in countries outside Europe.[35] If this holds true, Europe could be funding the development of new technologies, and the benefits would primarily be accrued in other world regions in the form of jobs and socio-economic growth.

3.1.1 Understanding the KET innovation process

The innovation process for KETs is often considered to be a linear process in which basic research results in products in market through a 'value chain' of first science, technological research, product development and competitive manufacturing, cf. Figure 2 below.

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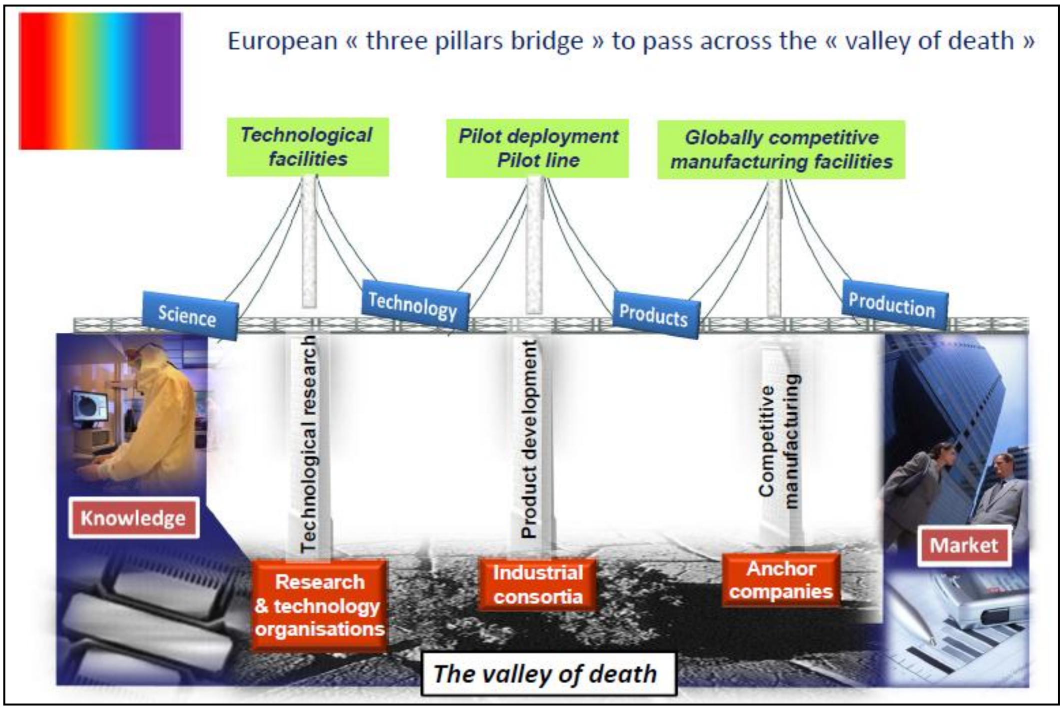
[33] Auerswald, P. E., and L. M. Branscomb (2003): "Valleys of death and Darwinian seas: financing the invention to innovation transition in the United States" in Journal of Technology Transfer, 28:227–239

[34] Berlin, Kenneth (2010): The Second Valley of Death, http://tpmcafe.talkingpointsmemo.com/2010/12/08/the_second_valley_of_death_by_ken_berlin/

[35] Berlin, Kenneth (2010): The Second Valley of Death, http://tpmcafe.talkingpointsmemo.com/2010/12/08/the_second_valley_of_death_by_ken_berlin/

Figure 2: The KET value chain - from basic research to market



Source: High-Level Expert Group on Key Enabling Technologies (2011): Mid-Term working document

In this understanding, the key innovation challenge for Europe is to overcome the various barriers to deployment, the "Valley of Death", by linking together the various parts of the value-chain using, for instance, tech transfer mechanisms, supporting demonstration projects, and creating favourable market conditions for innovative (yet often relatively expensive) products.

However, the discussion of deployment challenges and possible policy measures must also take into consideration other sources of innovation than basic technology research. It is also an issue of internal firm capacity to collaborate with and take-up of technological advance in innovations. Innovation can also be a result of the creative application by companies of existing technologies. This suggests that industrial deployment of KETs is not only a question of effective technology transfer mechanisms and demonstration projects. Open innovation processes involving industry and researchers with specialist knowledge with focus on application oriented solutions to a problem is another model– in the innovation literature discussed as *Mode Two* application oriented knowledge versus the more pure science based view of knowledge production called *Mode I.* More specifically, public funding should not only be allocated for projects focusing on the deployment of basic research within the different KET domains, but also for application oriented deployment projects.[36]

In addition to funding for R&D, public support for deployment of KETs can also include the introduction of new regulations (e.g. environmental requirements), strategic use of pre-commercial public procurement, subsidies, etc., as long as these measures do not

[36] Interview with Dr. Gernot Klotz, CEFIC

conflict with the EU's current legislative framework on, for instance, state aid. Market demand and the creation of markets for innovative products play a vital role for driving technological innovation. However, innovative products produced in small scale will have high initial prices, making the products uncompetitive and unable to achieve mass-market sales.[37] Public interventions could be a means to stimulate market demand for technologies is of political and societal importance. KETs provide an opportunity of first mover advantage, and have the potential to create new lead markets as new technologies substitute old technologies with few or no other players. The first mover will have an advantage even when other players try to penetrate the market[38]. One important aspect of KETs is that they are high-tech and require substantial R&D investments, and as a first mover this will need to be sustained in order to keep the advantage. The Polish case study provides an example where the early mover advantage is threatened by limited access to funding[39].

3.1.2 Linking research and industry for the deployment of KETs

With regard to the "Valley of Death", there are some cross cutting issues for all the KETs. Interview and literature suggest that the following market and system failures are of importance for the industrial deployment of KETs:

Basic research: Public funding is often available for KET research, but merits for researchers are typically based on the number of articles published in international research journals rather than the ability of transferring research into products on market. Incentives are required to ensure that research is carried out with a focus on market needs and commercialisation.

Applied research and proof of concepts/demonstration projects: Bringing the research results into commercial use implies (large) investments in further development, e.g., prototyping, testing and scaling up to full scale production facilities, but the available funding is not meeting the demand in this stage of the innovation process. Whereas other leading and emerging regions offer direct financial incentives, such long-term tax breaks and direct funding for prototype testing and support to large-scale demonstrators, the public funding for these activities, although available in Europe, is limited. Public funding for R&D in Europe is available but from many different sources (CIP, FP, structural funds, etc.). This makes it difficult for companies to navigate. Also, the European funding opportunities for research are characterised by longer waiting periods than in other world regions[40].

European venture capital markets are fragmented and underdeveloped. Venture capital (VC) funds find it difficult to operate across borders due to national legislation. Furthermore, state-backed venture capital funds are often restricted to operating within

[37] Berlin, Kenneth (2010): The Second Valley of Death, http://tpmcafe.talkingpointsmemo.com/2010/12/08/the_second_valley_of_death_by_ken_berlin/
[38] http://www.pearsoned.co.uk/Bookshop/article.asp?item=312
[39] See Ammono case in the Polish case study
[40] Technopolis (2008): Impact of the Community Framework for State Aid for Research and Development and Innovation on European Union competitiveness.

national borders. According to Grabenwarter (2006), Europe has 64% more VC funds than the US, yet European funds in aggregate manage 50% less capital. Moreover, the VC funds in Europe may even be too small to ensure sufficient capital for follow-on investments – they are simply not able to supply sufficient funding for the entire development process.[41] In addition, the financial crisis has put venture capital funds under substantial financial pressure, resulting in increased focus on low-risk, high-profit projects that are close to the market (e.g. clean tech). KETs may not be able to attract venture capital. KETs, particularly nanotechnology, which is a relatively young and research-driven technology, are characterised by a high-risk profile, asymmetric information, and long time to market, requiring long-term investments. As a result, venture capital funds tend to look for other, less risky investment opportunities. This market has spurred public intervention in the form of public co-investments, for instance in the form of public funds targeting high-tech companies. One example of a European public intervention is the Risk Sharing Financing Facility of the EIB explicitly targeting ICT and life science companies.

Culture and skills: There is a weak entrepreneurial culture among researchers and in the population as well as fear of failure in the entrepreneurial environment in Europe as a whole. In addition, there is a lack of business skills among entrepreneurial researchers which may hinder the long-term growth prospects for innovative start-ups.

Access to talent: The importance of skilled labour for competitiveness is widely acknowledged, but demographic developments and limited interest of young people in studying natural sciences and engineering are reducing the talent pool in Europe. The limited access to talents in Europe may spur off-shoring of knowledge intensive activities such as R&D to other world regions.

Size matters: SMEs play an important role in providing inputs and innovative solutions especially to large companies. However, SMEs may lack the organisational and financial capacity to place new products on the global market. Large companies are thus more likely to be better capable of deploying KETs for innovation advance.

3.1.3 The impact of globalised value chains

Value chains for the technology intensive manufacturing industry have become even more internationalised and fragmented in the last decades, and companies are locating their business activities close to growth markets and in countries offering the most attractive business conditions. In particular, the use of direct or indirect subsidies (state aid) in third countries as well as the imposition of various barriers to global trade pose a challenge to European competitiveness as a region and Europe's attractiveness to global high-tech companies.

The EU is typically seen as a very open and competitive market, which should encourage the development of a technology-leading (high technology intensive) industries producing

[41] British Private Equity and Venture Capital Association 2009

high value products. However, a closer look at the globalised value chains and the possibilities for deploying KET points at several critical factors: Large mass-producing, technology oriented companies are the among the key KET users, but in the last two decades Europe has undergone an increase in the off-shoring of manufacturing activities to countries outside Europe. As a result, KETs are increasingly deployed in countries outside Europe. Several interviewees from both industry and RTOs point to the following factors: the availability of funding for R&D outside the EU, testing and production with the condition of location of manufacturing remains in the funding region, and other financial incentives such as long-term tax breaks. Moreover, KET R&D depends on close collaboration between technology providers and the manufacturing industry because of the important knowledge feedback from manufacturing to R&D. In turn, second wave of of-shoring is not only a question of off-shoring low-value, low skilled job, but a strategic choice of also off-shoring R&D to those countries where manufacturing activities were off-shored in the first phase to ensure the interplay between the tacit and “sticky knowledge” from production processes and R&D.

3.2 Introduction to individual KET challenges

This sub-section discusses key deployment challenges for each KET and include an overview of the European competitive position in each KET. Several initiatives are presented in this section, but links to more initiatives can be found in the case studies (Annex 2), innovation profiles (Annex 3), and best practise examples (Annex 4). Moreover, a detailed discussion on the key policy challenges in the individual KETs are presented in Section 5.

3.2.1 Nanotechnology

Nanotechnology is slightly different from the other five KETs, as the maturity level of the technology is low and a high level of basic research is required, as is the number of patents required before a product is ready for commercialisation. This means that the patents taken in nanotechnology, compared to for example photonics, are more frequent and not of the same value.

A decade ago, nanotechnology was considered the next major investment object. This resulted in governments around the world investing heavily in nanotechnology R&D projects as a drive to commercialise. Much of this funding was directed towards the universities, either directly or through projects with industry, and very broadly defined as *nanotechnology*, not taking into consideration the strengths and weaknesses of the national/European innovation systems. As a result much funding was invested in research with little relation to national or European industry strengths, and the impact was beyond expectations. However, since then we have seen focused efforts in, for example, France. Germany, UK and Ireland (see Annex 2 and Annex 3).

Nanotechnology is still seen as a key technology for the future by many. The importance of the technology is for example highlighted in the LUX Research report[42] to Forfas, in which it is stated that nanotechnology R&D funding grew at a steady pace, up 15% in 2008, to reach $18.2 billion (approximately €13.3 billion) globally. Publications have grown 19% since 2006, reaching 48,426 in 2008. Patent filings were up 12% over the same period, reaching 12,391 in 2008. The table below shows that nations and regions are still investing heavily in nanotechnology.

Table 1: Examples of investment in recent nanotechnology programmes (average per annum)

	Programme or agency	Average p.a.
EU	FP7 NMP	€500m
Germany	Nano Initiative Action Plan 2010	€330m
France	Nano2012 programme	€400m
Netherlands	NanoNed	€130m
UK	BIS, Defra, RCUK	€60m
Austria	Austrian Nano Initiative	€27m
Finland	FinNano	€21
Norway	NANOMAT	€15m
USA	National Nanotechnology Initiative	€1bn
Japan	MEXT	€470
Russia	RusNano	€360
China	MOST, NSFC, CAS	€100m
India	DST (Nano Mission)	€29
South Africa	Treasure, NRF	€18m
Brazil	INCT, PACTI	€12.5m

Source: Institute of Nanotechnology, (analysis from UNU-MERIT and VDI-TZ), 2010

Deployment challenges within nanotechnology

Public funding in nanotechnology R&D in the EU actually exceeds that of the US. Europe accounts for 27% of global public nanotechnology funding, compared to Russia’s 23%, the USA’s 19%, and China’s 16% in China However, when looking at corporate investments in nanotechnology R&D, the US led the world in 2006 in with an estimated €1.3 billion investment followed by Japan with €1.2 billion. In total, U.S. and Japan-based companies accounted for nearly three-fourths of global corporate investment in nanotechnology R&D in 2006[43].

The European Commission states this in its recent Communication on key enabling technologies: In nanotechnology, the EU has similar levels of R&D spending as the US, but with a much lower private sector share. [44] Despite these relatively high levels of funding, the EU is not as successful in deploying nanotechnology as for example the US, when looking at the ability to transfer knowledge generated through R&D into patents. For instance, the EU’s share of publications is high compared to the US and Japan, whereas the share of patents is relatively low.

[42] Ireland’s Nanotechnology Commercialisation Framework. 2010 – 2014
[43] http://www.fas.org/sgp/crs/misc/RL34511.pdf
[44] European Commission (2009): Preparing for our future: Developing a common strategy for key enabling technologies in the EU, http://ec.europa.eu/enterprise/sectors/ict/files/communication_key_enabling_technologies_en.pdf

Table 2: World regions share of publications and patent applications

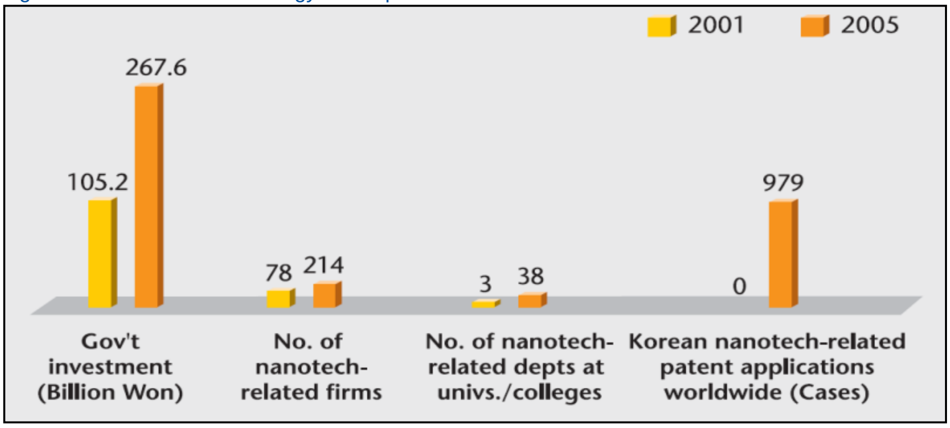
Major regions	Publications share	Patent application share
USA	13%	40%
EU	33%	17%
Japan	6%	22%
China	7%	0%
Others	41%	21%

Source: Source: Institute of Nanotechnology, (analysis from UNU-MERIT and VDI-TZ), 2010

The global distribution of R&D investments, publications and patents indicates that nanotechnology related *research and development activities* are concentrated in a few countries and regions of the world. The figures in R&D, patents and publications show that the US, Europe and Japan are leading the way, but countries such as Russia, Korea and China are catching up. According to the OECD (2004 figures), Ireland had the highest R&D investment in nanotechnology per capita[45].

The figure below shows how Korea has invested heavily in nanotechnology. It also shows the good outcome of these investments. However, although Korea has taken many patents, the commercial industrial deployment has been low.

Figure 2: Korean nanotechnology development 2001-2005[46]



Another indication of Europe lagging behind is the market introduction of nanotechnology-based products and applications. According to a recent nanotechnology product inventory compiled by the "Project on Emerging Nanotechnologies" at the Woodrow Wilson International Centre for Scholars in the United States, a total of 53% of identified nanotechnology-based products derive from the USA, followed by companies in East Asia (24%), Europe (15%), and other world regions (8%).[47]

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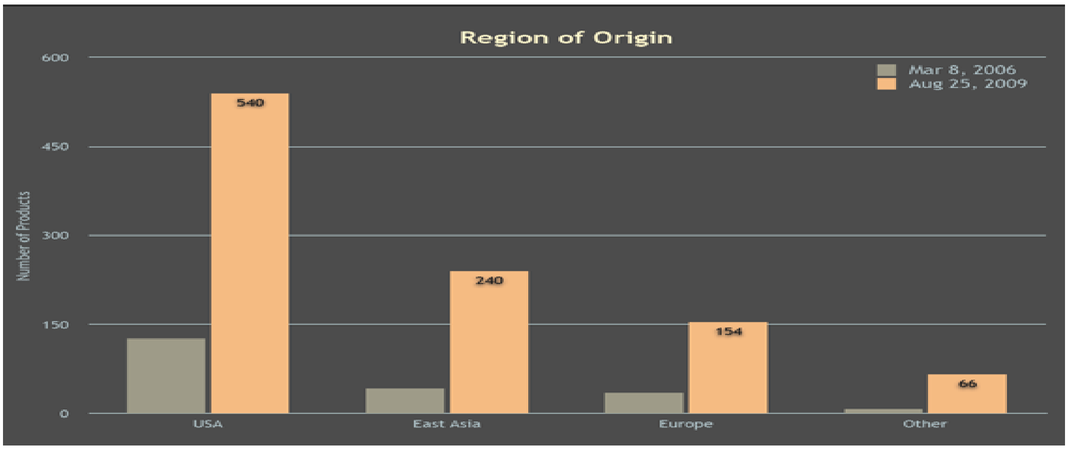
[45] http://www.oecd.org/dataoecd/59/9/43179651.pdf (2009)
[46] Nanotechnology Korea, http://www.microsystem.re.kr/data/tech/Nanotechnology%20Korea%5B1%5D.pdf
[47] OECD (2009): NANOTECHNOLOGY: AN OVERVIEW BASED ON INDICATORS AND STATISTICS, http://www.oecd.org/dataoecd/59/9/43179651.pdf. Note on methodology: Product listings for this inventory have been compiled through web-based searches using three selection criteria; namely that the products can be readily purchased by consumers, that they can be readily identified as nanotechnology-based by the manufacturer or another source, and that the nanotechnology-based claims for the products appear reasonable. As of August 2009, the nanotechnology consumer products inventory contains 1015 products or product lines, compared to 212 in 2006. The inventory now includes products from 24 different countries.

Figure 3: Nanotechnology production by region, 2006 & 2009.



Source: The Project on emerging nanotechnologies, http://www.nanotechproject.org/inventories/consumer/analysis_draft/

One of the major and oldest initiatives focused directly on nanotechnology is the National Nanotechnology Initiative (NNI) described in the text box below. The NNI has played a significant part in the new US Government innovation strategy – A Strategy for American Innovation.[48]

National Nanotechnology Initiative (USA)[49]

For 10 year the United States has invested federal funds in nanotechnology R&D through the National Nanotechnology Initiative (NNI), which is a multi-agency program designed to coordinate federal research efforts and ensure U.S. competitiveness on the global nanotechnology front. Large industry currently supports about half of the R&D in nanotechnology in the U.S.—about $2 billion per year. The other half comes from small business and investors, as well as Federal, state and local governments. NNI brings together expertise needed to guide and support the advancement of nanotechnology, through serving as locus for communication, corporation, and collaboration for all Federal agencies that wish to participate.

Industry liaison groups that include government and private sector representatives promote the exchange of information on NNI research programs and industry needs. One way that the NNI identifies pre-competitive research is through industry participation in the review of research proposals. The NNI also makes use of existing mechanisms for technology transfer and commercial development, such as the Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) programme.

At regional level a number of regional organisations and local governments have begun to create nanotechnology-based clusters, which are concentrations of universities, investors, and interrelated businesses with common manufacturing processes, customers, and suppliers. The NNI also engages in facilitating communication between local/regional nanotechnology initiatives to identify common barriers of commercialization.

A highly significant impact of the NNI has been the focused investment by the NNI-participating agencies in the establishment and development of multidisciplinary research and education centres devoted to nanoscience and nanotechnology - NNI Research Centers. NNI agencies have

[48] http://www.whitehouse.gov/sites/default/files/uploads/InnovationStrategy.pdf
[49] http://www.nano.gov/

developed an extensive infrastructure of over 60 major interdisciplinary research and education centres and user facilities across the country. Many such centres, with state of the art equipment for nanoscale S&T research, are designated as user facilities and are available to researchers from academia and the private sector, and to scientists at the national laboratories.

In addition to providing the facilities, the National Nanotechnology Initiative also has created programs to attract researchers across an array of disciplines and to facilitate discoveries. Centers and networks provide opportunities and support for multidisciplinary research among investigators from a variety of disciplines and from different research sectors, including academia, industry and government laboratories. Such multidisciplinary research not only leads to advances in knowledge, but also fosters relationships that enhance the transition of basic research results to devices and other applications. http://www.nano.gov/

However, a strong strategic focus on commercialisation of nanotechnology may also lead to a situation in which basic research and technology development are left behind. The Federal Government is finding itself struggling to promote innovation, while facing the increased privatisation of knowledge, funding restraints, lack of oversight, and unknown health risks. Nearly half of nanotechnology research is privately funded. Thus in 2006, $6 billion was invested in private sector R&D compared to $6.4 billion in federal R&D. Such heavy private sector investment in nanotechnology is seen as worrisome to NNI proponents, who say that with new technologies appearing in the private sector, federally funded efforts are undercut and progress becomes difficult.[50]

The interviews showed that there is an increasing tendency for European technology know-how financed through national and/or European public funds to be further developed and commercialised outside Europe. Thus, the EU and the Member States are not reaping the possible benefits of their investments in R&D.

One example is the Russian initiative RusNano. This initiative invests in nanotechnology companies if at least parts of the manufacturing activities are located in Russia, cf. box below:

RusNano, Russia

RusNano was founded in 2007 with an overall mission to implement state policy in the field of nanotechnologies. Its main tasks include commercialising nanotech industry projects and innovations and creating product volume of Russian nano-enabled products by 2015.

The RusNano Corporation's main investment tool is taking an equity share in nanotechnology companies with high potential for growth and innovation. It also provides investment loans, makes loan guarantees, and facilitates leasing for its investees. As a general rule, the Corporation holds less than 50% of the project company's nominal capital, leaving the rest to founders and private investors in order to ensure that the project is realised with maximum efficiency. The projects co-invested by RUSNANO vary in size from €1.6 million to €400 million. The overall budget for RusNano is $5bn, approximately 50% of the Russian budget allocated to nanotechnology.

[50] http://www.nano.gov/ and http://www.aaas.org/spp/cstc/briefs/nanotech/index.shtml

The key conditions and principles of RusNano's participation in the commercialisation of proposed projects are:

- RusNano exits the project as soon as private partner is able to support the business independently.
- Financing from the corporation is available regardless of the applying companies' country of origin, with the sole requirement that at least part of the manufacturing takes place in Russia. Foreign ownership can be up to 100%.
- The minimum total volume of funding by RusNano is $10m. For the projects with budgets below $10m, financing is carried out by means of venture and seed funds.
- RusNano finances up to 90 % of the required scope of project financing. Provision of funds in the form of loans with favourable terms (below inflation rates), purchasing of bonds and convertible debentures, granting of guarantees on credits and other obligations as well as leasing
- Financing schedule is up to 10 years
- Provision of financing as grants for research purposes in order to foster product competitiveness
- Provision of financing to conduct on-going training for project teams.

RusNano also participates in building nanotechnology infrastructure, which includes the nanotechnology centres of excellence, business incubators and early stage investment funds.

Source: http://www.rusnano.com/Document.aspx/Download/17905

One example that illustrates how investments and inventions in nanotechnology are sourced to destinations out of Europe is the British manufacturer of plastic chips Plastic Logic. The company is a spin-off company from University of Cambridge with production in Dresden in Germany, headquarters in California, and R&D department in the UK. Until recently, a group of investors including Intel and BASF, and venture groups Oak Investment Partners in the USA and Amadeus Capital in Britain had invested about $200 million in Plastic Logic. Rusnano have already invested $150 million in Plastic Logic, and the total investment will be $700 million, and includes building the world's largest volume production factory for next-generation plastic displays in Zelenograd. The aim is to establish a commercial plastic electronics industry in Russia.[51] The British company had plenty of options outside Europe, including opening its second plant in California where its headquarters are based, or in China that was also bidding for such a deal. However, the choice was in favour of the under-serviced Russian market. With the investment, Plastic Logic plans to bring out a new family of plastic chips by 2016 and to reach $1 billion in annual sales. Several comments from the UK emerged after the acquisition:

Lord Mandelson, Business Secretary in the last Labour government, said it now seemed that the technology would join the list of scientific areas "developed in Britain but commercialized elsewhere. Other areas of technology that Britain played a big part in developing but where the country's commercial strength is weak include computers, electricity generation equipment and medical scanners". However, David Willetts, the UK Science Minister, said there was "no way" that any UK government agency would invest $650m in a technology company to help its expansion.

Source: http://english.ruvr.ru/2011/01/19/40371519.html

[51] http://www.businesswire.com/news/home/20110118005950/en/RUSNANO-Finalizes-Investment-Plastic-Logic-700-Million

3.2.2 Micro- and nanoelectronics, including semiconductors[52]

The European micro- and nanoelectronics industry is a global player with substantial strengths in both research and industrial deployment. For instance, Europe has a strong R&D network consisting of industry, universities and research institutes. Europe has continuously increased R&D efforts during the last 10 years. Furthermore, a number of European regions have the critical mass and semiconductor competences that are recognised worldwide. The most significant European clusters are located around Grenoble (France), Dresden (Germany) and Dublin (Ireland), but other European clusters such as Eindhoven and Catania also have global potential.[53] Europe also benefits from a strong all-European value chain, which includes world leading equipment suppliers, substantial manufacturing capabilities, and strong downstream collaboration with industry sectors in which Europe has global leadership, e.g. the automotive, medical, power & wireless communication sectors. The European microelectronics industry faces considerable competitive challenges. For instance, Europe's share of the semiconductor market has declined from 21% to 16% since 2000, manufacturing capacity is declining, and the European industry has seen a declining share of worldwide investment in microelectronics, not least in manufacturing. In 2007, only 10 % of the total investments in microelectronics were in the EU compared to 48% in Asia.[54]

The US has been a key competitor for many years, but the current and - in particular - the future challenges for the European microelectronics industry is largely defined by the increasing importance of Asian countries. Japan has been a strong player in the global market for microelectronics for many years, but other Asian countries, such as China, Malaysia, and Taiwan, are moving up the value chain and developing their competences and capabilities in microelectronics. Countries in the Asia Pacific provide very attractive conditions for the microelectronics industry[55] and they have high economic growth rates compared to Europe and the US, and many industry players are therefore relocating or expanding their activities in these countries.

Below are two examples from Korea and the Philippines of how Asian countries are offering long-term incentives.

Tax breaks in Korea

Tax breaks on FDI are governed by the Special Taxation Restriction Act, which implements a system of tax breaks designed to facilitate the transfer of cutting edge technologies and to promote foreign investment. The tax breaks include both corporate and income tax for up to seven years for foreign companies and high tech businesses, five years full tax and two years with 50% tax breaks. According to some of the large European companies interviewed for this

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[52] Based on desk research and interviews with Enrico Villa, ST Microelectronics and Carlos Lee, SEMI Europe

[53] These three clusters are the result of very different national policy approaches: The Grenoble cluster has emerged on the basis of a dedicated industrial policy implemented by the French Government, while the cluster around Dresden has been established on the basis of European structural funds. In Dublin, the semiconductor cluster is mainly the result of a tax regime which has succeeded in boosting FDI.

[54] OECD (2009): Information technology outlook 2008

[55] Examples of strategic incentives include corporate tax exemptions, venture capital, free-of-charge access to research and manufacturing facilities, provision of land, support with education and training of staff, etc.

projects, this means that there is enough time to go from R&D to commercialize the technology. The Korean Government has created different types of zones[56] where companies will be eligible to different types of tax breaks, such as the one mentioned above. Also, the Korean government provides free or low cost industrial complexes exclusively for foreign invested companies according to specific criteria for eligibility[57].

Fiscal and non-fiscal incentives in the Philippines
In 2007 semiconductors and other components accounted for more than 74% of the total Philippine electronics exports and almost 50% of total Philippine exports. The most important destinations for electronics export are China, the US, Europe and Japan.

The number of multinational electronics companies in the Philippines is growing, with a majority of the companies coming from Japan, the US, and Europe. Thus, Enterprises registered with the Philippine Board of Investments are given a number of incentives in the form of tax exemptions and concessions. These include fiscal incentives in the form of Income Tax Holidays (ITH) for up to six years depending on the type of project: Projects with pioneer status can receive 6 years of ITH, while expansion/ modernization projects can receive three years of ITH. Non-fiscal incentives include simplification of customs procedures and tax and duty-free importation of consigned equipment for a period of 10 years. The Board of Investments also works closely with the Advanced Research and Competency Development Institute (ARCDI). ARCDI provides training and competency development support to semiconductor and electronics industry players. It offers training modules on specific competency areas which are centred on industry requirements.

Source: Philippine Department of Trade and Industry, http://www.dti.gov.ph/uploads/DownloadableForms/electronics_industry.pdf; ARCDI website, http://www.arcdi.com/about-us.php

China is playing an increasingly important role in the global semiconductor industry – as a consumer and a producer. Since 2000, China's consumption growth has continuously outrun the rest of the world, not least fuelled by an expanding middle class and rising demand for mobile devices. With regard to production, China's semiconductor production has also been growing for the past decade, and China has emerged as a significant source of new semiconductor companies and, more recently, of financial funding for semiconductor start-ups. China now accounts for 41% of global semiconductor consumption, over 50% of global semiconductor initial public offerings and employs 25% of the total global semiconductor workforce. The Chinese workforce employed in the semiconductor industry has been growing at a rate of 10% per year for the past five years and now accounts for 25% of the global semiconductor workforce. Also, 22% of the newly issued patents for the semiconductor industry are from China, up from 13% in 2005[58]. This development took off with the opening of two stock exchanges, i.e., the Shenzhen Stock Exchange Small and Medium Enterprise (SME) Board and the ChiNExt Board, both facilitating fund-raising for small and medium-sized enterprises and growing venture enterprises.[59] The US and Asian countries, such as China, Korea and

[56] Examples include complex-type foreign investment zones, individual-type foreign investment zones, free economic zones, and free trade zones.
57 Invest KOREA (Dec. 2009): The Investment Environments of Major Asian Countries.
58 http://www.pwc.com/gx/en/press-room/2010/china-continues-to-expand-footprint-in-global-semicond-market.jhtml
[59] PWC (2010): Global reach. China's impact on the semiconductor industry 2010 update, http://www.pwc.ru/en/communications/assets/China-Semicon-2010-nov2010.pdf

Japan have a different industrial policy approach than Europe. Thus, they have a sector specific policy compared to the European non-sectoral approach. According to industry stakeholders global companies therefore look to other regions with more enabling framework conditions and industry visions. One example of such focus is Taiwan that has clearly identified microelectronics as a strategic priority and provides incentives for companies to establish activities in the country.

Building a semiconductor industry in Taiwan

In less than 20 years, Taiwan has managed to become a major world producer of semiconductors. A dedicated industry policy has driven the transformation and thereby managed to create an innovative and attractive environment for global semiconductor companies. Global companies and know how has been attracted by the strategic focus and commitment from the Taiwanese government to the semiconductor industry in the form of funding and fast administrative support leading to the establishment of a national industry. ITRI, the Industrial Technology Research Institute in Taiwan, has played a fundamental role in the development of the national industry by facilitating technology transfer, investing in training of the national work force, and supporting spin-offs. External collaboration is a key element of ITRI's approach to research and innovation – the Institute collaborates with national industry champion TSMC when large scale facilities are needed for large pilots, and is also engaged in international collaboration with research institutes, including MIT (US) and AIST (Japan). ITRI is now 'moving away from a catch-up paradigm' and focusing on innovation by providing incentives for entrepreneurs to engage in ventures with a high-risk profile.

Source: Mina, Andrea, David Connell, and Allan Hughes (2010): Models of technology development in intermediate research organisations.

However, research from Stanford University suggests that though the Government of Taiwan played a very important role in the early development of Taiwan's IT sector, the region has more in common with Silicon Valley, Israel, and even with the nascent IT industries India and Ireland, than with the other East Asian NICs. The dynamism of Taiwan's IT industries, like those of Silicon Valley and its other 'imitators,' is rooted in the incremental deepening and broadening of the capabilities of a localised cluster of specialist producers as well as in its close economic ties to the original Silicon Valley. If the East Asian case is viewed as state-led development, then the experience of Silicon Valley, Taiwan, and its other 'imitators' is best understood as entrepreneurship-led growth. Taiwan's IT sector is dominated today by indigenous firms, most of which were started in the past two decades. The central dynamic in the cluster's growth and upgrading has been provided by Taiwanese entrepreneurs and firms. The majority of these firms remain small by global standards, although some have grown to dominate important segments of world markets. Even as they grow large, however, they continue to collaborate (as well as compete) with other local specialists in a way that is reminiscent of the Silicon Valley economy (Saxenian 2003).

The high-profiled establishment of LED cities in Chinese provinces is a flagship example, which could also be considered in Europe to create a market and further develop the semiconductor industry.

Chinese cities join the LED City Program
In February 2008, Tianjin Economic Development Area (TEDA) became the first of several cities in China to join the LED City program. The LED City program is a community of cities worldwide that are switching to LED lighting for significant energy and maintenance cost savings. The City of Raleigh, North Carolina, became the first LED City in early 2007. Bremen in Germany is currently the only European city participating in the program.

Source: http://www.ledcity.org/about_led_city.htm

The main markets for microelectronics and semiconductors in particular are currently located outside Europe. For instance, semiconductor sales in China are projected to reach $64.8 billion in 2010, an increase of 30 per cent compared to 2009, making the Chinese market one of the key growth markets for the global semiconductor industry.[60]

According to the interviews with representatives, market pull initiatives could boost the European market. Below is an example of a possible option to boost the demand through demand initiated by the public sector.

Boosting demand for MEMS Sensors in Korea and Japan
New government safety mandates have been set to increase the safety of vehicles in South Korea and Japan. This is expected to cause market revenue for MicroElectroMechanical System (MEMS) automotive sensors in those countries to rise significantly in 2012 and onwards. The mandates apply to MEMS sensors needed for Electronic Stability Control and Tire Pressure Monitoring Systems.

Source: iSuppli Corp, http://www.isuppli.com/MEMS-and-Sensors/News/Pages/Mandates-Boost-Car-Safety-MEMS-Sensor-Market-in-Korea-and-Japan.aspx

According to several sources the pool of European talent is shrinking, and in the near future, the microelectronics industry will not be able to recruit sufficient numbers of qualified engineers. Getting young people interested in studying natural sciences and engineering, attracting talent to the industry through awareness and competitive working conditions, and supporting the immigration of a high-skilled workforce will help the industry to address this problem.

Globalisation of value chains

The semiconductor industry is highly automated and capital intensive, and the relatively high price of labour in Europe is thus not as critical for the industry compared to labour intensive manufacturing industries such as textiles and food. Financial incentives provided by the US, Russia, and Asian countries matter for semiconductor companies in their localisation decisions. For instance, China, on the one hand, offers very attractive conditions for the industry in the form of tax exemption, access to production facilities, cash inflows and subsidies for training activities. On the other hand, Countries providing such favourable conditions gain access to leading edge technology that is driving innovation in other industrial sectors.

[60] iSuppli, http://www.isuppli.com/China-Electronics-Supply-Chain/MarketWatch/Pages/Semiconductor-Distributors-Enjoy-Soaring-Sales-in-China.aspx

In Europe, the EU Member States have also provided attractive financial “packages” to the industry. Ireland managed to attract several FDIs in the semiconductor industry at the end of the 1990s, and thanks to smart investments in the past by the German government and Saxony region, the US company AMD established an advanced wafer manufacturing facility in Dresden, Germany, with subsequent expansions.[61]

3.2.3 Industrial biotechnology

Industrial biotech provides new production methods for existing products and offers the possibility for developing entirely new products. Due to its various application possibilities, modern industrial biotechnology is seen as an important strategic opportunity for the EU.[62] Many EU Member States have developed national biotechnology strategies and launched cluster initiatives focusing on developing national capabilities in biotechnology. An example is the "BioIndustrie 2021" competition of the Federal Ministry of Education and Research of Germany in 2007. Among the current hotspots in Europe are Cambridge (UK), Berlin-Brandenburg (Germany) and cross-regional clusters such as BioValley (Germany, France and Switzerland) and Medicon Valley (Denmark-Sweden). Overall, most European biotechnology companies are involved in healthcare (red) biotechnology[63], but regional specialisations vary. For instance, Danish companies such as Danisco and Novozymes account for almost half of the world’s production of enzymes.

Europe is facing fierce competition from the USA and Japan, both countries having committed substantial funding to R&D in industrial biotechnology.[64] Other countries, such as Malaysia, Brazil, China and Korea, are also launching strategies and initiatives to strengthen the development and deployment of industrial biotechnology.

Bio X-cell strategy in Malaysia for industrial and health care biotech

The Bio-XCell strategy is part of Malaysia’s efforts to attract global companies to set up operations in Iskandar Malaysia, Johor. Bio-XCell is a biotechnology ecosystem that is currently being developed through a public-private partnership between BiotechCorp and UEM Land Holdings. It is intended to be a hub with special focus on industrial biotechnology, particularly in green technology, and it will have ready-built and customized commercial-scale shared facilities that are available for lease to interested local and global companies. Companies and researchers are provided with various incentives under the BioNexus Programme and other nation building programmes for biotechnology (as provided for under the National Biotechnology Policy 2005). The Malaysian Industrial Development Authority (MIDA) also provides incentives for biotechnology manufacturing and services.

A company undertaking biotechnology activity that has been approved with BioNexus status may apply for incentives that include exemption from tax on 100% statutory income in a specified time period, exemption of import duty and sales tax on raw materials/components and machinery and equipment, double deduction on expenditure incurred for R&D and double deduction on expenditure incurred for the promotion of exports.

Sources: Ernst & Young (2010): Beyond Borders. Global Biotech Report 2010, http://www.ey.com/Publication/vwLUAssets/Beyond_borders_2010/$File/Beyond_borders_2010.pdf; http://www.biotechcorp.com.my/Pages/TaxIncentives.aspx?AudienceId=3; http://www.bio-xcell.com.my/

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[61] European Commission, http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1109

[62] JRC-IPTS (2007): Consequences, Opportunities and Challenges of Modern Biotechnology in Europe http://ec.europa.eu/dgs/jrc/downloads/jrc_reference_report_200704_biotech.pdf

[63] EuropaBio (2006): Biotechnology in Europe: 2006 Comparative study, http://www.europabio.org/CriticalI2006/Critical2006.pdf

[64] SusChem (2010): European Technology Platform for Sustainable Chemistry (http://www.suschem.org/Default.aspx)

European global strengths include a strong chemicals sector, which forms an integral part of the value chain for industrial biotechnology. Furthermore, the industry has actively engaged in efforts at European level to strengthen the competitiveness of Europe in industrial biotechnology. Relevant initiatives at European level include the European Technology Platform SusChem, the Industrial Biotech Council, the KBBE-net (Knowledge Based Bio-Economy) and CLIB2021, a virtual, cross-regional cluster for industrial biotechnology. These initiatives strengthen the collaboration between important partners in industrial biotech, which strengthen the value chain and the opportunity to find local partners for R&D projects[65]. According to the European Technology Platform SusChem, industrial biotechnology currently faces several challenges, e.g., “the integration of scientific disciplines such as biochemistry, microbiology, molecular genetics and process technology to develop useful processes and products”.[66] Exploiting the opportunities following the convergence between nanotechnology and biotechnology is also an important challenge that the sector needs to address to ensure a competitive research base for the industry.

Competitiveness in biofuels, which is an important subsector of the industrial biotechnology industry, is closely linked to the available agricultural resources. The US, Brazil and China have access to substantial national resources, while Europe and in Japan, in particular, are less fortunate. In the EU, the bio-based feedstock production is heavily regulated by the Common Agricultural Policy, which makes it difficult to meet the demand with competitively priced supplies, and thus there is a risk that the process of biotechnology development is slowed down.[67] The discussions about land-use for food vs. fuel and about increasing food-prices could lead to restrictions on the use of agricultural resources for industrial purposes. Furthermore, European consumers are more reluctant to take up bio-products than consumers in other world regions, which is reflected in European consumers reluctance towards the use of GMO’s. Better information can be one means to raise the social acceptance of further development and deployment of biotechnological processes and products.[68]

The public support programmes for development and deployment of industrial biotechnology in Europe are underfunded and complex in administration compared to other world regions, according to industry in formants. In the US, the Department of Energy recently established the Advanced Research Projects Agency-Energy (ARPA-E) to support innovative technology projects.

At ARPA-E a commercialisation division has been set up in order to commercialise the results for the research projects. The commercialisation staff will, if necessary be involved from the start of the projects, and will also actively promote the results when the projects have come to an end in order to find investors to increase the technological

[65] Interview with Dr. Michael Roeper, BASF

[66] SusChem 2010, European Technology Platform for Sustainable Chemistry (http://www.suschem.org/Default.aspx)

[67] EuropaBio (2010) Policy Guide: Building a bio-based economy for Europe in 2020 http://www.europabio.org/positions/white/EB_bio-based_brochure.pdf

[68] European Commission (2010): *European Competitiveness in key enabling technologies*

readiness level through either VCs, industrial partners, potential customers or other US Departments, especially the Department of Defence[69].

Supporting innovative energy technology projects in the US
In April 2009, U.S. Department of Energy (DOE) launched the Advanced Research Projects Agency-Energy (ARPA-E). ARPA-E is a new organization which will fund energy technology projects that translate scientific discoveries and cutting-edge inventions into technological innovations. The organisation will also accelerate technological advances in high-risk areas that industry is not likely to pursue independently. ARPA-E's mission will be to develop new energy technologies that offer significant progress toward reducing imported energy; reducing energy-related emissions, including greenhouse gases; and improving energy efficiency.

Source: US Department of Energy, http://apps1.eere.energy.gov/news/news_detail.cfm/news_id=12478

Two of the companies interviewed mentioned that the ARPA-E projects provide greater market potential than the R&D programmes in Europe. There is a potential large market if the project is successful as the project is based on an actual need along with national investments. The European companies participating in these projects have invested several million dollars because of the market potential.

According to EuropaBio and the interviewed companies, it is difficult to access public money for public-private partnerships and demonstration projects in Europe.[70] In contrast, the US has launched ambitious demonstration programmes with significant amounts of funding. In particular, the establishment of pilot facilities for biorefineries is considered an important step for the further development and deployment of industrial biotech in Europe.

European biorefineries are already being established with government funding, for instance in Leuna, Germany (CBP) and Lestrem, France (BioHub). Also, Finland has launched the biorefine project 2007-2012 aimed at generating expertise in the processing of biomass and applying it to the development of processes, products and services related to biorefineries. An additional objective is to promote the development and use of second-generation production technologies in biofuels for transport.[71]

However, more large-scale facilities are required to match international competitors. Complementing government efforts, companies such as BP and Dupont are actively engaging in the establishment of demonstration plants as a part of joint ventures to develop and commercialise biofuels (see text box next page).

[69] Based on interview with Srini Mirmira (Program Director, ARPA-E, US Department of Energy), and Leshika Samarasinghe (Commercialisation advisor, ARPA-E, US Department of Energy)
[70] EuropaBio (2010) Policy Guide: Building a bio-based economy for Europe in 2020 http://www.europabio.org/positions/white/EB_bio-based_brochure.pdf
[71] TEKES, http://www.tekes.fi/programmes/biorefine; Mkinen, Tuula and Jukka Lepplahti (2009): Review of the Finnish BioRefine—New biomass products program

Joint ventures to develop and commercialise biofuel

Butamax Advanced Biofuels is a joint venture between BP and Dupont to develop and commercialise biobutanol, an advanced biofuel, from corn, cane, and wheat. The company is based in Wilmington, Delaware, US, but a biobutanol technology demonstration plant has been established in Hull, UK to prove out Butamax's proprietary process for producing biobutanol. In November 2010 Butamax's opened its biobutanol technology laboratory in Brazil, located at the City of Paulínia in São Paulo state, to accelerate the commercialization of sugar cane to biobutanol production.

The potential of macroalgae is also being explored in a related biofuels project, which was recently awarded a Technology Investment Agreement by the U.S. Department of Energy (DOE), Advanced Research Projects Agency-Energy (ARPA-E). Under this award, the DOE will fund $8.8 million and DuPont and subrecipient Bio Architecture Lab will cost share the balance of the total award. Butamax Advanced Biofuels will be responsible for commercialization of the resulting technology package.

Sources: US Department of Energy, http://us.vocuspr.com/Newsroom/Query.aspx?SiteName=DuPontNew&Entity=PRAsset&SF_PRAsset_PRAssetID_EQ=113189&XSL=PressRelease&Cache=; BP website, http://www.bp.com/sectiongenericarticle.do?categoryId=9030051&contentId=7055185

Perceived uncertainty about the properties of bio-based products is hindering their uptake. The European Commission's Lead Market Initiative for bio-based products is an example of a synchronised approach to stimulating demand for innovative bio-based products in Europe. Also, the Renewable Energy Directive will increase the demand for alternative energy sources, including biofuels.

3.2.4 Photonics

The European photonics industry is concentrated in a number of European clusters. France, Germany, and the UK dominate the industrial landscape in terms of absolute number of photonics companies, while the Netherlands has a relative large number of photonics companies compared to other European countries. Europe has over 19% of overall world-wide photonics production volume and is a global leader in a number of subsectors, including lighting, production technology and optical components and systems[73]. However, competitors in other world regions are building up capabilities; supported by massive government investments and a strategic focus that cover the whole value chain.

Support for domestic clean energy companies in China[72]

Various Chinese regions are emerging as centres of clean energy manufacturing, providing for instance solar panels for the American and European markets as well as developing new equipment to manufacture the panels.

The Chinese government at national and local levels is very active in supporting the domestic clean energy companies, for instance by providing urban land close to downtown at a low price. Furthermore, state banks lend to companies at a low interest rate and the provincial government is reimbursing companies for a high share of the interest payments.

Chinese companies also benefit from the Chinese government's imposed restrictions on the exports of raw materials that are crucial for solar panels and wind turbines.

US Solid State Lightning programme

The US Department of Energy (DOE) has developed a comprehensive national strategy that encompasses Basic Energy Science, Core Technology Research, Product Development, Manufacturing Research and Development (R&D) Initiative, Commercialization Support, SSL Partnerships, and Standards Development:

Basic Energy Sciences Program aims at conducting basic research to advance the fundamental understanding of materials behaviour, with the goal of impacting future directions in applied research and technology development.

Core Technology Research is conducted primarily by academia, national laboratories, and research institutions and involves applied research efforts to seek more comprehensive knowledge about a subject. These projects fill technology gaps, provide enabling knowledge or data, and represent a significant advance in the US knowledge base.

Product Development is conducted primarily by industry and refers to the systematic use of knowledge gained from basic or applied research to develop or improve commercially viable materials, devices, or systems. Specific activities include laboratory testing on prototypes leading to improved prototype design. In addition to technical activities, market and fiscal studies are performed to ensure a successful transition to the marketplace.

Manufacturing R&D Initiative focuses on achieving significant cost reductions through improvements in manufacturing equipment, processes, or monitoring techniques. Projects address the technical challenges to be addressed before prices fall to a level where SSL will become competitive with existing lighting on a first-cost basis.

Commercialization Support. The DOE has developed a national strategy to guide market introduction of SSL for general illumination. This includes testing of commercially available SSL products; demonstrations to provide real-world experience and data on performance and cost effectiveness; design competitions for SSL lighting fixtures and systems; and technical information resources on SSL technology issues, test procedures, and standards.

Source: US Department of Energy, http://www1.eere.energy.gov/buildings/ssl/about.html

The launch of national flagship initiatives, such as creating "the world largest solar farm", also stimulates demand and drive innovation in the industry.[74] These initiatives are an expression of national commitment to the industry, which may help guide global photonic companies in their localisation decisions.

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[74] http://cleantechnica.com/2009/01/02/china-planning-worlds-largest-solar-farm/; http://www.businessgreen.com/bg/news/1869942/brightsource-breaks-ground-worlds-largest-solar-farm

US government strengthening the national photovoltaic value chain

U.S. Department of Energy has announced that the Department will invest more than $200 million over five years to expand and accelerate the development, commercialization, and use of solar and water power technologies throughout the United States. The announcement represents a down payment that will help the solar and water power industries overcome technical barriers, demonstrate new technologies, and provide support for clean energy jobs for years to come. The investments include:

- Photovoltaic Manufacturing Initiative (up to $125 million over five years) to accelerate manufacturing-related technologies and provide maximum leverage to federal funding based on collaborative research models.
- Photovoltaic Supply Chain Development (up to $40 million over three years) focusing on identifying and accelerating unique products or processes for the photovoltaic manufacturing supply chain that will have a major impact on the industry. The projects will help meet the Department's goal of achieving cost-competitive solar PV systems compared with conventional forms of electricity, and accelerating and facilitating the widespread implementation of solar technology.

Also included is funding for a National Administrator of the Solar Instructor Training Network (up to $4.5 million over five years) that will act as a central coordinating body for the Training Network. The Network was created in 2009, by the Department of Energy to establish high-quality, local and accessible training for personnel involved in the sales, design, installation, commissioning and inspection of solar photovoltaic and solar heating and cooling systems.

Source: http://www.energy.gov/news/8874.htm

3.2.5 Advanced materials[75]

Europe has a long history of R&D in material sciences. The current focus areas of the European research ecosystem within materials are reflected in the working group structure of EUMAT – the European Technology Platform on Advanced Engineering Materials:

- Modelling and multiscale. Fraunhofer, CEA, VTT and TNO are key European actors, but the group also includes smaller actors. Arcelor Mittal as an industrial actor is very active in the steel area.
- Nanomaterials and nano-assembled materials
- Functional materials. Many R&D actors are involved in this domain, and especially Poland is very active
- Energy for materials. Cranfield University, UK is leading the WG, and key industry players include Solvay
- Materials for Information and Communication Technologies (ICT). ST Microelectronics is a key actor.
- Biomaterials. The UK is very active and also various industry actors from pharmaceutical industry, e.g. Johnson & Johnson and Bayer.

Europe has strong research capabilities in materials for energy and nanomaterials, while its competitive position in other areas is less pronounced. In the advanced materials

[75] Based on desk research and interview with Dr. Marco Falzetti, International Affairs Deputy Manager, Centro Sviluppo Materiali

domain, Europe also benefits from well-developed industrial systems as an enabler for fast deployment of new inventions.

The US and Japan are currently key competitors in this domain, but the Asia Pacific is also emerging as a strong competitor. For instance, the Korea Advanced Materials Fund – a venture capital fund – was recently established to nurture Korean technology-start-ups with promising technologies in advanced materials.

Korea Advanced Materials Fund

The Korea Advanced Materials Fund is a venture capital fund established by the Belgian chemicals firm Solvay together with two Korean partners, Korea Venture Investment Corp. and AJU IB Investment. Solvay will contribute EUR 13 million and the Korean partners will each contribute EUR 6.5 million. According to Leopold Demiddeleer, senior executive vice president for future businesses at Solvay, Solvay will bring its industrial knowhow and its global business network to the fund, helping to accelerate the expansion of portfolio companies. AJU IB Investment will manage the Korea Advanced Materials Fund, which is expected to have eight year duration. http://www.plasteurope.com/news/SOLVAY_t217582

The cross-cutting nature of advanced materials and KETs in general is very important - advanced materials are an interdisciplinary science. The US has invested heavily in projects that generate a lot of cross-cutting knowledge on materials, while joint technology initiatives in Europe tend to be more focused on sector-specific topics. Europe could learn from the US and develop its knowledge in advanced materials which is relevant across industry sectors, for instance by giving priority to collaborative research in the FPs and at national level. Instead of addressing sector needs, the development and deployment efforts could be focused on the grand societal challenges facing Europe, including energy, sustainability, and health.

There is a range of relevant clusters identified in Europe, but most clusters are sector specific i.e. specialised in plastics and chemicals. Clusters with a more general profile within advanced materials are found in the US and China:

The Northwest North Carolina Advanced Materials Cluster

The Northwest North Carolina Advanced Materials Cluster was established in 2004. The cluster is a public/private partnership for economic development focused on research, education, job growth and infrastructure. The cluster is supported by multiple county governments and includes universities, community colleges and a range of "Champion" industries with national and international industry leaders such as Martin Marietta Composites (transportation, construction and defence), Smiths Aerospace, and Louisiana-Pacific (building materials).

Source: Hauser, John D. (2008): White Paper to provide information in support of a Business/Industry Economic Development Program for the North Carolina Emerging Advanced Materials Industry, http://www.nccommerce.com/NR/rdonlyres/E3C02AB0-547D-430C-9A02-E123EEE41E35/2185/NorthwestNCAdvancedMaterialsClustersSummary3.pdf

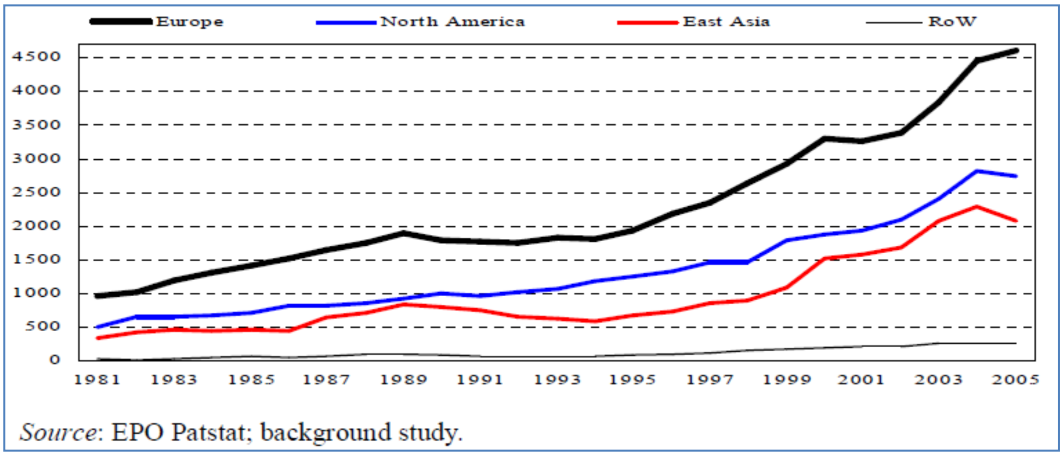
Changsha material cluster
In 2007, the Ministries of Commerce, Industry, and Information Technology and Science jointly announced their ambition to make Changsha the outsourcing services centre of China. In order to encourage the development of the services sector, the Changsha regional government has set up an ad hoc number of outsourcing conglomerations and formulated preferential policies (e.g. financial policies or tax incentives) aiming to promote the development of small and medium-sized high-tech companies in the creative industry and advanced materials. In addition, Changsha also hosts a number of clusters in the areas of industrial engineering and mechanics, automobile industry, household appliances, electronic and optical equipment, and bio-medicine. Changsha has recently seen a speedy increase of the materials industry which now constitutes its most competitive enabling industry.

Source: Competitiveness report (2010)

3.2.6 Advanced manufacturing technologies

Europe is no doubt the leading region within the Advanced Manufacturing Technologies (AMTs) domain. Europe takes more patents than other world regions and the gap increased from 1981 to 2005. Three world regions are the main players, namely Europe, North America and East Asia. The figure below shows Europe's leading position:

Figure 2.3: Number of advanced manufacturing technology patent applications



Source; European Competitiveness Report 2010

However, within some of the main fields of advanced manufacturing such as robots and computer-integrated manufacturing, North America and East Asia are almost performing as well as Europe. In Europe, Germany is the leading player accounting for almost half of the European patent applications. In the same period, France applied for 14% of the patents and UK applied for 10%[76]. Leading European companies include Siemens, Robert Bosch, and Continental.

Although manufacturing in Europe has declined over the past decades, especially due to the off-shoring of manufacturing activities of European industries, advanced manufacturing technologies are still extremely important for the European economy. For instance, the market size for advanced manufacturing technologies is expected to increase

[76] European Competitiveness Report 2010

from $150bn (2008 figure) to $200bn in 2015.[77] Manufacturing is and will continue to be an essential path for attracting investments, spurring innovation, and creating high-value jobs. For instance, the UK has allocated £200 million to establish elite R&D centres. These centres will act not only as research institutions, but also as bridges between universities and businesses to drive growth in the UK's high tech industries.[78] The Advanced Manufacturing Park (AMP) is the UK's premier advanced manufacturing technology park, where research and manufacturing organisations collaborate. These include AMRC (University of Sheffield partnership), Rolls Royce, Castings Technology International (CTI), Dormer Tools, and TWI's Yorkshire Technology Centre.[79]

Leading countries and regions are rethinking their strategies for manufacturing as the global competition become fiercer, exemplified through initiatives and programmes such as Manufacture America.

Manufacture America – Rethink, retool and rebuild

The Manufacture America program is designed to help American manufacturers to rethink, retool and rebuild their operations through exploring new products, markets, processes and sources of finance. As part of this program, a series of regional conferences will convene to allow manufacturers to learn how they can retool and rebuild with focus on:

- Entering new market segments, new industries, or new supply chains
- Modernizing processes to become more sustainable and efficient while lowering operation costs
- Hear success stories from manufacturers who have successfully retooled
- Learn about growing industries, export opportunities as well as how to export
- Learn about resources and funding that are available to help rethink and retool, including technical assistance and financing
- Discuss issues the manufacturers face with federal, state, and local governments
- Network with representatives from other companies.

Source: http://trade.gov/manufactureamerica/index.asp

This is also the case for the Europe, where the economic importance of sustaining a strong manufacturing base is evident as it provides jobs for around 34 million people and produces added value exceeding €1500 billion. In Europe there is also focus on further developing knowledge intensive manufacturing, exemplified through the European Technology Platforms and for manufacturing especially *Manufuture*.[80]

Europe has an advantage through leading in scientific innovation (patents) within advanced manufacturing. However, the number of patents does not show commercial success; only industrial deployment of these patents creates real value for the economy. One major strategic challenge for Europe is to retain manufacturing activities in Europe in order to ensure repetitive value creation. There is a need for advanced manufacturing technologies in order to make manufacturing activities in Europe competitive.[81] One

[77] European Competitiveness Report 2010
[78] "PM takes inspiration from AMRC" (2010): http://www.amrc.co.uk/news/headlines_details.php?pr_id=189
[79] Advanced Manufacturing Park (AMP) (2010): http://www.ampuk.com/the-amp
[80] http://www.manufuture.org/manufacturing/
[81] High Level Expert Group for Advanced Materials.

challenge is to make optimal use of the large manufacturing base located in some of the New Member States such as the Czech Republic, Slovenia, and Hungary. Slovenia is very internationally oriented. Several manufacturing clusters are found in Slovenia with close links to European clusters and Framework Programmes.

The pressures to innovate and sustain competitive advantage in global markets within manufacturing are shifting the innovation structure of advanced manufacturing industries from indigenous company development in large enterprises to external, smaller clusters of companies as well as international consortia and technology licensing. Some of the leading world regions within advanced manufacturing, East Asia and North America, are focusing on the informal transfer of knowledge through industrial cluster policies and initiatives. The example below shows how Japan has focused on establishing industrial clusters.

Industrial clusters focused on manufacturing in Japan

The Industrial Cluster Project started in 2001 with the aim to form industrial clusters to increase innovation and venture companies in Japanese regions. Presently, 18 projects nationwide, with the joint cooperation between public authorities and promotion organizations of the private sector, are building close cooperative relations with no less than 10,000 SMEs and more than 560 universities in total (including industrial colleges). 16.6 billion yen (approximately €150m) has been allocated as the budget related to activities in 2009. The clusters have been divided into four major areas, Bio, IT, Manufacturing, and Environment, based in the different regions of Japan.

One example of a manufacturing industrial cluster is the *Project to Create Manufacturing Industry in Tokai Region*. The strategy for the Tokai region is "sustainable development as a leading global manufacturing centre." One objective is to utilize advanced nanotechnology to improve the quality of materials and manufacturing technologies at the leading core enterprises and SMEs that form the basis of the automobile, machine tool, and aircraft industries in this region. This is achieved through the *Tokai Region Nanotechnology Manufacturing Cluster*. In cooperation with the Tokai Manufacturing Industry Creation Project and other parties, regular updates regarding R&D results are provided to a large number of leading core enterprises and SMEs. Integrated projects are also carried out, with the aim of commercializing the research results and promoting the use of intellectual property.

Source: "From metal bashing to materials science and services: advanced manufacturing and mining clusters in Transition" in European Planning Studies, Vol 17 No 2 2009, pp281-301

There is a need to ensure that European workers have the right skills to operate in European key sectors. One of the recommendations from the paper *The Future of EU Competitiveness: From Economic Recovery to Sustainable growth*[82] for a more strategic approach to EU skills applies particularly to the advanced manufacturing sector. The EU needs specialist skills and the intermediate analytical, IT, and process-management skills that support modern industry. The skills challenges are stated in the *2010 Global Manufacturing Competitiveness Index*[83], where *talent-driven innovation* ranked as the highest driver of global manufacturing competitiveness.

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[82] The Future of EU Competitiveness: From Economic Recovery to Sustainable Growth (Department of Business Innovation and Skills (BIS), June 2009)

[83] http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Manufacturing/DTT_Global_Manufacturing_Competiveness_Index_6_23_2010.pdf

Table 3: Drivers of global manufacturing, 2010

Rank	Drivers	Driver score
1	Talent driven innovation	9.22
2	Cost of labour and materials	7.67
3	Energy costs and policies	7.31
4	Economic, trade, financial and tax systems	7.26
5	Quality of physical infrastructure	7.15
6	Government investments in manufacturing and innovation	6.62
7	Legal and regulatory system	6.48
8	Supplier network	5.91
9	Local business dynamics	4.01
10	Quality and availability of healthcare	1.81

Source:http://www.deloitte.com/assets/DcomGlobal/Local%20Assets/Documents/Manufacturing/DTT_Global_Manufacturing_Competiveness_Index_6_23_2010.pdf

Development of new advanced manufacturing technologies also face the challenge of high investment costs and a long wait for return of investment due to a long R&D process. This requires an extensive knowledge about the particular industry for which the technology is developed. Furthermore, Market-driven innovation therefore is central as it offers producers opportunities to get the feedback from the market about new technological opportunities as part of the innovation process[84].

Policies that offer access to funding for both technological development and market research are therefore critical for the development of advanced manufacturing technologies. Demonstration projects can likewise offer a framework for market driven innovation, thereby reducing both risks and at the same time stimulating market up-take.

Below is an example from Ontario in Canada, where there is an investment strategy for advanced manufacturing.

Ontario - Advanced Manufacturing Investment Strategy (AMIS)

To help manufacturers become more innovative and competitive, the Ontario government created the Advanced Manufacturing Investment Strategy (AMIS). It is a $500 million program to encourage companies to invest in leading-edge technologies and processes. AMIS is open to all manufacturing sectors. Companies that are planning to invest in advanced manufacturing projects in Ontario are eligible to apply. Companies can get interest-free loans to invest in leading-edge technologies and processes. $500 million over six years is earmarked for the AMIS incentive loan program, which is meant to encourage innovative activities in advanced manufacturing and the development of highly skilled and value-added jobs. Projects should fall under the category of "advanced manufacturing", including industrial R&D, design, prototyping and engineering, advanced materials, robotics/software development, waste reduction or energy conservation, and centres of excellence.

Source: http://www.ontariocanada.com/ontcan/1medt/downloads/AMIS2pager.pdf

[84] European Commission (2010): European Competitiveness in key enabling technologies

4 Industry and innovation policies - Challenges

4.1 Introduction

The previous sections discussed the competitive situation in the individual KETs and highlighted some of their challenges. This section discusses key policy challenges that Europe faces to deploy KETs successfully for innovation purposes. Examples are provided based on the literature review, case studies, innovation profiles, and interviews.

For each policy challenge illuminative examples are provided of how these challenges have been addressed through initiatives either within Europe or in leading and emerging regions outside Europe. The evidence is based on more than 70 interviews carried out with industry, cluster organisations, universities/research organisations, and policy makers from Europe and leading/emerging regions.

Five major challenges for industrial deployment of KETs in Europe have been identified through the data sources:

- Alignment and prioritisation to achieve sufficient scale
- Transfer and uptake of research in industry
- Lack of support for demonstration and commercialisation activities
- Access to risk capital
- Value chain issues.

4.2 Challenge 1: Alignment and prioritisation to achieve sufficient scale

Critical mass is vital to staying globally competitive, as technological R&D is generally costly to bring to the global commercial market. A clear vision and strategy to obtain and sustain this critical mass is essential to success. Several leading and emerging countries such as China, Korea, Japan, Russia, and the US, are currently investing heavily to create a critical mass in KETs. Examples of such investments are:

- the US National Nanotechnology Initiative with a budget of €1 billion a year (matched by industry);
- the annual funding for SMEs in the SBIR programme in the US is $2.6 billion;
- RusNano with approximately $5 billion, which is 50% of the Russian budget for nanotechnology;

- 16 mega-projects in China with an investment of up to €10 billion per project,
- Japan's Industrial Cluster Project with €150 million of public funding in 2009.

Another example of the level of investments by competing countries is the fact that R&D spending in China increased from €9 billion in 2000 to €46 billion in 2008.[85] In Europe, France has recently announced that it will raise €35 billion to fund strategic investments. Special attention will be devoted to developing research teams to boost competitiveness and increase efforts in biotechnology and nanotechnology.

Substantial investments are made Europe in the individual Member States and through the Framework Programmes (approximately € 1 billion per annum).

The scale of overall investments in the KET areas is significant, but the investments made by the Member States are not explicitly aligned to the EU level investments and are not always prioritised in areas where investments would likely lead to the creation of new markets also on a global scale, as indicated in several interviews across Europe. The risk is that no substantial critical mass in knowledge, funding, and facilities can be built in Europe in due time. As pointed out by multiple stakeholders, there is very broad focus in the different programmes at European level and the structure is extremely complex. This makes the prioritisation of research, investments, and identification of market potentials unclear for companies, research organisations, and policy makers in the individual Member States.

Need for a clear and focused strategy through alignment of national strategies

On the one hand, the 2020 strategy formulates a long-term broad vision for Europe 2020. On the other hand, the direction of the programmes and initiatives at EU level needs to be sufficiently clear and tangible in terms of providing a guiding framework also in the short and medium term, not least in the wake of the crisis. Moreover, it also needs to provide Member States, regions, and sectors of economic activity with a clear long-term focus in order to prioritise, direct, and redirect resources as needed. Without a *long-term* focus, actions and investments may become ad-hoc and investments will not create sufficient critical mass to compete with leading regions outside the EU. Alignment of the EU programmes and clearer focus could help Member States and companies to align their activities.

The message from all interviewed companies is that the funding structure is extremely complex in the EU funded programmes, and that EU-funded programmes do not have sufficient strategic commercial focus and scope. R&D projects in other regions, such as the US and China, have a clearer focus according to the interviewees, and they are often aimed at addressing grand challenges and are therefore also a gateway to potential growth markets.

[85] James McGregor (2010) China's Drive for 'Indigenous Innovation': A Web of Industrial Policies (http://www.uschamber.com/sites/default/files/reports/100728chinareport_0.pdf)

Several Member States, such as the Netherlands, Ireland, and Denmark, have engaged in prioritisation processes on applied research funds and further alignment of national strategies and research prioritises to the 2020 Agenda taking into account national positions of strengths in the industry base and in the research environment. This focus could be in key technology areas through focus on the technologies themselves or through focus on grand global challenges such as energy, access to raw materials, and health, where KETs play a vital role in ensuring better access to new and emerging markets, and where innovations could be achieved through multidisciplinary approaches as well.

Currently, there are multiple initiatives building on KETs that are set up in a European, cross-national, and national scales. A good EU policy example is the Joint Technology Initiative[86] (JTI) under FP7.

The JTI is an example of how critical mass of funding and knowledge is coordinated across different Member States in large-scale projects. JTI is a new strategy of implementing FP7 to support large-scale initiatives that could not be implemented efficiently, using the other R&D funding mechanisms. JTIs focus on one specific industrial area and address a market failure, funded by a combination of mainly private and different public investments (such as national R&D programmes, EUREKA, and the FPs). One example is the nanoelectronics JTI (ENIAC) with focus on pre-competitive collaborative R&D through large-scale strategic partnerships between industry and research institutes.
http://www.kowi.de/Portaldata/2/Resources/fp7/fp7-factsheet_eniac_en.pdf
http://cordis.europa.eu/fp7/jtis/about-jti_en.html#concept

The JTI is a good example of what could be a model on a greater scale in Europe. Another example is the Heterogeneous Technology Alliance (HTA)[87], where four of the leading European research organisations have joined forces to pool resources together.

The main goal of the HTA is to develop partnerships with the European and global industry using working tools such as technological platforms intended to facilitate the transfer of technologies towards the industry. The format of cooperation ranges from feasibility studies or training courses to technology and process development, the solution to questions related to environment and reliability.\, or the special manufacturing of demonstrators and prototypes. The HTA platform aims to fulfil pre-industrial research requirements, but it will also be able to produce prototypes and small series and optimise designs and processes in an iterative way by technology mixing.

These are interesting examples of opportunities of addressing some of the “Valley of Death” issues in Europe. However, as pointed out by companies, RTOs, and policy makers in the interviews, the lack of a clear conceptual understanding of vision and focus is bound to lead to a duplication of efforts and initiatives with the imminent risk of not achieving the same critical mass in facilities, knowledge, and funding as that of the competitors outside Europe. As mentioned earlier, this is especially an issue for smaller and new Member States and to lesser extent for Member States such as Germany, France and the UK. However, more synergy can lead to the creation of more volume in terms of especially knowledge, demand, and funding.

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[86] ftp://ftp.cordis.europa.eu/pub/fp7/docs/report_jtis_en.pdf
[87] http://www.hta-online.eu/uploads/media/HTA-2010_web.pdf

Creation of market opportunities

The Swedish national FP8 consultation has voiced such requests for better synergy for FP8- also to ensure coherence between research, innovation instruments, and exploitation.[88] Similar concerns have been raised in the UK the Royal Society of Chemistry.[89]

> The "Contribution from the Swedish Government to the discussion on the next Framework Programme (FP8)"[90] derived from a process with more than 80 stakeholders, including governmental funding agencies and research councils, universities, research institutes, businesses, and regional authorities. The contribution suggests that the FP 8 is significantly different from its predecessors.
>
> Suggestions included the increasing importance of exploring and developing synergies with other instruments, programmes, and policy areas at the regional, Member State, and European levels, as well as integrating the global dimension. The FP8 should be adapted to support this need, together with the Structural Funds and the Union programmes for education resources at national/regional level. It is also suggested that processes are needed to identify the challenges where Europe should join forces. This should occur in areas where European research and innovation can make a difference and create new markets, being a player in a global context.
>
> The structure could be a combination of a Grand Challenge module complemented with specific themes and "*Key Enabling Technologies" (KETs)*. The approach could be challenge-driven joint calls involving different thematic areas, complemented by the introduction of an additional Grand Challenge module. This Grand Challenge module should provide additional funding to joint calls (to stimulate joint actions), offer additional flexibility, and help to further stimulate interdisciplinary research and cross-sector collaboration involving areas that may be outside the thematic structure or unforeseen (page 4).

KETs activities in Europe tend to be scattered and they do therefore not reach a critical mass. Creation of critical mass is especially important for the small European Member States, as these lack research facilities and access to skilled labour, and has a limited number of national large industrial partners and often limited funding, especially compared to the larger Member States and leading and emerging regions outside the EU. A coordination of efforts may avoid duplication of efforts in different Member States. For example, all 27 Member States have their specific sectoral strengths, so picking a sector specific focus could prove to be too complex. However, a European KET strategy could be based on specific global grand challenges, which could create a common focus relevant to all KETs and several sectors, and which furthermore could position European firms in emerging new growth regions, where these challenges have to be overcome to achieve sustainable innovation.

Increased cross-border collaboration

Several national programmes/projects do not allow foreign companies to participate. Nevertheless, in recent years, there been increased focus by the European Commission on

[88] Ref. Ares (2010)941644 - 13/12/2010- Swedish Government. www.era.gv.at/space/11442/directory/21784/doc/21951.html
[89] www.rsc.org/.../RSC_Response_to_BIS_Consultation_on_the_EU_Framework_Programme_tcm18
[90] http://ec.europa.eu/research/csfri/pdf/contributions/prior/sweden_ministry_of_education_and_research.pdf

funding for coordination of existing national/regional research programmes, besides the more "classical" grants given centrally at project level. Good examples of these new instruments are the ERA Net Scheme and the Art 185.

Art 185 enables the Community to participate in research programmes jointly undertaken by several Member States and can therefore contribute to integrating national programmes at European level. The ERANet scheme was launched in 2002 as part of FP6. It aims at stimulating the cooperation and coordination between national (regional) research programmes, including their mutual opening and the development of joint calls. It typically targets research programmes' owners or managers (ministries, government agencies, or research councils) and invites them to submit proposals in self-nominated topic areas (bottom-up principle). The ERA Net scheme is one of the flagship instruments of the European Commission for the further development of an integrated 'European Research Area' (ERA)[91].

The Slovenian case study (Annex 2) also provides an example of an initiative (Centres of Excellence) in which participation and funding is available to both Slovenian and foreign companies. However, in many other Member States participation is restricted and this is a barrier for especially smaller Member States as highlighted above and in the Slovenian case.

To recap, it is critical to create synergy and coherence between the regional, national, and European Strategy for Smart Growth. The interviews conducted show that synergy and horizontal policy coordination are critical to ensure coherence between different funding instruments to achieve value added in areas where Europe can really become a global player – and in the short to medium term also to achieve socio-economic objectives, not least relating to job creation. Given the enterprise structure in Europe with many SMEs, cross-border collaboration can be a means to enable more SMEs to position themselves as advanced sub-suppliers in global markets. Steps taken now will be critical to sustainable competitiveness in the medium to long term.

4.3 Challenge 2: Transfer and uptake of research in industry

The research carried out at European universities is often state-of-the-art, and Europe leads the publication/article rankings in most KETs. However, according to interviews with companies, TTOs, and policymakers, the knowledge is not sufficient either codified in the form of patents, or commercialised through spin-off companies or taken up by leading industrial companies. The transfer of knowledge from RTOs is according to interviewees better organised than for the universities, as highlighted in for example the Jena and Grenoble case studies (see Annex 2). The RTOs also play a vital role in the strong clusters in Europe.

In terms of knowledge creation, European universities carry out the majority of basic research, while the research institutes (RTO's) are the main providers of applied research with closer connection to the industry.[92] Universities are very active in taking out patents

[91] final report of SME specific measures (jan 2010) by IDEA Consult
[92] http://www.earto.eu/fileadmin/content/03_Publications/corr-Technopolis_report.pdf

to protect their research, and basic research is critical to technological advance. However, promising discoveries need to be absorbed into applied research and collaborative partnerships to turn a codified body of knowledge into innovations in the market, which can be further developed, customised, and scaled. Collaboration between European universities and research organisations with involvement of industry is therefore vital to Europe's overall innovation capacity.

The majority of interviews with European stakeholders reveal that much of the Intellectual Property (IP) developed in European research programmes is anchored in universities with limited incentives to use the results. In recognition of this, the University of Glasgow, where 90% of the IP is unused, has adopted a model whereby which they give away the IP.

The University of Glasgow is giving away its intellectual property (IP) in a move designed to maximise dissemination of knowledge and increase commercial collaboration. Businesses and individuals can browse a list of IP deals and apply for license agreements using a dedicated website called Easy Access IP. *"We reckon that a small percentage - under 10 per cent - of IP generated here has significant potential such that an external partner will work with us to commercialise it, either through spinout or licensing*," says Kevin Cullen, director of research and enterprise at Glasgow University. That leaves 90 per cent of IP unused. *'That doesn't mean it isn't useful to someone. If the university isn't in a position to develop, promote or commercialise IP, we have taken the decision to put it into the hands of people that can'.*

Source: http://www.rsc.org/chemistryworld/News/2010/December/01121001.asp

Limited incentives for universities or research institutes to commercialise
However, there are limited incentives for universities to commercialise the results of research, patents, or technologies, and this is a major concern expressed by many research organisations, TTOs, companies, and policy makers.

The metrics for measuring the commercialisation performance at universities has its limitations, as demonstrated in several studies. A study from New Zealand illustrates this through an example derived from Massachusetts Institute of Technology (MIT) in the US. MIT is a globally recognised leading edge university when it comes to research commercialisation and is the top choice of venture capitalists looking for investment opportunities. An analysis of technology transfer from MIT shows that only 7% of the knowledge transferred from the highly-regarded Mechanical and Electrical Engineering Departments takes the form of patented inventions (Collier A, Gray B 2010).[93] According to Mr. Nair from the US National Science Foundation, the most successful TTOs in the US are run by individuals with backgrounds in industry and venture capital funds/business angels.

Moreover, there is evidence of a cultural divide between researchers and industry. The environment and culture of universities have significant influence on the likelihood that

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[93] Collier Alan, Gray Brendan (2010 The commercialisation of university innovations A qualitative analysis of the New Zealand A qualitative analysis of the New Zealand situation.
http://www.otago.ac.nz/entrepreneurship/docs/Qual%20report_31%20August%202010.pdf

research will be commercialised. Enabling factors which universities could introduce include intellectual property policies, procedures, and practices; career trajectories that reward involvement in commercialisation. The way in which issues of risk and conflicts of interest are handled by the university in the context of commercialisation also plays a role. In Australia there are examples that an entrepreneurial climate in a University Department is stimulated by having "tech scouts" working with and for a University Department rather than being part of a centralised tech-trans office. There are also several examples from the USA Universities that limited seed money actually function as an incentive for university staff to exploit commercialisation opportunities. Several informants also mention the importance of the value set communicated by the university chancellor.

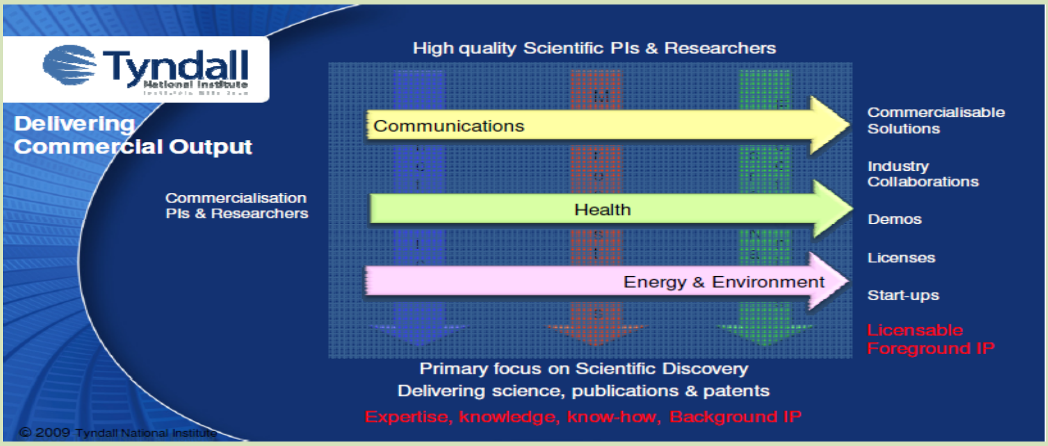
New models of open innovation are one way to speed up the process from knowledge creation to commercialisation. These can transform classical linear tech-trans models and ensure that applied research is closer to potential market demands - and thus commercialisation. However, this also raises new challenges concerning IPR and business models.

Communication

Interviews with both industry and universities showed that many researchers are more focused on the scientific novelty of research rather than on commercial aspects. In most countries, and particularly in the New Member States, Poland, and Slovenia, interview dialogues with industry showed that engaging with industry is not necessarily a priority. Newer research that looks at knowledge creation and diffusion as a matter of an inter-dependent knowledge-value chain, as discussed previously in this report, can prove to be a way forward when it comes to the design of demonstration programs..

When demonstrating promising commercial opportunities, basic research results could ideally be fused into applied research through increased collaboration with research organisations or through large-scale demonstrators in partnership with industry with a view to bringing technological advance to the market place (see Challenge 3). A successful example is Tyndall National Institute in Ireland. They have employed a communication employee experienced in both industry and technology, whose job it is to liaise with industry – not only regarding technology but also about using technology in a market context.

Tyndall National Institute is addressing the *communication gap* within three main themes aligned with the national priority areas. Distinguishing between scientific researchers and Principal Investigators/researchers has closed the communication gap between basic research and the companies and improved collaboration with companies, both in terms of volume, but also quality.



One important change in strategy for Tyndall is quite simple, but rather effective. It was decided to hire a communication employee at Tyndall, with focus on talking to industry about *usage of technology* – not technology on its own. This activity along with a strong factual basis has led to increased company interaction and closer to market research.
For more information see Irish case study in Annex 2.

The principal investigators in the Ireland example come from industry, RTO's, and universities, but common for all is that need to have an understanding of both the technologies and their application. The principal investigators are therefore often engineers, and not scientists.

Commercial orientation depends on values and mind-sets. The three New Zealand South Island universities have operated an entrepreneur-in-residence programme since 2006. Starting in biotechnology, the programme expanded to embrace all areas of science and technology. Currently, the financial support provided is up to around $80,000 to each university over a two year period to pay for the entrepreneurs-in-residence and to encourage the transformation of inventions into innovations (i.e. commercial ideas) including staff time buy-out. Pre- and post-involvement surveys show there has been some success at improving the science faculty's and graduate students' interest in commercialisation. Evidence suggests that an ideal entrepreneur-in-residence is not from a university or big business, but is a serial entrepreneur. A serial entrepreneur is accustomed to working with limited resources, being self-reliant and identifying ideas that have market potential. (Collier and Gray 2010 p. 58)

Technology transfer offices

Traditionally, US universities have been the most successful in tech-trans. There are several explanations for this. One is the ability of US universities, especially the private universities, to fund the infrastructure for tech-trans because of their substantial financial strength arising from private donations, a factor that continues to the present day. The second reason is the consistency of national public policy regarding university tech-trans enabled in particular by the Bayh-Dole Act – the *University and Small Business Patent Procedures Act*,**[94]** which has been consistent American policy since 1980. A third reason is the culture of entrepreneurialism that permeates many leading edge universities in the US, and which is also mirrored in contractual arrangements for research staff. In the US, there is clear correlation between the length of time that a university has operated a tech-trans office and its success. The older the unit, the greater the results achieved. At the same time, many of the older Technology Transfer Offices TTOs were established before the Bayh- Dole Act and include universities such as Stanford and MIT that have had a long history of success in commercialisation. As discussed earlier in the report and based on data from MIT, the metrics for measuring commercialisation performance do still not have sufficient granularity in particular to capture new models of innovation. According to a study from New Zeland from 2010 (Collier& Gray), similar data do not exist in Europe.

In order to transfer knowledge from universities to industry, technology transfer offices traditionally play a key role. They identify promising research in the different research groups of the university and support researchers to transfer this research to industry. Technology transfer officers therefore traditionally have had an important gatekeeper role. With the uptake of ICT, the creation and dissemination of knowledge has become a commodity. Existing models of tech-trans are being revisited to better understand efficient commercialisation of research.[95] An analysis from Australia from the national Innovation Centre points for example to that existing models regarding rights do not sufficiently take into account that discoveries with a large commercial potential increasingly occur in multi-disciplinary teams (Australian innovation Centre 2002).

Where tech-trans environments function well they not only have an overview of promising research results, but also have deep insight in industry needs so they can link research to these industry needs. From Australia there are examples of universities forming partnerships in order to specialise in different technological areas and build strong industrial contacts to identify commercial opportunities linked to the innovative deployment of increasing complex technologies such as KET's. Particularly for small Member States, such models could be a way to increase capacity.

The BEP Challenge in the UK has been set up to improve the management of publicly funded bioscience intellectual property through the formation of academic consortia and by part funding the employment of bioscience specialists in university technology transfer units.[96] In the evaluation of the programme, they found that the size of the TTO is crucial.
See UK case study in Annex 2 for further details.

The skills and the industry relation embedded in the technology transfer office require highly motivated senior employees with industrial experience. However, most TTO staff have an academic background and have made a career change towards technology transfer. This can be a critical barrier to obtaining sufficient scale in commercialisation

[94] http://en.wikipedia.org/wiki/Bayh%E2%80%93Dole_Act
[95] http://www.sciencestudies.fi/system/files/Tupasela.pdf *Intellectual Property Rights and Licensing:* Can Centralised Technology Transfer Save Public Research? Aaro Tupasela- Sciences Study 2000
[96] Interview Gordon Malan

activities. As mentioned above, the most successful TTOs in the US are run by business people and/or venture capitalists who often combine both university and industry experience.

However, there are also examples where scientists at universities see opportunities in the markets and at the same time remain active at the university, a model often seen in the US. The example below shows the importance of boosting entrepreneurial activities.

ME Group – a service spinoff company
In 2003, four colleagues from the Material Science Department at the Technical University of Warsaw decided to start a service company implementing knowledge of material research into industrial practice. The people behind the company saw an opportunity in smaller contracts, which were often turned down by the university because of the heavy bureaucracy. The four founders made a bilateral agreement with the university to use the specialized equipment at the university, which meant they could offer state of the art services without heavy investments. Since then they have opened their own laboratory and today employ 22 people. The founders are still working at the university as scientists and in ME Group where they have managerial roles. The rest are employed directly by the company. http://www.megroup.pl/en/home.html

The business model used by ME Group provides mutual benefits for the university, company, and industry.

- *University:* increased income from the fees paid by the spin-off company for the use of their equipment to help the companies that the university has previously turned away because of bureaucracy (small contracts)
- *Spin-off company:* can offer state-of-the-art equipment through the university, and because they are still working for the university, they have access to the latest knowledge and developments in material science. The spin-off company can offer cheaper rates for small projects because of lower overhead costs
- *Industry:* the industry gains quick access to service and avoids bureaucracy for small projects; it also saves costs because it does not have to pay large amounts of money for overhead.

Whereas TTOs in Europe seems less effective, the interviews showed that RTOs play a key role in transferring knowledge in for example FP7, but also in direct collaboration, especially in established clusters (see case studies and Innovation policy profiles in Annex 2 and 3).

Buy-up of patents from leading and emerging regions outside the EU-27
A major issue in Europe is the recent trend that some of the best results from patents leave Europe because of buy-ups from emerging and leading countries outside the EU-27. Initiatives such as the Russian initiative RusNano are offering a vast amount of funding for innovative companies to exploit knowledge embedded in patents into market-ready products. However, the condition is often that these companies have to move or start production in the countries offering the funding, e.g. Russia.

Mr. Alec Reader, Director of the Nanotechnology Knowledge Transfer Network in the UK, confirmed that at least one company in the KTN network has left the UK after receiving investments from RusNano, but also that several others are in talks with RusNano to follow suit. These companies are all high-tech companies that had received national and European funding to develop their research. Now, that research is being valorised in Russia.
Based on telephone interview with Mr. Reader in October 2010.

Two laser manufacturers from Poland, i.e. Ammono and TopGan, mentioned that it is almost a weekly occurrence that visitors from companies and different organisations from especially Japan, China and Korea come to see what they do. Ammono was unable to find funding to grow crystals for lasers in Europe. It found a Japanese company that wanted to invest, but one condition was that the patents be transferred to the Japanese company. Unfortunately, not all organisations visit these companies with the intention to invest; several just want to gather information and take it back to their own countries. This leads to a further leakage of knowledge. However, as long as there are funding issues, these companies will invite potential investors from outside Europe.

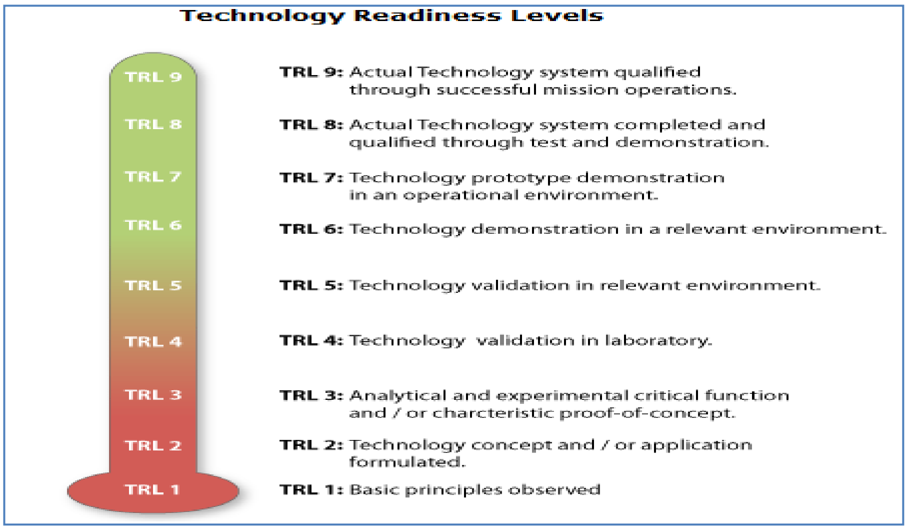
Asian countries are not only copying European technologies, but increasingly developing their own IP and patents. They focus their research on specific areas, making it interesting for large companies to transfer certain activities to Asia and the US. According to some of the interviewed industrial biotech companies, a lot of funding is available in the US and China, and an increasing number of sub-contractors and IP-licenses are found in China, Japan, and Korea. If this trend continues, it may certainly be an option for European companies to consider relocation to these regions with regard to certain activities.[97] This poses a major challenge for Europe, and it is a difficult challenge to tackle. Other countries such as the US have taken action through legislation requiring that patents filed in the US have to stay in the US. The question remains if this is the right approach for Europe.

4.4 Challenge 3: Lack of support for demonstration and commercialisation activities

When the majority of European research projects come to an end, the technology or result achieved is a patent or in some case a prototype, which is also what the FP7 is aimed to achieve. In the US, the concept of Technological Readiness Level (TRL) is used by several government agencies and major companies to monitor and assess the technological development from research to technology .The figure below shows the TRL scale, which runs from 1 to 9, where level 0 describes a level where the technology is ready to enter production.

[97] Interview with Marcel Wubbolts from DSM Netherlands.

Figure 4: Example of Technological readiness level chart, US



Source: http://www.aof.mod.uk/aofcontent/tactical/techman/content/trl_applying.htm

If a company has a patent or a basic prototype, this would translate into a TRL of 2 to 4 on the TRL scale. Progress has been achieved, but that there is still work to be done to get the new technology or innovation to a technological readiness level of market maturity. The higher the TRL, the more interested are companies and investors and the more commercially attractive is the product.

As the TRL is low when European research projects are completed, there are two major barriers towards industrial deployment of KETs:

- large-scale demonstrators and pilot test facilities,
- lack of support to commercialise results of research.

Lack of support for large scale demonstrators and pilot test facilities
Funding and facilities are needed to advance to the next stage where the results of the research can be tested in an operational environment. Some of the largest companies have such facilities and the funding for this stage. The interview with Intel Ireland showed that all activities after technological research (prototype, testing etc.) take place internally at their R&D premises in Portland in the US, no matter where the basic research is undertaken.

In order to climb up the TRL ladder, other companies need funding either through new R&D projects with a large industrial partner or public or private funds (for example venture capital funds). According to the interviewees, at European level and in most cases at the national level there is insufficient support for large-scale demonstrators and pilot test facilities. The Irish CCAN and CRANN initiatives are interesting examples of how industry-led initiatives use state-of-the-art facilities in nanotechnology at premises shared by universities and research institutes (see Irish case study in Annex 2). However, those running these successful initiatives argue that European state-of-the-art facilities are needed to be on a level playing field with the facilities available in other regions outside Europe and to meet industry demand.

Another good European example is Minatec in France where programmes are set up to develop pilots and prototypes driven by industry demand.[98] They offer lab infrastructure and state-of-the-art equipment to universities, research institutes, and companies to facilitate and stimulate the development of pilots and prototypes.

Organisations like Minatec in France are creating critical mass by involving several industrial and academic partners in their activities. This in turn allows them to offer state-of-the-art equipment, which is often too expensive for an individual company or university to buy. Moreover, through their offering they are an important attraction factor to industry as companies gain access to the best lab facilities, knowledge, and skills on pilots and prototypes. This allows them to compete against major companies in Japan, the US, and China.

According to the industrial biotech companies DSM and Novozymes, test and demonstrator facilities are publicly funded and available in some countries outside Europe. However, in Europe these facilities are only present in companies and not available for the public. According to the interviewees, competition law prevents funding for these activities in Europe. This is a barrier to European development in industrial biotechnology and other KETs.

One example of such a pilot test facility in industrial biotechnology is the investment in Lawrence Berkeley National Laboratory test facilities for advanced biofuels funded through the Department of Energy.

The US Department of Energy's Biomass Program has been awarded nearly $718 million in Recovery Act funds to accelerate the commercialization of advanced biofuels and foster the growth of a sustainable US bioindustry. €18 million of these funds has been used to build an advanced biofuels process development facility aimed at speeding the commercialization of advanced biofuels by allowing researchers and the private sector to test and integrate innovative technologies. http://newscenter.lbl.gov/news-releases/2010/03/31/advanced-biofuels-user-facility/

Large scale demonstrators and pilot test facilities also create opportunities to enhance the economies of scale for a specific product. This stimulates the manufacturing of products by creating intensive knowledge on prototypes and the scaling process. Knowledge on manufacturing is often necessary to exert control over the entire value chain needed to commercialise a technology. In the last decade, commodity production has been increasingly off-shored to Asia, leading to a lack of mass volume production in Europe. However, to influence value creation within the value chain, it is important to exercise control over the value chain, and this requires extensive manufacturing capability. Therefore, pilot plants and test facilities offer the potential to ensure that high value manufacturing remains in Europe, or even is sourced back to Europe as suggested by one informant[99].

A recent initiative can be found in the UK as the Technology Strategy Board will establish a network of elite *Technology and Innovation Centres.*[100]

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[98] Interview Jean-Charles Guibert, Minatec
[99] Interview Martin Spät, ESIA
[100] BIS Annual Innovation Report 2010

The Technology Strategy Board will establish a network of elite *Technology and Innovation Centres*, the first of which will be in the area of High Value Manufacturing. These centres of excellence will allow businesses to access equipment and expertise that would otherwise be out of reach, as well as to conduct their own in-house R&D. They will also help businesses access new funding streams and point them towards the potential of emerging technologies[101]. The aim is to support the commercialisation of research results by focusing on a specific technology where there is a potentially large global market and a significant UK capability. £200m is reserved to invest in these Technology and Innovation Centres.

Large scale demonstrators and test facilities are major issues for both large and small companies, but general support initiatives to climb the technological readiness ladder is especially a problem for SMEs and medium-sized companies with more than 250 employees but few R&D facilities. Especially companies with more than 250 employees could benefit from boosting their production. The Structural Funds could potentially provide a funding framework for such an innovation infrastructure.

Support for commercialising research results

There are few support measures in Europe to help to commercialise research results, whereas in competing countries there are more opportunities to move towards commercialisation.

An interesting example is the US Innovation Accelerator Initiative where companies not able to find an investor themselves get assistance from the Program Directors in the SBIR/STTR Program (see US Innovation policy profile in Annex 3) to join the initiative.

The Innovation Accelerator Initiative is sponsored by the National Science Foundation (NSF) with a budget of $6.5 million over a five-year period. NSF has used the budget to contract a private company, which role basically is to commercialise the technologies developed in SBIR/STTR by helping the companies find potential investors and customers, evaluating the potential of the technology, creating an IP strategy, and finally helping the companies negotiate with potential customers or investors. Each company gets a mentor with many years of business experience and a large network.

The initiative is addressing a major challenge for small companies, which is that many small companies have limited management skills/resources to commercialise their technology. The key, according to Mr. Nair, who is Director for the Innovation Accelerator Initiative, is the extensive network and personal relations of the people working in the private company who won the contract.

The initiative has been a huge success and brought in more than $80 million in the two years it has existed for the 40-50 companies selected.

Other examples of this type of activity are found in the innovation policy profiles (Annex 3). Support for this stage is a key to addressing the ‘Valley of Death’.

Korea has also placed emphasis on the commercialisation of the value of patents and technologies developed in their research programmes.

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[101] http://www.innovateuk.org/deliveringinnovation/technology-and-innovation-centres.ashx

In 2000, the Korean government introduced the Technology Transfer Promotion Act. The idea behind the act was to change focus from quantity to quality of patents and technology, the advantage being that high-quality patents and technology will increase market interest. The Korean Invention Patent Association (KIPA) reviews the technology to be sold, assesses the commercial viability of the market and industry trends, and identifies potential licensees or partners. Furthermore, the KIPA offers support for legal issues and deal closing.
See Korean Innovation profile in Annex 3.

In the six case studies, some European programmes were highlighted as positive in terms of commercialisation opportunities. Examples include Eurostars and Factories of the Future. However, according to the interviews with companies and examples found in the literature, the European programmes, which also include the CIP, do not have the same volume of funding available as some initiatives outside Europe.

4.5 Challenge 4: Access to risk capital

As previously highlighted, the funding available in Europe is considerable, but the structure is complex and the administrative process is slow. Whereas in many competing regions, especially Asia (China, Japan and Korea) and the US, the process from idea to market is an integrated process where funding is obtained from a limited number of sources, the funding structure in Europe is extremely complex and public support does not cover the whole R&D-to-commercialisation chain in a continuous way. Gaps appear between the end of the R&D phase and the deployment as such, because the conditions are inadequate for KETs:

- The *R&D phase* can be accommodated both at EU level and at national level through the different sources mentioned throughout the study.
- The *demonstration phase* can be funded at national level under certain conditions. The R&D&I State aid framework 2006 provides a definition of research (experimental development) that usually includes prototypes, experimental production, and testing of products, processes, and services, provided they are not used in industrial applications or commercially. If used for commercial demonstration or pilot projects, any revenue generated from such use must be deducted from the eligible costs.
- The *post demonstration phase, pilot, and market replication projects* can be funded at EU level through the CIP, but the budget is very limited especially compared to competitor regions and countries.
- The *deployment / investment* phase can be funded at national level under specific circumstances.[102]

Further to the above, literature review and company interviews showed two major issues:

- Funding for basic research is focused on technology and not on market potential.
- Banks, venture capital funds, and business angels are reluctant to invest in high-risk projects.

[102] Internal document from European Commission ENTR-B2 "Industrial Policy" (State Aid)

Funding for basic research prioritises scientific technological advance and not market potential

According to the interviewed companies, funding for basic research is relatively easy to obtain. The Framework Programmes are the most important R&D funds available in Europe, and are oriented towards basic/technological research. The projects are mostly based on developing technologies, and societal challenges or general market needs are under prioritised.

Furthermore, according to the companies interviewed, the results of the FP projects are not sufficiently close to the market, and the technology readiness level is often quite low as highlighted above.

Therefore, further investments are required for the pilot/testing phase and the commercialisation stage, but here access to funding is scarce and complex, and this is a major contributor to the "Valley of Death" in Europe. The majority of the interviewed companies mentioned a lack of market focus in European research projects as a major barrier. Funds that target projects aimed at further developing the knowledge to raise the European technological readiness level could be helpful in this regard.

> INEOS Bio, for example, has so far found it easier and faster to get financing in the US than in the EU for its first industrial scale plant. This is because the US department of energy (DoE) and the US department of Agriculture (USDA) have quickly established respectively grant programmes and loan guarantee programmes with streamlined selection processes. INEOS Bio has received a $50 million grant from the DoE and a conditional commitment for a $75 million loan guarantee from the USDA for its plant in Florida. In the UK and in the EU, there are so many opportunities to get funding that it is very difficult to identify the most appropriate funds. The amount of funding however is often limited, while the process of obtaining funding is time consuming and the administrative burden is quite heavy. As a result, Ineos Bio has been able to secure financing in the US and not in the UK or the EU, although it is fully aligned with the Europe 2020 Strategy and in particular the objectives of the flagship initiative "Resource Efficient Europe" through its process technology to convert waste into bioethanol and renewable power.

The lack of market potential in for example the FPs is a major issue. The previous sections have mentioned the option to focus on grand challenges and thereby create a large European market, but the evaluation and selection criteria as well as the appointment of evaluators will need to include state of the art expertise regarding emergent market opportunities. Several of the examples highlighted in previous sections have a much stronger market focus.

In the US, several programmes support R&D projects while having a valorisation aspect at the same time. One example is the SBIR/STTR programs (see next page).

SBIR/STTR Program (US)
The programme focuses considerably on market opportunities when selecting proposals for funding. The NSF webpage states that '*all proposals submitted must describe a compelling business opportunity to be enabled by the proposed innovation. The proposal must show scope and nature of the business opportunity. All proposals shall provide evidence of a market opportunity*'[103]. According to interviews with James Rudd and Murali Nair from NSF, approximately 25% Phase 1 and 50% of Phase 2 the selection criteria are related to market potential. *For more info, see US Innovation profile in Annex 3.*

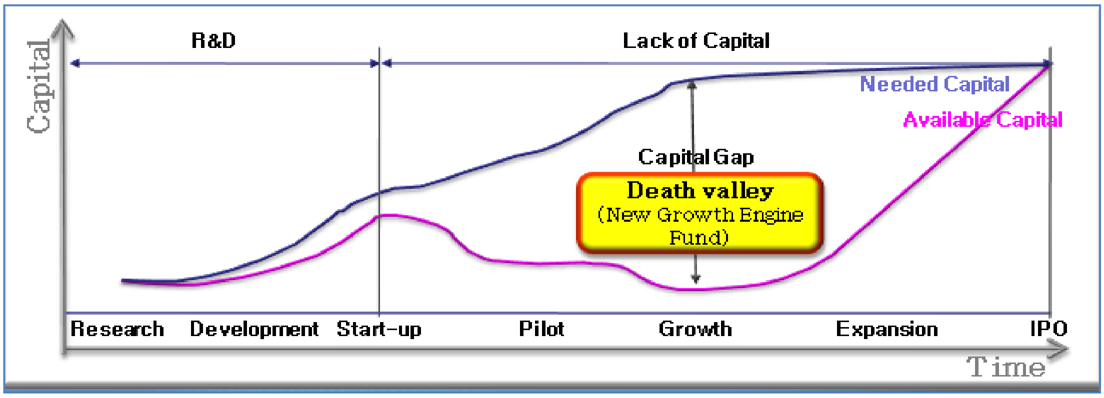
The US SBIR programme is divided into distinct phases, and companies need to submit two proposals. During the feasibility research phase (Phase I – 6 months) the commercial potential needs to be highlighted and during the second phase (research toward a prototype) the proposal needs to present a 15-pages commercialisation plan; 50% of the projects will not receive funding for Phase II because they lack either technological innovation or market potential.

Several countries have copied the SBIR/STTR approach, especially Asian countries, such as Korea, India and Taiwan. The text box below shows how India has adopted the SBIR/STTR approach.

The Small Business Innovation Research Initiative (SBIRI)[104] is a new scheme launched by the Department of Biotechnology (DBT) to boost public private partnership efforts in the country. The distinctive feature of SBIRI is that it supports the high-risk pre-proof-of-concept research and later stage development in small and medium sized companies. The SBIRI scheme operates in two phases: Phase I for the establishment of pre-proof of concepts of innovations, and Phase II for product and process development. In both phases, projects are to be implemented at the industry site. *For more info, see India Innovation profile in Annex 3.*

In Korea, the "New Growth Engine Fund" addresses the "Valley of Death" issue in regards to access to risk capital, especially for medium sized companies. The figure below show that the R&D stage, including the start-up phase, is well supported. However, the lack of capital starts to occur towards the pilot stage and the gap is even larger at the growth stage.

Figure 5: New Growth Engine Fund, Korea



103 http://www.nsf.gov/eng/iip/sbir/program.jsp#PhaseI
104 www.bcil.nic.in and http://sbiri.nic.in/

The New Growth Engine Fund supports medium sized companies at the growth stage, which is where funding is scarce in Europe, especially for high risk projects. The fact that these types of funds are available in leading and emerging regions outside Europe and not in Europe is a challenge for Europe and especially European companies. The fund was supported with €62 million in 2009 from the Korean Government and private funding (large companies and capital funds) is expected to reach €420 million.

Banks, venture capital funds and business angels are reluctant to invest in high-risk projects

Companies active in high-tech research such as advanced materials and nanotechnology find it extremely difficult to find investors. According to the companies interviewed the reason is threefold. First, the investments are high; second, the risk is high; and third, the return on investment is often several years away. According to the companies, banks are not an option as the risk is too high. The venture capital companies are concerned about the time it takes before they see a return on investment and the conditions are therefore very strict if they choose to fund the projects. However, although the willingness of US VCs seems to be greater than in Europe, US-based companies are experiencing similar problem in high-tech/high-risk sectors such as advanced materials. In order to combat this gap the NSF has set up a $10 million equity fund for these companies in the SBIR programme. The funds can be used as Phase IIB funding (see US innovation policy profile in Annex 3) with the aim of finding a potential customer or industrial partner who can bring the technology closer to commercialisation by bringing further investments and knowledge.

The opportunities for funding high-risk projects in regions outside the EU are much greater, especially in the US and China. The is partly due to culture, but also to the fact that the research programmes and public funding structures take companies further up the technology readiness level ladder than the EU research projects, which make the results more interesting for investors. A quality stamp, like in the Korean KIPA or the Minatec label, could encourage investors.

However, access to risk capital is not the only barrier. According to some interviewees, the enterprise culture is different in Europe than in the US, and EU based firms are reluctant to take the risk associated with venture capital, such as management influence. This was an issue discussed at the High Level Expert Group Open Day sessions, and the companies commenting on this agreed that involving venture capital is often seen as a last resort. This could imply that the mind-set of European companies itself is a barrier to accessing funding from potential investors, and that many of the initiatives from especially the US would likely not immediately be accepted in the EU as viable.

One further challenge facing European companies is that they face restrictions in some countries outside Europe. Consequently, it can be difficult to obtain funding in areas with large potential markets. Below is an example from China.

Chinese industrial policy employs several support instruments; for instance enterprises that establish themselves within one of the strategic emerging industries (SEIs) will receive financial subsidies, fast and easy accesses to funding, and enjoy overall government support. In theory, these sectors should be open to all companies, yet it is unclear whether this is actually the case.[105] Every year, the NDRC publishes three catalogues guiding foreign investments. Here all industries in China are ranked in three categories: 1) FDI encouraged, 2) FDI restricted, and 3) FDI prohibited. One of the targeted sectors of the Fife Year Plan (FYP), biotechnology (especially stem cell and life sciences), which is seen as key to the development of an innovation driven economy, is FDI restricted.[106][107] *(see Chinese innovation policy profile in annex 3)*

These restrictions also prevent Europe from providing incentives for investments that can compete with other world regions. One example is that in Europe there is a negative relationship between the level of investment and the level of public support. This, according to industry, creates an incentive for companies to invest outside Europe

4.6 Challenge 5: Value chain issues

One of the key strengths in Europe is the strong clusters and networks built up over a many decades. The case studies (Annex 2) show examples of many of these strong clusters. They also provide examples of the benefits, such as easy access to knowledge (including tacit knowledge), research partners, and sub-contractors, and strong linkages to especially research organisations and universities.

In regions with strong clusters, e.g., the automotive cluster in Slovenia, the photonic cluster in Jena (Germany), and the ICT cluster in KISTA in Sweden, the collaboration between universities and industry is based on close personal relationships developed through the clusters. This allows for effective knowledge spill-over. This highlights one of the reasons for investing in the creation of strong clusters, as this will not only enhance collaboration in the value-chain, but also strengthen connections between the industry and researchers at universities and research institutes. Like the TTO example, it also shows that it takes time to build up the trust needed to collaborate between industry and universities, and it gives unique advantage as social capital is hard to copy.

Promising examples of creating critical mass through collaboration between clusters, such as Grenoble and Dresden in Nano- and Microelectronics, could strengthen the competitiveness of Europe in the individual KETs.

Gaps in the continuous support to all firms in the value-chain

Multinational companies have substantial funds and are likely to carry out most R&D internally. SMEs benefit from a large range of public support opportunities at both European level and national level. However, many mid-cap firms (or médiane in French), which do not come under the SME definition, face many of the same challenges

[105] Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, European Union Chamber of Commerce in China (EUCCC)

[106] Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, European Union Chamber of Commerce in China (EUCCC)

[107] http://www.fdi.gov.cn/pub/FDI_EN/default.htmv

encountered by SMEs, such as internal means to ensure the deployment of KETs. Such firms, which are often crucial for this deployment in the whole value-chain, are defined as large firms according to state aid rules and can benefit from investment aid only in assisted regions (Regional State aid Guidelines 2006).

Several companies in the mid-cap firm category mentioned that it is very difficult to obtain funding for deployment activities. The results of good R&D projects are often lost as the companies are unable to continue work with potential foreign partners if they are receiving national funding which prohibits the inclusion of foreign companies. In contrast, the rules are not perceived to be as strict in the US or China.[108]

Several of the large interviewed companies increasingly find sub-contractors outside Europe, also that many R&D programmes outside Europe take in the whole value-chain, which could have implications for future programme design in the EU.

Clusters and networks provide an important innovation environment in the EU, and as more and more clusters operate across borders programme design will need to reflect this, as is the case for example in the INTERREG programme. For mid-cap firms and companies in small and new Member States cross-border collaboration is an important driver of innovation, but yet not easy to explore further due to the funding rules in many national programmes.

One good example is the Eurostars initiative launched in October 2007. The Eurostars initiative aims at providing financial support from the EU and the participating countries' funds to research-performing SMEs. Through this initiative, the EU Commission is providing Community funding to support the integration of national schemes into one joint programme (the EU funding amounts to up to €100 million on top of €300 million provided by the 32 participating countries).[109]

It could be beneficial if programmes and initiatives were set up with the aim to strengthen emerging or existing ecosystems and clusters. This would allow a focus on certain technologies, which could stimulate the growth of small, medium, and large companies in that area. For companies that are part of an ecosystem or cluster, it is important for that particular country to keep its companies within that ecosystem or cluster. An example of this is the *crédit d'impôt recherche* (CIR), a research tax credit measure in France aimed at supporting corporate R&D investments through tax incentives[110]. Medium-sized companies can also take advantage of this measure.

108 Interview Alfred Hoffmann, Infineon
109 Final report of SME specific measures (jan 2010) by IDEA Consult:
110 ERAWATCH Country Report 2009 France

4.7 General conclusions

The above challenges all refer to the “Valley of Death”, which is not only a European phenomenon. However, the response to the challenges seems more focused in other of the leading and emerging regions, so there is an urgency to react to retain and increase a competitive edge in Europe.

One of the main challenges is to create a long-term vision for the EU27, which will encourage an alignment of European and national policies and encourage clusters in KET areas to focus on this vision. This is necessary in order to create critical mass in knowledge, skilled labour, and funding, in line with that of competitors in the long term.

Tech transfer and other models of commercialisation both through European research programmes and generally between universities, research organisations, and industry should be stimulated and thoroughly evaluated to ensure efficient use of public funding. There is a lack of facilities for large scale demonstrators and pilot testing with a view to stimulate market uptake, this is a major challenge as such structures already exist and are funded in competing regions. However, there is a general lack of thorough evaluations and time series data to assess the effectiveness and efficiency of different models

Access to funding is a challenge for companies working with KETs because R&D projects are high-risk and there is a considerable time delay on return on investment. This makes potential investors reluctant to invest in KET R&D projects.

5 Strategic outlook for KETs in Europe and conclusions

5.1 Introduction

The strategic outlook for KETs is based on the findings of the previous chapters as well as the case studies and innovation profiles found in Annex 2 and Annex 3.

The challenges were highlighted in the previous chapter, and below we summarise the main strengths, weaknesses, opportunities, and threats (SWOT) of the European competitive position of KETs in the overview table and give a brief description of each point.

Finally, this Chapter will provide input to the High Level Expert Groups and the European Commission towards a long-term European KET strategy.

5.2 SWOT analysis

5.2.1 Overview table

Strengths	Weaknesses	Opportunities	Threats
- Strong research base - Talented researchers and workforce - Large knowledge base - Leading companies in some KETs - Strong clusters - Some interesting policy measures	- Lack of focus - Lack of critical mass - Too much focus on existing market opportunities - Lack of transfer and other models for commercialisation of knowledge in industry and between industry players - Insufficient commercialisation of public funded programmes - Lack of funding for commercialisation activities for high tech companies	- Create critical mass - Increase support and focus on the commercialisation phase - Deployment of structural funds for large scale demonstrators aligned to national contexts - Alignment of programmes and initiatives on European and Member State level	- Lack of sufficient high skilled labour in science and technology - Major investments in leading and emerging regions - Risk adverse orientation at European and Member State level - Insufficient funding to support the growth of clusters to turn them into global centres of excellence

5.2.2 Strengths

The major European strengths are connected to the established systems and organisations. The research and knowledge base is state-of-the–art within the KETs, and some of the established clusters and eco-systems are strong global players, with the presence of multinationals operating and strong multi-disciplinary research institutes in several KET areas. There are also examples of policy measures taking advantage of the strengths and they should be used to create critical mass in knowledge and scale.

5.2.3 Weaknesses

Europe has critical mass, but without alignment and synergy between policy measures regarding KETs in the individual Member States the critical mass is not used to its full potential, and this is a weakness. The lack of knowledge utilisation in commercial products is a weakness, and the support for demonstration and commercialisation has not been developed to take full advantage of the strengths. There also seem to be barriers to obtaining funding for high-risk projects. In general models for knowledge utilisation and commercialisation are not sufficiently assessed in light of new models of knowledge flows.

5.2.4 Opportunities

There are several opportunities for increasing the deployment of KETs. The deployment of KETs could be improved by using existing funding differently. This could be done by using the Structural Funds for large-scale demonstrators also to build capacity in SMEs to engage in innovation processes with the knowledge system, and/ or reserving part of the FPs for commercialisation activities, and by focusing research on grand challenges with a view to opening up market opportunities in new and emerging markets. Manufacturing still plays a huge importance in the European Economy, and prioritised investments in KETS could also drive value –added service innovation relating to technologies for a sustainable growth.

5.2.5 Threats

Large investments in leading and emerging countries are creating fierce competition and could lead to a second wave of off-shoring where high value manufacturing and R&D functions are sourced to destinations outside Europe. If a European competitiveness strategy is not supported by aligned policies and prioritises regarding funding investments there is a possibility that Europe will lose market shares in some KET areas with a negative effect also on employment.

5.3 Conclusions

The study has identified a number of challenges for successful deployment of European policy initiatives in Europe and in emerging and leading regions outside Europe.

Chapter 4 provided several good examples of international initiatives, but it is important to note that we have not studied the challenges persisting in the regions outside Europe. Examples of such challenges include lack of access to qualified labour, dependence on inflow of foreign scientists, challenges for companies in high-tech/high risk sectors to attract private funding in the US, limited research infrastructure in China, and limited success with commercialisation of R&D results and patents taken out in Korea. In especially the US and in Korea, several programmes have also been launched to overcome barriers to commercialisation.

In terms of global competitive advantage, the work of the HLG shows that Europe has been holding a constant level of patent applications over the last years. However, it also stresses that Asia has accelerated its efforts and has in the meantime overtaken Europe, whereas the US has lost ground. Nevertheless, Europe still has significant strengths in research and industry in all KETs. Emerging regions and leading regions outside the EU are also facing challenges to overcome “the Valley of Death”.

There are several areas where European policy could be improved to increase industrial deployment of KETs and strengthen Europe’s competitive position in a global economy with increased focus on KETs. Some of the interesting policy initiatives identified outside Europe cannot directly be transferred to Europe due to different framework conditions; nevertheless they offer important policy lessons.

The study points to four areas that are particular critical with regards to KETs deployment competitiveness:

- create critical mass in knowledge and funding through increased synergy
- increase market focus on R&D projects
- large scale demonstrators and pilot test facilities; and
- provide post-R&D commercialisation support.

Create critical mass through increased synergy

As one geographical entity, Europe has the critical mass in knowledge and funding needed to compete with leading and emerging regions. However, as the EU consists of 27 Member States with different agendas, strengths and weaknesses, cultures, and funding schemes, the benefit of size is not used to its full capacity. There are obvious limitations, but in some areas related to KETs, Europe needs to increase this critical mass since its competitors are investing heavily in the KET value chain. Such measures comprise an integrated approach to research, demonstration activities and test infrastructure as well as investment in human capital.

There are many examples of emerging and leading regions outside Europe with clear long-term strategies for their research programmes in the KET areas, and projects are integrated from idea to commercialisation.

There is a need for a joint long term EU strategy to align policy priorities and instruments and to guide investments and initiatives within the KETs. If this strategy is focused and clear, it may also provide a framework for Member States to align national strategies and priorities with the EU focus on KETs. A second value added could be increased cross-border collaboration, thereby stimulating cluster formation.

Increased cross-border collaboration will especially benefit small and new Member States and address the lack of critical mass in terms of access to funding, knowledge, large industrial partners, and facilities (research infrastructure).

The European Commission should also consider how or if Structural Funds could be made available to and provide the funding basis for large-scale demonstrators and pilot test facilities in which KET-based technological solutions are deployed to address specific national/regional challenges and opportunities. This could boost national/regional innovation capacity. Such measures are likely to contribute considerably to creating positive spill-over effects from European R&D to national and regional innovation priorities. Finally, this could also strengthen the clusters and value-chains in Europe operating in KETs areas.

National funded projects often exclude participation of foreign companies to ensure that the taxpayers get a return on investment. However, for innovative companies in small Member States with lack of critical mass in a particular technology, it is a major barrier that they cannot participate in national R&D projects with relevant industry partners.

Increase market focus on R&D projects

Basic research is essential in order to stay competitive, but part of the European Research Programmes, such as the Framework Programmes, should have a clear strategy for commercialisation of results in areas where European research and innovation can contribute to the creation of new markets – also in a global context.

This could be aligned to strategies aimed at addressing the grand societal challenges in Europe and/or globally, which could also open up for European industry to emerging new markets. In that context, it is important to note that although there is a growing shared understanding of what constitute the grand global challenges, new challenges may develop over time. This calls for supportive instruments such as foresights to ensure a dynamic policy framework.

The design of programmes and the appointment of evaluation teams will be critical to ensure a stronger market focus in European Programmes. One option would be to use the technological readiness levels as a tool for assessing the results and expectation of the projects. There are likely also important lessons to be learned from programme design and implementation from countries outside the EU, as the cases chosen for this study illustrate.

In order to ensure results, a two-phase programme could be an option in order to boost commercialisation. The proposal for the first stage should provide evidence of commercial potential, whereas after the feasibility stage a new proposal should be submitted including both technological progress and a commercialisation plan. This is inspired by the US SBIR/STTR programme. (see US Innovation policy profile in Annex 3)

Enhancing the market opportunities will make highly innovative European companies more prone to participating in the Framework Programme. It will also increase the potential for industrial deployment after the end of a project.

The lack of a coherent funding framework for European R&D projects poses a considerable barrier to industrial deployment of the funds, which should be considered in the design of FP8 as suggested by some Member States.

Large scale demonstrators and pilot test facilities

An important step in increasing technological readiness levels is testing prototypes in large-scale demonstrators and pilot test facilities.

In order to exploit the results of R&D, large scale demonstrators and pilot test facilities create opportunities to enhance the economies of scale for a specific product and it stimulates the manufacturing of products by creating knowledge intensive prototypes and stimulating scaling in a real market context. Many Member States have invested in test equipment and facilities, but this is often not of a commercial scale. Small Member States and companies without internal test facilities could benefit from European state-of-the-art large scale demonstrator and pilot test facilities available to the public in order to exploit the R&D results.

Considerable public investments in large scale demonstration and pilot testing facilities are made in competing regions. It may be necessary for Europe to go the same way. This would strengthen the clusters and encourage cross-border collaboration, and it could also spur the capacity of SMEs to engage with the knowledge system, thereby driving innovation. Finally, improved demonstrator and test facility infrastructure could also attract leading foreign companies to locate innovation activities in Europe with positive impact on job creation.

Provide post-R&D commercialisation support

As many of the European R&D projects are early stage and pre-commercialisation research, it is necessary to spur continuous innovation by matching the results of R&D projects with potential investors. As shown in this study, this can be achieved in many ways. A sort of brokering mechanism at the EU level between investors and SMEs participating in the Framework Programme could be one model to be tested to improve commercial output of the FPs. Throughout the report and in the country innovation profiles there are several interesting examples of how diffusion of R&D can drive commercially viable innovation strategies.

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8 Annex 2: Case studies of clusters and ecosystems in Europe

Case study Grenoble, France – Micro- & nanoelectronics

8.1 Introduction

France is the third largest economy in the EU, following Germany and the UK, contributing with 13.8% of EU27 GDP in 2008[111]. The trend for output growth however, is slowing down since 2000. The growth rate of Gross Domestic Product (GDP) decreased from 2.2% in 2006 to 1.9% in 2007[112]. In 2008, real GDP growth slowed down to 0.2% and decreased further to -2.6% in 2009, following the global financial crisis.[113]
With regard to the economic structure of the French economy, Eurostat data for 2008 indicate that 77.6% of the gross value added (GVA) in France was created in the services sector[114], which was six percentage points higher than the share of services in the total gross value added in the EU27. Industry and construction accounted for 20.5 per cent of the gross value added in 2008. The fourth sector, the agricultural sector, accounted for 2% of the French GVA. In comparison to 1998, the share of the services sector has increased by 4.3 percentage points whereas the importance of industry & construction decreased by nearly 3 percentage points.

In terms of R&D expenditures, France has the second largest research system in the EU. France's Gross Expenditures on R&D amounted to €37.8 billion in 2006, which accounted for 17.7% of EU27 expenditures. With an R&D intensity of 2.08% in 2007, France was above the European average (1.84% in 2006), although the R&D intensity has considerably declined since the 1990s (e.g. 2.33% 1992).[115]

Why is France interesting to look at?
France is very active in taking patents in the area of micro- and nanoelectronics. Next to the presence of some large companies like ST Microelectronics, Thales, Soitec and Alcalel Lucent, two research institutes namely the Commissariat à l'Energie Atomique (CEA) and the Centre National de la Recherche Scientifique (CNRS) are present in the top 30 applicants in micro-and nanoelectronics. These two research organizations have carved out international reputations as leading research organisations, producing some notable results in the field of microelectronics. Building on this strong base, France has

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[111] Measured in terms of PPS (purchasing power standards). Source: Eurostat Yearbook 2010.
[112] Erawatch Country Report for France, 2009.
[113] Institut National de la statistique et des études économiques : http://www.insee.fr/fr/themes/tableau.asp?reg_id=0&id=159
[114] Services are defined as (a) Trade, transport &communication services; (b) Business activities & financial services and (c) Other services. Source: Eurostat Yearbook 2010.
[115] Erawatch Country Report for France, 2009.

developed its research infrastructure into a network of micro-nano platforms to meet the future challenges of developing micro and nanoelectronics[116]. According to the Manufacturer's Association of IT Industry (MAIT), France's excellence in microelectronics is due to its concentration of specialized skills in the field of design, chips and semiconductor development, integrated circuits design, and embedded systems and smart card production. This expertise is concentrated in several universities, research institutes, small and large companies, and several networks and business development organisations.

8.2 Background

Grenoble is located in the Rhône-Alpes region, the second most important in France in economic and scientific terms[117]. Rhone Alpes stands in the top 50 world regions for patents appliance; in France it is second only to Paris. Grenoble-Isère is a major European site for innovation in micro and nanotechnology, and information technology[118]. Grenoble-Isère is a vibrant ecosystem thanks to the presence of major market-leading firms such as STMicroelectronics, Hewlett Packard, Soitec, Bull, Sun Microsystems; innovative and dynamic start-ups, advanced R&D centres, universities, Minatec, Minalogic and many other initiatives. The Agence d'Etudes et de Promotion de l'Isère (AEPI) provides a good overview of this ecosystem (see box below)[119].

Major strengths of the Grenoble-Isère region

- A high-tech, industry-oriented business environment, with a longstanding tradition of cooperation between research, industry, university and local government.
- Industrial fabric reaching all the way from component design to production, through equipment manufacturers and service providers.
- Several public and private research centres such as CEA-Leti, CNRS, Inria, Nanosmart Centre
- Grenoble-Isère's higher education system, offering a master's degree in micro and nanotechnology for integrated systems
- International dimension through the presence of foreign-owned companies and international students
- Cluster organizations
- An attractive mountain environment

With an industrial fabric, comprising multinationals and innovating SMEs, and a scientific and technological environment of international standing, the region of Grenoble-Isère houses more than 456 wholly or partly foreign-owned companies, are totalling 42,200 jobs[120]. It also houses over 68,000 students, which represent about 15% of the population of the greater Grenoble area[121]. Table 1 provides an overview of the employment in the Grenoble-Isère region which totals more than 387,000 people[122].

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[118] Grenoble Isère France, Agence d' études et de promotion de l'Isère, october 2008
[119] http://www.grenoble-isere.com/etudes-et-territoires/pdf_filieres/Micronano2008_4pages_GB.pdf
[120] http://www.grenoble-isere.com/eng/Why-invest-in-Grenoble-Isere/Synergy-between-research-training-and-industry/Industry/Des-investissements-etrangers
[121] http://www.inc6.eu/grenoble_industrie.htm
[122] http://www.minalogic.com/13-partenariat-innovation-cluster-grenoble.htm

Micro-nanotechnologies & electronics		Informatics & logistics	
Research	3000 employees	Research	2000 employees
Companies	21700 employees	Companies	12000 employees
Total	24700 employees	Total	14000 employees
Higher education	12000 graduates/year	Higher education	22000 graduates/year

The balance and the various forms of synergy between the universities, research and industry, the quality of the workforce, the large number of international companies, efficient subcontracting and logistics services, the advantages of its position in the center of the Rhône-Alpes region as the second most important in France in economic terms, all contribute to the success of the area[123]. In the past decade, more than €6bn has been invested in micro and nano-electronics in the Grenoble-Isere region. The Nano2012 programme is a good example of this[124].

'Nano 2012' programme

The Nano 2012 R&D programme was officially launched in 2008, bringing together IBM's research centres at Fishkill and Albany, New York state, STMicroelectronics and CEA-Leti. It got the go-ahead in April following the signature of a framework agreement setting forth the programme's objectives and the responsibilities of the various partners. Nano 2012 is a cooperation program which aims to boost the technological lead and competitive position of the Grenoble area in the changing conditions of the global semiconductor industry and consolidate its leadership position in the development of (32 and 22 nm) CMOS technologies and derivative technologies for system-on-chips (embedded memory, analog/RF devices, etc.).

Over the next five years Nano 2012 will be allocated a €2.3bn R&D budget with a further €1.25bn for capital investment, making it one of France's biggest industrial projects. National and local government are providing substantial support for the project, contributing some €457m. Realization of this project will make Grenoble- Isere a global centre for tomorrow's nanoelectronics, with potential for creating about 650 jobs in the Grenoble area.

8.3 The Grenoble cluster

In the region of Grenoble-Isère, several interesting initiatives have been developed. In the next paragraphs, we will elaborate on a few initiatives such as Minalogic, Minatec, and CEA-LETI. These initiatives play a crucial role in nurturing the ecosystem.

Minalogic

On 12 July, 2005, the Interministerial Committee for Regional Development approved the Minalogic project, granting it world-class competitivity centre status to enhance the international visibility of the Grenoble area and to increase its drawing power[125]. The aim of the Minalogic cluster (MIcro NAnotechnologies et LOgiciel Grenoble-Isère Compétitivité) is to pool research and cooperation in developing miniaturized chips[126].The objective is to give the micro and nanotechnology and embedded software education, research and industry in France a lasting competitive edge. The centre hinges

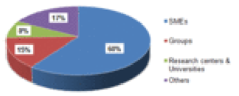
[123] http://www.design-reuse.com/ip07/location/grenoble.php
[124] http://www.nanowerk.com/news/newsid=11367.php
[125] http://www.inc6.eu/grenoble_industrie.htm
[126] http://www.grenoble-inp.fr/presentation/minalogic-industrial-cluster-27470.kjsp

on two clusters, one focusing on micro and nanotechnology, the other on embedded software on chips[127]. Below is an overview of some key figures for Minalogic.

Key figures of Minalogic[128]

189 Members

- 142 companies (81% SMEs)
- 15 research centers and universities
- 15 local governments
- 14 economic development organizations
- 3 private investors



Member distribution

143 Projects

Since the creation of Minalogic in 2005, **143 projects** were certified and financed for total funding of €515.1 million, with a total R&D budget of around **€1.7 billion**.

> **Fonds Unique Interministériel** (FUI) :
116 certified projects, **58** financed by the FUI and local governments, for total funding of **€177,5 million**.

> **National Research Agency** (ANR) :
127 certified projects, **59** financed by the ANR, for total funding of **€49.8 million**.

> **Programme d'Innovation Stratégique Industrielle** (ISI, ex-AII) :
5 certified projects, **5** financed for total funding of **€220 million**.

> **Oseo** :
18 projects were financed by Oseo for total funding of **€21.8 million**.

Minalogic has developed 2 major activities. The first activity is the project factory, which often starts with a brainstorm during which a company presents its idea for a project. This idea often follows up on industrial leads or university research. Next, Minalogic helps the company to create a consortium of relevant partners to address the project. When the project and the consortium are formed, Minalogic performs a first selection to assess the feasibility of the project. It is important that the project offers a perspective to the development of an application that can answer a particular market need. The project needs to be application driven. When the project is selected, it gets a Minalogic label. Then, Minalogic supports the consortium in their search for funding from national and/or regional departments by setting up a tour de table to fund the project. In March 2010 for example, Minalogic announced that five projects proposed by companies and public research laboratories of the cluster were selected by the Fonds Unique Interministériel (FUI) and will be funded up to €11.9 million, totaling a budget of 30.2 million euros[129].
The second activity concerns the offering of services to SMEs. This offering includes IP training, securing IP, support in applying for a patent, support in setting up collaboration agreements with large industry players, guidance to export and internationalize. They also offer tools to SMEs to perform a strategic technological survey, and to support them in human resources and skills issues. They have also set up agreements with banks to provide loans to SMEs.

Minatec

The Minatec micro- and nanotechnologies innovation cluster was founded by Grenoble Institute of Technology and CEA Grenoble on January 18, 2002, with support from the

[127] Grenoble Isère France, Agence d' études et de promotion de l'Isère, october 2008
[128] http://www.minalogic.org/85-keys-figures.htm
[129] http://www.minalogic.com/Actualites/51%23%26resultats-AAP9-FUI/17-les-actualites.htm?utm_source=RSS&utm_medium=rss&utm_campaign=Projets+%2F%2F

State and local government authorities[130]. Their mission is to become one of the world's top five centers for research in micro and nanotechnologies[131]. The goal is to share knowledge and technology in order to design micro and nano-devices, right from materials development up to applications, particularly in software and embedded systems[132]. The various buildings, officially opened in June 2006, consist of 45000 square metres of laboratories, offices and clean rooms, housing almost 4000 people ranging from students and researchers to employees of various firms[133]. Currently, the MINATEC innovation campus is home to 2,400 researchers, 1,200 students, and 600 technology transfer experts on a state-of-the-art 20-hectare campus offering 10,000 square meters of clean room space[134].

The Minatec campus offers industry strong research competencies, state-of-the-art equipment and a strong IP platform, implying that industry can use the developed technologies worldwide. Minatec attempts to build long term relationships between research and industry as this makes it easier to create trust. This trust is essential for industry to outsource larger parts of their research to researchers. Minatec has access to great research potential as CEA-Leti, the CNRS, Grenoble National Polytechnic Institute and Joseph Fourier University (UJF) have several facilities in the cluster. This trust is further enhanced by strong IP protection services and the fact that Minatec is strongly oriented toward technology transfer. MINATEC represents investments of €152.45 million from the following sources[135]:

- Local governments: €76.22 million
- The French Atomic Energy Commission (CEA): €32.32 million
- The French government: €13.42 million
- Private investors: More than €22.87 million.

Further to Minatec's success, the local partners have launched the GIANT initiative, enlarging the Minatec concept to develop a complete innovation campus dedicated to 3 major societal issues: information society, energy and biotechnologies, supported by large scale instruments, fundamental research and the Management School of Business. Together with urban facilities and transportation improvement, this 1B€ investment will serve the largest technological centre in Europe.

CEA-LETI

CEA's Electronics and Information Technology Laboratory (LETI) was started in 1967 and now ranks as one of the largest centres in Europe for applied research in electronics[136]. LETI has established unique technological resources, including a nanocharacterisation platform and 300mm and 200mm lines for nanoelectronics and MEMS, in 8,000 m² of clean rooms[137]. Its main mission is to help business increase its

[130] http://www.grenoble-inp.fr/presentation/minatec-26580.kjsp
[131] http://www.minatec.com/en/minatec
[132] http://www.grenoble-inp.fr/presentation/minatec-26580.kjsp
[133] Grenoble Isère France, Agence d' études et de promotion de l'Isère, october 2008
[134] http://www.minatec.com/en/minatec
[135] http://www.minatec.com/en/minatec/history
[136] Grenoble Isère France, Agence d' études et de promotion de l'Isère, october 2008
[137] http://www-leti.cea.fr/en/Discover-Leti/About-us

competitive edge through technological innovation and to transfer its technical know-how to industry[138].

CEA/LETI has acquired a strong practice of developing and transferring technology by providing a strong interface between industry and academic research. They have built state-of-the-art experience in advanced process development. Companies can access the application labs and be in contact with the employees. LETI is a recognized Institute Carnot since 2006 and is involved in international partnerships with Fraunhofer, CSEM, VTT, IMEC, etc[139]. It has formed the basis of several start-ups, including SOITEC. It has also played a decisive role in the former Crolles 2 Alliance and the Minatec innovation centre[140]. LETI strengthens the competitiveness of its industrial partners through its portfolio of 1,500 families of patents and its 1500 employees[141]. The critical mass present in LETI contributes to the realization of substantial growth of companies in the region.

8.4 Lessons to be learned from France

Easy and quick collaboration is becoming increasingly important

Due to internationalization and changes in the global economy, collaboration has become crucial for several companies to develop and deploy new products and services in order to stay competitive. In the past, companies in France often competed against each other to receive regional or national funding. Nowadays, they are working together to write proposals to get funding for a project. This is necessary in order to face the competition with American and Asian players as the semiconductor market is a global market.

Although they really welcome collaborations, SMEs find it often difficult to set up projects with other partners due to time constraints and the bureaucracy involved. Most projects, regional, national or European, take several months to be created and receive funding[142]. This is often too long for SMEs that want to build on opportunities which have a limited timeframe. Especially in the semiconductor industry, the industry might look very different one year into the future. Moreover, there is often a heavy administrative burden that accompanies these projects. Therefore, easier and quicker access to funding is really beneficial for SMEs. Recently, several regional funds in France have started to work with a project outline instead of a full proposal to approve funding for projects. A project outline (~10 pages) is much easier to write for SMEs compared to a full proposal (~100 pages). This enhances the collaboration opportunities for SMEs which in turn might lead to growth.

There is a need for clarity in state aid and policy measures

During recent years, a lot has happened in France with regard to the change and evolution of different state aid and policy measures. With these changes, France hopes to get research and industry more aligned, and to put more emphasis on the development of applications. For example, the French government has launched a new proposal to

[138] Grenoble Isère France, Agence d' études et de promotion de l'Isère, october 2008
[139] http://www.inc6.eu/grenoble_industrie.htm
[140] http://www.mait.com/admin/enews_images/MAIT%20Country%20Intelligence%20eNews104.pdf
[141] http://www-leti.cea.fr/en/Discover-Leti/About-us
[142] Interview with Jacques Perrocheau, SEMI

reorganize the universities in an attempt to stimulate technology transfer between universities and industry.

French announce 'big loans'[143]
The French state is to raise 35 billion euros to fund strategic investments. Of the total, some 22 billion euros of the so-called "big loan" will be raised on the financial markets and 13 billion euros will come from banks reimbursing recent state aid. President Nicolas Sarkozy said the priority for spending the money would be higher education and scientific research. 11 billion euros has been earmarked for higher education. Sarkozy said too often there had been "walls between research and the economy." Special attention will be devoted towards developing research teams to boost competitiveness and increase efforts in biotechnology and nanotechnology.

The recent and frequent changes to state aid and policy measures are hard to follow for SMEs and intermediate sized companies. These companies can often not afford to pay an advisor as this is too expensive. Moreover, they seldom have the internal resources to spend time to study the changes. Therefore, more clarity and an enhancement of readability of these measures would really help SMEs and intermediate sized companies. A clear vision and financial means to support this vision is really beneficial for companies, research institutes and universities to focus their activities.
Intermediate sized companies (between 2000-5000 employees) also experience difficulties in realizing benefits from state aid and policy measures. This category of companies currently falls in between measures oriented towards SMEs and measures oriented toward large companies. More flexibility in the state aid rules could solve this problem. As France houses many of these intermediate sized companies, state aid and policy measures that target this specific group would really support these companies in their growth.

Mobilization of researchers
Academic researchers often stay in academia throughout their entire career. The main reason is the fact that there are no incentives for academics to go to industry and then return to academia. On the contrary, it is often harmful for the career of the academic to leave academia for a while. Therefore, they prefer to stay in academia[144]. With regard to the deployment of KETs, this poses an important obstacle as this hinders the transfer of knowledge from academia to industry.

France launched a Law for Innovation and Research in July 1999 to incite researchers to participate in the creation or development of innovative technology companies that make use of their research work. The framework allows French researchers to be involved in a start-up without losing their position in the research organization. It specifies the conditions under which researchers are allowed to join a start-up without losing their day-to-day job. This job security limits the perceived risk of an entrepreneurial career. A review of the program in 2007[145] found that the number of civil servants eager to create a company based on their research work had dropped significantly from 2000 to 2006: from

[143] http://www.euronews.net/2009/12/14/french-announce-big-loan-details/
[144] Interview Jean Charles Guibert, Minatec
[145] Innovation et Recherche Technologique : Etat et Bilan au 31 Decembre 2006 by Ministry of Research, see http://www.enseignementsup-recherche.gouv.fr/pid20236/innovation-et-recherche-technologique-rapports.html

30 cases/ year in average to approximately 10 since 2004. Staff from public research organizations seems more reluctant to quit their status of civil servant and consider in priority other ways transferring their technologies.

In order to stimulate researchers to engage or go to industry, a strong political message is necessary that stresses the importance of creating value added through innovations in industry. The incentives need to change, making it more appealing for researchers to transfer their knowledge to industry and create value and employment through the development of innovative products.

8.5 Some efficient initiatives to retain from the French case

Crédit d'impôt Recherche is a key measure in supporting R&D investments within companies

Crédit d'impôt Recherche (CIR) is a research tax credit measure which is aimed at supporting corporate R&D investments through tax incentives[146]. The French Research Tax Credit is a general horizontal measure that does not target any specific sector or type of company[147]. This tax credit is complementary to other forms of public support such as subsidies, refundable loans. The tax credit is well used and well appreciated by small, medium and large companies as it really supports companies in performing R&D.
The Research Tax Credit already exists for several years. It is a popular initiative that is used by a large number of companies. It contributes to the growth of research activities in France and is considered the best tax credit measure compared to other tax credit measures present in other European countries. Enrico Villa of STMicroelectronics states, that in his view, it is the best horizontal leverage in Europe and should be used as a benchmark in all other countries.

Ecosystems exercise an important attraction to companies and people
Major corporations, small and mid-sized businesses, research institutes and universities are co-located in Grenoble and this makes a big difference. Moreover, the area also houses several government agencies and networking organizations from the public and private sector. This interplay of organizations contributes to and constantly feeds the Grenoble ecosystem by offering an extraordinary **convergence** of **technological research** and **industrial applications**[148].Its participatory governance model is designed with one objective in mind: to ensure efficient, results-oriented cooperation among cluster partners[149]. It attracts the best students and researchers because it offers the possibility to grow to high tech jobs. On the other hand, it attracts several high-tech companies because it has the best students and researchers on its campus. The relation is mutually reinforcing. The cluster plays a key role in facilitating communication and sharing of knowledge and information between actors, leading to growth opportunities for all actors.
An important factor which helps nurturing the ecosystem is the fact that the coordination and management of the Minatec campus is handled by a single, major operator since

[146] ERAWATCH Country Report 2009 France
[147] http://www.enseignementsup-recherche.gouv.fr/cid20358/le-credit-d-impot-recherche-cir.html
[148] http://www.minalogic.org/149-missions.htm
[149] http://www.minalogic.org/84-presentation.htm

2008. One operator can streamline the activities between the different partners, and set a particular direction by making sure that the emphasis lies on innovation and not only on bluesky research. A clear message and vision helps to attract international companies to the region. For example, the California-based analogue semiconductor company Monolithic Power Systems, ranked as one of the fastest growing companies in Silicon Valley by Deloitte has opened its headquarters in Bernin-Crolles, and Boc Edwards, part of the Linde Group, has also moved its European semiconductor business headquarters from London to Grenoble to be closer to its electronics customers and to recruit skilled talent in the region[150].

The advantage of being located in an ecosystem is the fact that it allows for a good interaction with the customer. A close vicinity to R&D centers and a close proximity of customers is often very important in the microelectronic industry to get fast on the market. Also the networking possibilities in combination with good and skilled human resources are of great value.

Addressing the 'Valley of Death' issue
The Minalogic initiative in the Grenoble region provides a good practice example on how important it is to address 'Valley of Death' issues even in a strong cluster and eco-system. The Minalogic label and the support for companies to find industrial partners or investors for the invested technologies is a good example of how important this stage is. Often, companies are left to find an investor and especially for small companies this requires skills that are often not present in these companies. Creating a quality label is therefore a major marketing benefit for companies, as this label creates a level of trust in the quality of the product received from a larger organization.

8.6 List of persons interviewed

Association/Company	*Name*	*Title*
Minalogic	Jean Chabbal	Chief representative
Minatec	Jean Charles Guibert	Director
SEMI	Jacques Perrocheau	Director
Inopro	Hervé Rouch	CEO
STMicroelectronics	Enrico Villa	Senior Advisor to CEO
Microelectronics and semiconductors	Yves Gamberini	CEO

[150] http://www.mait.com/admin/enews_images/MAIT%20Country%20Intelligence%20eNews104.pdf

Case study Ireland - Nanotechnology

Introduction

The Republic of Ireland is a small, open and export-oriented economy with an estimated population of 4.5 million people in 2010151. In 2007, Ireland accounted for around 2% of total output in the Euro Area[152]. Since the middle of the 1990s, Ireland experienced unprecedented growth, a phenomenon known as the Celtic Tiger. This has been accredited to a series of factors, among others, a boom in the construction sector, EU membership and a large multinational presence in Ireland due to, a number of factors including, an excellent education system providing a highly skilled workforce and a, a low per cent rate of corporate tax, which is still effective today. Ireland's GDP growth was averagely 6% in the period from 1995-2007; however, GDP fell by 3% in 2008 and almost 8% in 2009 as Ireland was severely struck by the world financial crisis.

During the last few decades, the Irish economy changed from being based on agriculture and traditional manufacturing to being increasingly based on hi-tech and internationally traded services. In 2007, the services sector accounted for 64% of GDP, while industry accounted for 33% and agriculture for 3%[153.] The openness of the Irish economy can be seen by the mobility of labour and capital as well as from the amount of inward FDI; FDI accounts for €110 billion (>70%) of total exports in the Irish economy, 240,000 jobs, 55% of corporate tax, and 73% of business spend on R&D&I[154] and thus has a significant impact on the Irish economy.

Why is Ireland interesting to look at?
One of the major issues for Ireland is that it lacks a market-driven demand pull for research, due to the fact that there is no 'super customer' and in general lack of critical mass. There is also limited critical mass when it comes to Ph.D.'s and qualified engineers. Many other countries of similar size face the same problems, yet the difference is how this is dealt with. It depends on how the countries deal with the fact that they will never be able to compete with the major World or even European powers.
This is where Ireland makes an interesting European case. Although Ireland is a small country, they rank relatively high in terms of nanotechnology publications and patents. More importantly, the ratio between publication and patents (more patents per publication) is high compared to the rest of Europe and in public investment in

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[151] Central Statistical Office Ireland (CSO), Population and Migration Estimates http://www.cso.ie/
[152] The Economic and Social Research Institute (ESRI), Irish Economy http://www.esri.ie/irish_economy/
[153] The Economic and Social Research Institute (ESRI), Irish Economy http://www.esri.ie/irish_economy/
[154] The Irish Times (2010) "Are we ready to wean off FDI?"
http://www.irishtimes.com/newspaper/innovation/2010/1126/1224283817891.html

nanotechnology, Ireland ranked 1st in 2004 in terms of public R&D investment when looking at per capita investment. Furthermore, Ireland has, as one of the only Member States, a commercialisation programme where the area of nanotechnology has been coupled with the strengths in both indigenous R&D and industry. This has meant that the funding and R&D is more focused on industry needs and opportunities based on identification of niche areas and creation of a high quality research infrastructure.

Background

Today, Ireland has a strong research infrastructure in several technology fields, a focused strategy for commercialisation and performance in nanotechnology output, such as publication and patents, have improved. However, this has been a long process, which is still on-going.

Prior to 1998, Ireland had no history of coordinated investment in research and investment in property seemed to be preferred. One major cornerstone was in 1998 where a major technology foresight exercise[155] was undertaken. This exercise identified the gaps in the Irish economy and suggested that the Irish economy had to reposition itself from predominantly production-oriented plants to research, knowledge-based and innovation-driven firms.

More specifically it was suggested to increase the national capability in niche areas of information and communication technologies (ICT) and biotechnology for the continued development of important national sectors. A world class research capability in selected niches of these two enabling technologies was seen as an essential foundation for growth and creating a supporting research infrastructure for development in the niche areas of the enabling technologies was seen as the key elements for a commercialisation strategy.

The foresight exercise was followed up by the setting up of a new funding agency – the Science Foundation Ireland (SFI[156)] established in 2000 with a budget of €646 million. SFI provides grants for researchers, both indigenous and international, for outstanding investigators[157], conferences and symposia, and for collaboration with industry. The majority of the funding is in line with the recommendations from the technology foresight exercise and focus on science and engineering underpinning three Government-prioritised industrial sectors: biotechnology (Bio), information and communications technology (ICT) and sustainable energy and energy-efficient technologies.

These priority sectors were selected by the main agencies in Ireland for the Government's Strategy for Science Technology and Innovation 2006 -2013. This was done in partnership with a steering group including academics from the main institutions and universities and representatives from industry. The objectives were (are) to increase economic impact by attracting and retaining FDI, spurring development of indigenous companies, promote collaboration between industry and academia. The criteria for success were amongst other things to map out research quality and quantity, plus

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[155] http://www.Forfás.ie/media/icsti990430_technology_foresight_overview.pdf
156 http://www.sfi.ie/index/
[157] Later mentioned as principal investigators

corresponding markets. Another important element was to set up a national coordination group for implementation. It also included a target of doubling of the number of PhDs based on the 2003/04 base. Furthermore the Irish Universities Association were tasked to reform the 3rd level and set about the creation of fourth level Ireland, in the development of the knowledge economy.

In the past decade Ireland has invested heavily in research infrastructure and has created state-of-the art research facilities, which has created an environment for technological exploitation for both academia and industry. This has provided an opportunity to take R&D closer to the market.

Finally, a recent report – Ireland's Nanotechnology Commercialisation Framework[158] - sponsored by Government advisors Forfás has created a programme for commercialisation of nanotechnology R&D. This was done though exploiting the potential of the high level investments in the nanotechnology, taking an inward look at the indigenous innovation system and to benchmark this against other key nanotechnology regions. The key messages were to increase focus on the niche strengths of Irish innovation system and to set up a group to coordinate and focus funding and efforts on fewer and more applicable technology combinations.

The Irish nanotechnology network

Ireland's strategy for commercialisation is based on a focus on niche areas within three major priority areas and by building up a strong research infrastructure. Increased industry participation in the policy formulation process and industry orientated strategies at the key universities and research institutes have created an interesting network for industrial deployment of nanotechnology and other key enabling technologies. In the following we will look deeper into some of the initiatives by introducing the competence centre concept, and look closer at how the research institutes and universities jointly has improved the framework conditions for industrial deployment of key enabling technologies.

One action implemented after the launch of SFI is the *Strategic Research Clusters (SRCs).* The SRCs has been designed to facilitate the clustering of outstanding researchers to carry out joint research activities in areas of strategic importance to Ireland, while also giving the time and resources to attract and cultivate strong industry partnerships that can inform and enhance their research programmes. The topics are proposed by research providers and supported by industry. One example is presented in the textbox below[159.]

[158] http://www.Forfás.ie/media/Forfás310810-nanotech_commercialisation_framework_2010-2014.pdf
[159] http://www.tyndall.ie/forme/index.html

The FORME, "Functional Oxides and Related Material for Electronics" Strategic Research Cluster (SRC)
FORME SRC aims to examine cutting edge issues of direct relevance to Irish ICT companies in both the medium term and the longer. FORME SRC is linking two areas of high strategic importance to the ICT industry namely, Evolutionary CMOS and Revolutionary CMOS technologies.

FORME is bringing together academics and industrialists across Ireland to form a unique multidisciplinary team. As well as aimed at producing real advances in the technologies listed, FORME aims to contribute to the training of 18 PhD's. The participating companies are Glebe Scientific, Intel and SAFC Hitech and the principal investigators come from universities and research institutes from all over Ireland.

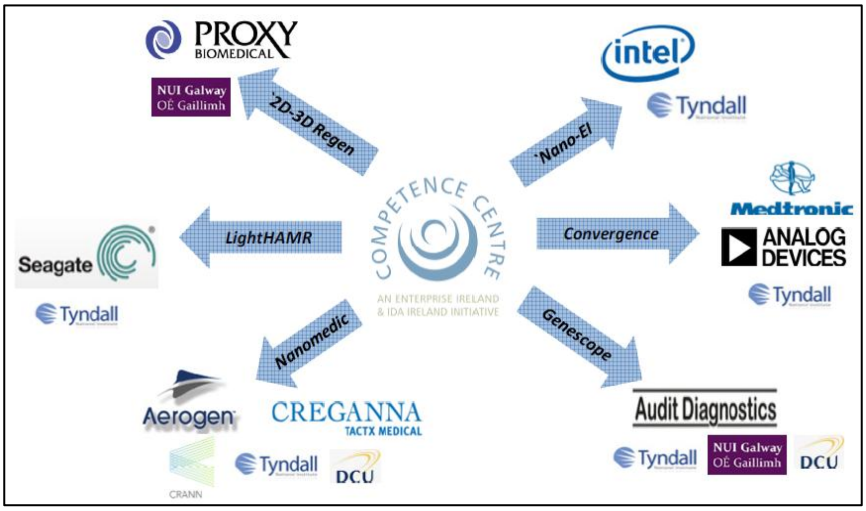
Another key development is the launch of the industry-led Competence Centres, a joint initiative between Enterprise Ireland and IDA Ireland allowing Irish companies and MNEs to work together in the centres. The topics are proposed and led by industry and bid for by research providers. This initiative was launched in 2007 with the aim to achieve competitive advantage for industry in Ireland by accessing the innovative capacity of the research community. The Competence Centres will focus on research focused on addressing clearly defined and validated industry needs. Six Competence Centres are already established.

One of these centres is the Competence Centre for Applied Nanotechnology (CCAN).

Competence Centre for Applied Nanotechnology (CCAN) – national applied research group led by industry
Competence centres were launched in 2007 and the Competence Centre for Applied Nanotechnology (CCAN hereafter) was launched as a joint initiative in 2010 by Enterprise Ireland and IDA Ireland as part of the Government's Strategy for Science Technology and Innovation 2006 -2013. CCAN is co-hosted by Tyndall National Institute, University College Cork and CRANN, Trinity College Dublin. In brief, CCAN acts as a central hub enabling companies from the ICT and biomedical industries to work together, with each other and with research institutes, to develop nano-enabled products and solutions to industry-defined problems. The members point out that this focus on industry-defined problems and the ability to collaborate with multiple partners are the major enabling factor for increasing the speed of the commercial deployment of nanotechnology.

CCAN carries out industry-directed research based on an open innovation model in order to accelerate project delivery in a collaborative environment with shared nanotechnology and product development expertise. The cumulated nanotechnology expertise is a key aspect as it creates the critical research infrastructure formerly missing from Ireland. Members can access the best nanotechnology R&D partner(s) for their needs and this is independent of location or university. This means that companies and researchers can use research capabilities from multiple universities all focused on the delivery of the best outcome for the member companies. The members span from indigenous technology orientated SMEs and international MNEs paired with universities and research institutes. Currently the member companies are collaborating across six medium-term product development projects with applications spanning from medical device, diagnostics and ICT markets, all part of the priority sectors pointed out in the Government strategy. The partners and projects are presented in the figure below.

Figure 1: Current members and project under CCAN



Due to the fact that this forum is strictly confidential and the members represent different markets areas, the exchange of knowledge and sharing of competences can take place without any IP-concerns. The differentiated member profiles enable the companies to develop networks and relationships with companies beyond their core market and find new applications and markets for their own background IP outside their core market. One positive effect is that the presence of Intel in Ireland has led to the establishment of the Competence Centre which in turn is benefiting Ireland SMEs, such as Proxy Biomedical, by introducing them to the benefits of nanotechnology.

The research institutes involved also have a strong industry and deployment focus. One example is Tyndall National Institute.

Tyndall National Institute – Creating clear communication between researchers and industry

Tyndall National Institute was created in 2004 at the initiative of the Department of Enterprise Trade and Employment and the University of Cork. Tyndall is the largest research institute in Ireland with 400 researchers, students, support staff and more than 110 PhD students. Tyndall has partnerships with more than 200 industry partners and customers worldwide, plus 5 start-ups based at the institute.
The focus at Tyndall is threefold:

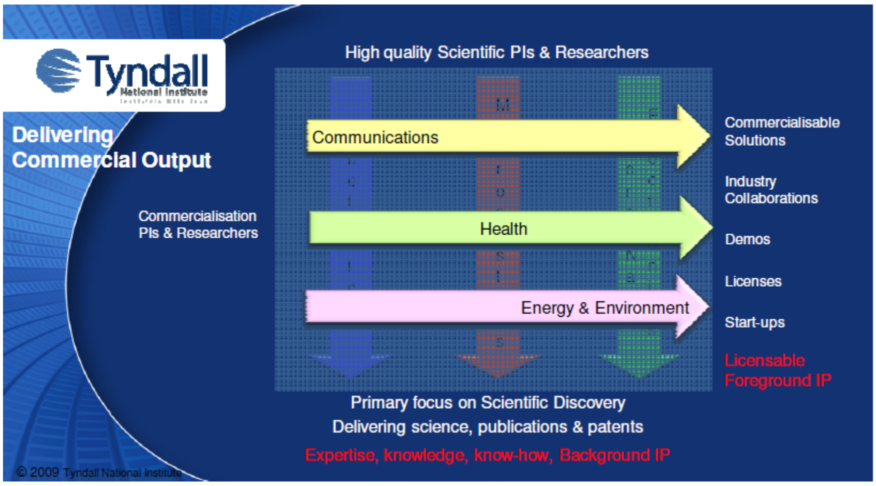
- *Scientific Research* – creating new technology in the field of Photonics, Micro/Nano-electronics and Microsystems
- *Commercialise Research* – by applying research outputs to real world challenges in Communications, Energy Health and Environment
- *Educate* – next generation of researchers & innovators through their Masters and PhD programs.

One of the major barriers for industrial deployment of enabling technologies is the communication gap between the scientific researchers and industry. This is not an Irish phenomenon, but Tyndall has an innovative approach to this.

In the strategy for delivering commercial output Tyndall distinguish between scientific researchers and principal investigators (PI's)/researchers (engineers). The scientific researchers are basically the 30% best scientific researchers and the PI/researchers are picked out amongst the remaining 70%. The 30% best scientific researchers will ensure high quality scientific research and the PI/researchers are the 'translators/brokers' who are able to close the 'communication gap' between scientist and industry as they understand both sides.

At Tyndall this is done within the three main themes aligned with the national priority areas. Distinguishing between scientific researchers and PI/researchers has closed the communication gap between basic research and the companies and improved collaboration with companies, both in terms of volume, but also quality (relevance).

Figure 2: Model for delivering commercial output at Tyndall National Institute



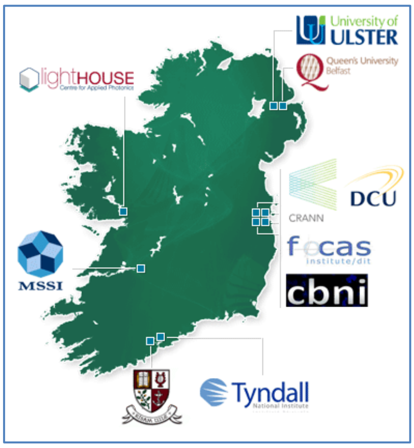
One important change in strategy for Tyndall is quite simple, but rather effective. It was decided to hire a communication employee at Tyndall, with focus on talking to industry about *usage of technology* – not technology on its own. This activity along with a strong factual basis has led to increased company interaction and closer to market research.
Tyndall also have a strong focus on expanding the number of PhDs, actually they aim to double the number of PhDs. Increasing the number of PhDs is also a key element in the Government's Strategy for Science Technology and Innovation 2006 -2013, as this will improve the knowledge base and thereby also the scientific critical mass.

Another research centre CRANN[160] is also supporting the nanotechnology research infrastructure.

[160] http://www.crann.tcd.ie/index

Centre for Research on Adaptive Nanostructures (CRANN)
CRANN was established in 2003 by a partnership between Trinity College Dublin and University College Cork and is funded through Science Foundation Ireland (SFI). The institute works across the research spectrum from the development of new technologies to their subsequent application in new devices or systems. CRANN currently has 17 principal investigators (PIs), who are linked to a broad range of disciplines. Each PI has a specialty area and an expert team.
What is particular about this centre is its high level of industry engagement. The main aim of CRANN is to develop new knowledge and build links with industry. Therefore, the infrastructure, which CRANN possesses, can be leveraged by industry. CRANN can either train companies in using the tools of the laboratories to create prototypes and/or conduct tests or the companies can pay the centre to conduct the testing for them. In this way, CRANN enables the companies to understand and characterise the technologies they got and provides them with support, which makes companies think about their competitiveness; thus the way from idea to commercial product is not as long as investments in expensive tools and equipment are not needed for the companies.
CRANN carries out collaborative research programmes with 30 companies, from small indigenous companies to large multinationals e.g. Intel, Hewlett-Packard. CRANN, in partnership with the Tyndall National Institute, also co-hosts the newly established Competence Centre for Applied Nanotechnology (CCAN).

INSPIRE – integrated nanoscience Platform for Ireland



Whereas the model for CCAN is primarily based on the commercial partners identifying the research needs and the research partners conducting the research, Both Tyndall and CRANN are also part of the **INSPIRE** (Integrated Nanoscience Platform for Ireland) network, a consortium of all Irish third level institutions with international leading research capability in nanoscience and nanotechnology. INSPIRE was funded to the level of €31.6M by the Higher Education Authority (HEA) and the mission is to foster, facilitate and ultimately ensure collaboration and partnership between top ranking Irish and international scientists and engineers in nanoscience research and education. INSPIRE's goal is to enable Ireland to join an elite group of the highest ranking nanoscience countries worldwide making it an increasingly attractive location for relevant indigenous and foreign investment. The vision is to establish Ireland as an internationally-recognised centre of excellence in nanoscience research and graduate education, providing shared access to advanced instrumentation, graduate courses and new strategic research partnerships.

Lessons to be learned from Ireland

Over the past decade Ireland has improved the infrastructure significantly and created conditions inviting to industrial deployment of key enabling technologies, especially within nanotechnology and photonics. This has been achieved through large infrastructure investments, but also through a focus on the indigenous strengths of the national innovation, which has resulted in a policy and investment focus in areas that will benefit the Irish economy in the long run. The focus in policy has also allowed research institutes to focus on both commercialisation and basic scientific research, and this has benefited the industry.

The results are already showing through increased number of industry led R&D projects, general industry involvement, and also by looking at Ireland's position globally in for example number of publication and especially patents in areas such as nanotechnology. It is still too early to judge if Ireland's efforts will lead to success in term of industrial deployment of KETs, but so far they have succeeded in increased industry involvement in R&D, and the next step will be to ensure that this will lead to high degree of commercialisation of the output from the projects mentioned above.

In order to fully exploit the knowledge created, Ireland still faces a number of challenges. The lack of critical mass is still an issue. Ireland cannot depend on the MNEs based in Ireland in the long run, so building up indigenous critical mass is extremely important. There are very few large companies in Ireland and according to the interviewees there is a lack of both Irish researchers and CEO pool. There is also a culture of investing in property instead of R&D, which is a barrier. The issue of Intellectual Property (IP) still remain a barrier for collaboration between universities and industry. The companies and research institutes all mentioned this as a major barrier. The issues are that the SMEs cannot afford the IPR and also the length of time it takes to come to an agreement is a major issue, as it delays the R&D and is extremely costly. It was also highlighted that it is a major issues that universities are judged on publications only, which a hindrance for commercialisation of the IP taken by universities.

Regarding the IP issue, both Tyndall and CRANN saw this as an issue that could be solved relatively pain free in their initiatives, but that it became a much larger issue in for example the European Framework Programmes. An IP brokerage service at the different host organisation could reduce the time of IP negotiations in the research projects.

How does Intel use the Irish research infrastructure and how does Ireland get return of investment?
One way of utilising the Irish nanotech network can be illustrated by how Intel operates. Intel has used the good research infrastructure and knowledge in Ireland for the initial stages of R&D. Intel Ireland work closely with their colleagues at Intel's Portland site in the USA to ensure that technologies developed in Ireland are relevant for future needs of the company. These technologies are transferred to Portland where they are evaluated in detail and if successful are integrated into future technology roadmaps. Intel Ireland is currently working on transferring such learnings to Portland in a number of areas.. Intel always tests and eventually deploys its technologies in-house and they are not interested in using the facilities in Ireland for the testing and commercialisation stage. Ireland's research network with Ireland's research infrastructure is an important factor in maintaining competitiveness for Intel Ireland within the corporation by upskilling of Intel's workforce in the technologies of the future as well as providing a pipeline of skilled post graduates to meet Intel's future hiring needs. Finally, as the previous example with Proxy Biomedical showed, the indigenous SMEs can benefit from having Intel and other international MNEs in the research projects at Tyndall, CRANN and the CCAN projects, but there are only scattered examples of this type of collaboration.

What can be learned from the Irish case?

- Focus on the niches strengths in both industry and research

The way Ireland has focused their policies to key niche areas has proved to be a key factor for increased industry involvement. The strategy has also been implemented and followed by the key research organisations and universities, which has strengthened the research structure significantly.

- Industry involvement/focus

Industry representatives have been involved in choosing the key priorities identified for policy and there is large industry involvement through steering groups, principal investigators and industry led projects. In CCAN projects are stopped if they are no longer relevant for industry or the Irish economy, which is a very strong signal.

- Addressing the communication gap between scientific researchers and industry

Letting the best scientists carry out the basic research, and engineers/researcher (for example PIs) use their knowledge on both industry and basic research to ensure that the communication/understanding gap with industry is minimized.

- Avoid duplication of expensive R&D facilities

Ireland has invested heavily in research facilities and scattered these in many different locations. However, through the competence centres and other initiatives, Ireland has secured that the different knowledge centres are collaborating when it is necessary. This has created a larger network for the industry and also a better network between researchers. Finally, this has also avoided duplication of the large investments in research facilities.

- Increase cross-sectoral research

The open innovation model works in projects where there are no direct competitors. This is possible when the projects are related to key enabling technologies, with application across industries. This will often avoid IP issues and it is also more likely that the R&D can get much closer to market compared to projects within one sector.

Issues and recommendations raised by interviewees

- *Simplification*:

There are too many programmes and differences in approach in FP7 and accompanying programmes – The terminology and rules need to be streamlined and simplified – CIP, JTIs, Article 169, KICs, ERC, ERA, STREPs, CSAs, NOEs, KETs, ERA NETs, ERANET+, PPPs etc. This is too much, particularly for companies to understand and to get to grips with the landscape.

- *Increased company involvement:*

Increase the involvement if industry in policy making, both national and EU.

- *Post project commercialisation*

Post project commercialisation should be a mandatory aspect of the evaluation criteria. Evaluation of impact currently calls for "dissemination and/or exploitation of project results". This is NOT strong enough. It should be AND Commercial Exploitation not "and/or" and this should be ranked the most important.

- *Access to infrastructure and networking of existing European facilities*

It should be easier to access European research facilities and there should be European Fab-labs in order to create European critical mass. This will also help smaller countries to access state-of-the art facilities.

- *Create a new program that is focused on commercialisation*

Allow a program to fund marketing, innovation and business consultants to monitor and implement commercialisation work packages in the work program. The projects should be allowed change direction during the course of the project. Most commercialisation projects (and R&D projects actually) end up somewhere different than originally intended.

- *Publish real-life RoI case studies demonstrating how cost effective it is for SMEs to take part in FP programs or other programmes.*

Interviewees

Name	Title	Association/company
Paula Maguire	Science Policy Advisor	Forfás
Liam Brown	National Delegate – NMP	Enterprise Ireland
Sergio Fernandez-Ceballos	National Contact Point - Framework Programme 7	Enterprise Ireland
Kieran Flynn	Head of Business Development	Tyndall National Institute
Leonard Hobbs	Engineering research Manager	Intel Ireland
Bernard Capraro	EU Research Project manager	Intel Ireland
Alan Hynes	Executive Director	CCAN
John O'dea	Director	Crospon
Jerry O'Brien	CEO	Radisens Diagnostics
Jim Whelan	Programme Manager	IDA Ireland
Diarmuid O'Brien	Executive Director	CRANN

Case study Jena, Germany - Photonics

Introduction[161]

Within the opto-electronics in a global perspective, Germany ranks third after Japan and USA[162]. In Germany, Thuringia is one of the centers for photonics with the city of Jena as the main center for a world-class cluster (see map). Jena has a very long tradition within optic technologies, which can be dated back to the foundation of the company "Carl Zeiss" in 1846 – a successful producer of microscopes.

Several changes and transformations have taken place since then. The very large Carl Zeiss-company is now operating on market conditions and encouraging entrepreneurial activity, and developing and strengthening a research and industrial infrastructure have been in focus[163]. An indication of success is that Jena has experienced the highest growth rates in the former East Germany, and the gross domestic products per inhabitant is 34,000 Euro compared to 28,500 Euro as the average for Germany.

Some key figures can shortly illustrate the uniqueness of Jena:

- Jena has about 105,000 inhabitants (31.12.2009)[164].
- About 100 companies within the optical industry are located in Jena and surrounding areas and they have a turnover of 1.32 billion Euro.
- In Thüringen, there are more than 170 companies with a total of 14,000 employees within the optic industry. Besides the above mentioned large, internationally oriented industrial groups, the industrial structure is also characterised by many medium sized companies (in average 80 employees per

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[161] Based on:
LEG – State Development Corporation Thüringen: Optics in Thüringen
JenaWirtschaft Business Development; http://www.jenawirtschaft.de/

[162] Hendry, Chris et. Al (2002): Understanding innovation: How firms innovate and what government can do to help – Wales and Thuringia compared. Angle-German Foundation for the Study of Industrial Society.

[163] Beibst, Gabriele et all. (2003): The Internationalisation of Thuringian Start-up Companies in High-Technology Industries Paper Prepared for Presentation at The Sixth McGill Conference on International Entrepreneurship University of Ulster, Northern Ireland. September 19 – 22, 2003

[164] Thüringer Landesamt für Statistik

company). These companies have a combined turnover of €2.5 billion and an export rate of 65 per cent.

- A well-developed research infrastructure with two universities and several research institutes for applied research[165].
- The labour market in Jena is characterised by very high skills:
  - 25 per cent of the employees have a university degree (Germany: 8 per cent) and 5.7 per cent of the employees are engineers.
  - 3,300 scientists are working in Jena and about 25,000 students (some 3,500 with optical science) are enrolled at the universities of the region.
  - Continuing training/education programmes are in operation to secure the supply of skilled workers.
- Photonics is only one of several technological areas present in Jena, and this means access to interdisciplinary research or technological deployment characterised as technological convergence.
- Since 1995, about 2,000 patents for optical technologies have been granted.

A company survey carried out by the OptoNet Association, shows that the industry considers itself as internationally leading as 24 per cent of the companies find that they are technological leaders and 69 per cent of the companies think that their main product has a top position[166].

All in all, Jena represents a unique specialization with photonics which covers the entire value chain from R&D, technological development, production to marketing and sales. A closer examination of Jena might highlight why this research and industrial infrastructure have performed rather successful.

Background and context

In order to understand the Jena-case, it is important to underline that Jena – the city council and other institutions in Jena – does not have any legal authority (legitimacy) to develop and implement R&D or industrial policy in terms of schemes and programs. This authority is in the hand of the federal government and, for some initiatives, the regions (Länder) (here Thuringia) who implement some funding schemes – e.g. within the framework of EU structural funds.

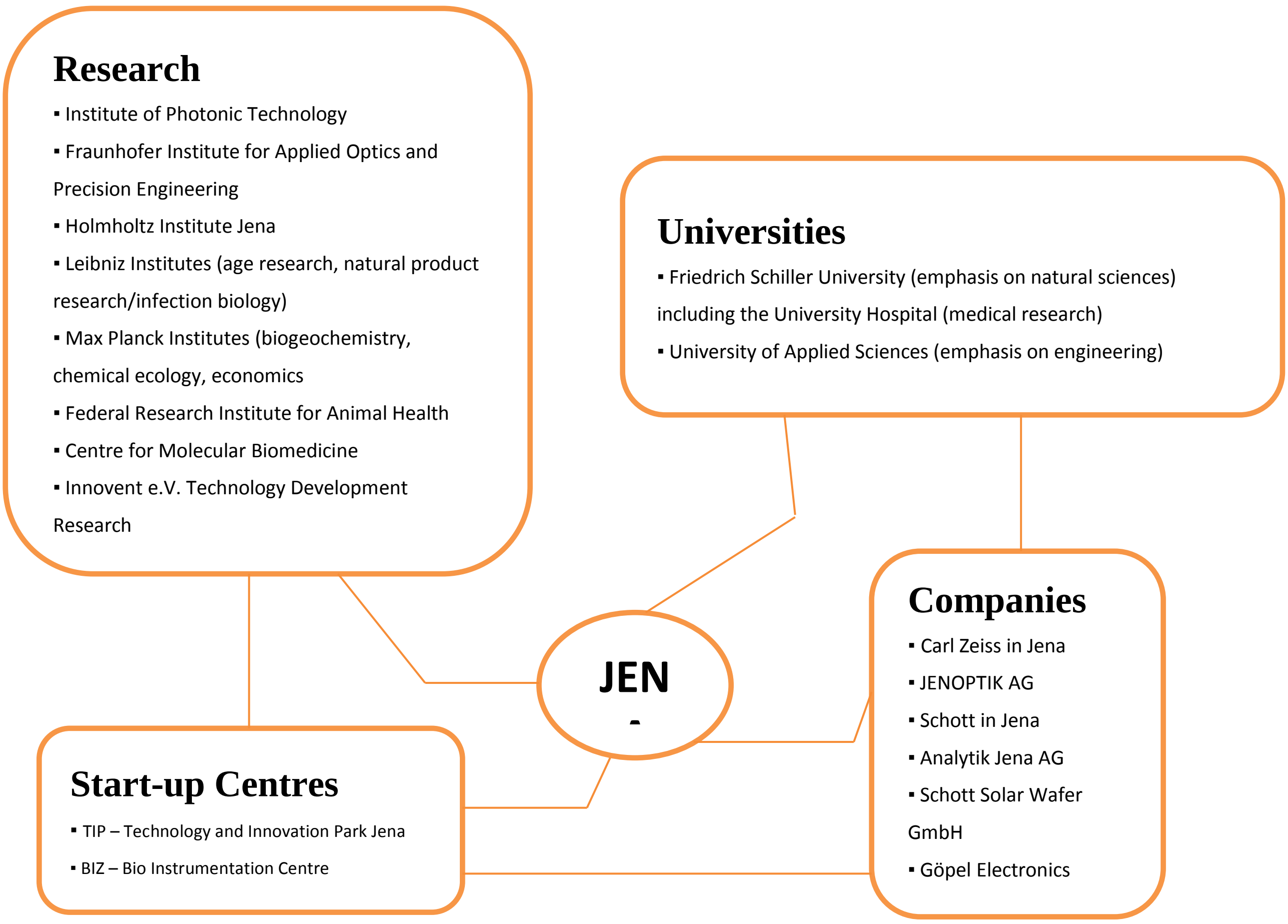
The local actors in Jena, e.g. R&D-institutions, companies, educational institutions etc. can use these funding opportunities to initiate activities that aim at encouraging the scientific and industrial specialization within photonics. These activities are typically limited to activities that are strengthening the general framework condition or facilitating initiatives of mutual interest. The success of photonics in Jena is not based on an overall master plan or strategic planning, but is embedded in a mutual interest (and ambition) of strengthening development and deployment of photonics. This ambition has been planted in some key facilitating preconditions, which has enabled an evolutionary bottom-up

[165] The Founders' Association of German Science has awarded Jena the title "Science City 2008" as a unique place for getting and developing new ideas.
[166] The OptoNet Association – survey among Jena based companies

process to take place. The common denominator is proximity and critical mass, which is present in two ways:

1. In Jena – and within in a very short distance - a number of research institutes, companies and universities are located and this number has even increased, se figure 1. Originally, there has been a tradition for applied research and a close collaboration between research and industry.
2. The institutional structure has been knitted together by informal relations who originate from the many employees who have been trained in Jena and work in the industry or at the research institutes afterwards.

Figure 6: The research and industrial structure in Jena



Source: JenaWirtschaft Business Development: Jena Light: Technology site Jena (a flyer)

The geographical proximity of the research and the industrial structure has been maintained even though the number of research institutes and companies has increased. Urban planning and urban marketing of commercial zones, technology parks and business parks have been some of the used instruments[167].

[167] Investing in Jena is subsidized until 2013 where especially small companies can receive up to 50 per cent investment supplement and funding from the Development Bank of Thuringia. Eligible for subsidies are acquisition and production costs for

However, the attractiveness of Jena is not only characterized by the research infrastructure and the industrial concentration and specialization but in the way technology transfer and knowledge flow are understood and organized. The technology transfer is more understood as a knowledge chain where knowledge is conveyed and transformed from basic to applied research and finally turns up in commercial products. Some of the key elements of kitting the knowledge chain together are:

- Access to *qualified labour* typically locally trained.
- Industry driven network and/or clusters as platforms for *informal and more formal relationships* and exchange of knowledge.
- *Collaborative R&D-projects* (pre-commercial and commercial projects).
- Networks and clusters as facilitators of *international business relations*.

All in all, the development and deployment of photonics (technology) is very much considered as a flow of knowledge where the capacity to transfer and to absorb new technology and products based on new technology is vital while the new technology in itself is crucial but not what makes the research and industrial system dynamic.

The first part of the knowledge chain is formed by the local universities, their institutes and local scientific networks, aiming to strengthen the Jena research focus for optics, photonics and photonic technologies. For example, The Friedrich Schiller University Jena[168] is hosting several institutes with a long tradition and competences within optics and photonics such as The Institute of Applied Physics, The Institute of Optics and Quantum Electronics, The Institute of Condensed Matter Theory and Solid State Optics and The Institute of Applied Optics. Further to be mentioned is the “Abbe Center of Photonics” (ACP)[169] [170] which has been established by the three science faculties and the medical faculty of Jena university e.g. to act in interdisciplinary research in the field of optics and photonics, materials and life sciences[171]. Apart from the research, the “Abbe School of Photonics” within the ACP is also playing an important role within training of young scientists.

Secondly, the research institutes, such as The Fraunhofer Institute for Applied Optics and Precision Engineering IOF[172], Institute of Photonic Technology[173] and Helmholtz-Institut Jena[174] are working with fundamental and applied research which is also vital for the development and deployment of photonics. Private and public funding are available for collaborative R&D-projects and the outcome is new technological knowledge and solutions. The value of these institutes were recognised in the interviews.

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economic goods of the tangible fixed assets (e.g. edifices, machinery and equipment). http://www.jenawirtschaft.de/en/investing/investing-in-jena/

[168] http://www.asp.uni-jena.de/Research/University.html

[169] http://www.asp.uni-jena.de/Research.html

[170] http://www.photonics4life.eu/P4L/News/Jena-strenghtens-Photonics-Cluster-with-the-Abbe-Center-of-Photonics

[171] Other interdisciplinary initiatives are also found in Jana such as The Interdisciplinary Center for Medical Optics and Photonics founded in 2010.

[172] http://www.iof.fraunhofer.de/center/index_e.html

[173] http://www.ipht-jena.de/en/institute.html

[174] http://www.helmholtz.de/en/research/promoting_research/helmholtz_institutes/helmholtz_institute_jena/

Thirdly, some initiatives play an very important role in facilitating an efficient knowledge flow between research and industry and within the industry itself:

- OptoNet - The competence Network for Optical Technologies in Jena
- CoOPTICS - Cooperate in Optics, a cluster initiative
- JenaWirtschaft Business Development

In the remaining part of the case, the focus will be at initiatives that are dedicated to improve the functionality of the knowledge chain.

Description of the initiatives

The description of initiatives will be focused at activities that originate from Jena. Attention will not be paid to initiatives implemented by the federal state or the regions (Länder) – except in the case where these initiatives are important for the Jena based initiatives. In these cases, there will be a link to these non-Jena initiatives or programmes, but without any further description[175].

OptoNet[176] is a network in Jena that promotes networking among its members and it is a platform for defining topics or issues of common interest which can result in collaboration within e.g. R&D.

The network was founded in 1999 and today it counts 90 members representing companies, research institutes, educational facilities, investors (including banks), tech-trans units and public institutions with the goal of promoting optical technologies.

The network was founded through a bottom up process initiated by the industry and today the network is still an industry driven network subsidised by the Federal Ministry of Education and Research.

The main purpose of the network is to be a platform for exchange of information which in some cases result in common R&D-projects or in business collaboration. Workshops are organised for discussions of technological issues or sharing information of mutual interest. Due to informants in the industry, collaboration is highly needed – and the companies invest in keeping and developing their network relations. These partnership networks are highly valued as the value chain is rather short including R&D, applied research, innovation, manufacturing and sale on a B2B market. The companies are typical specialised in a number of (niche-) markets, but they all have a technological platform within photonics. The shared platform of technology represents 90 per cent of their know-how while 10 per cent is unique selling propositions for the individual company which typically includes specific market knowledge. This means that the Jena-companies, in business, have different kinds of relationships to one another ranging from competitors, costumers, supplier and even developers/partners in R&D-projects. Consequently, the

[175] In Jena, founding is accessible for R&D-projects (individual projects for companies and institutes as well as for collaborative projects. Cluster initiatives, start up-companies and investment in news facilities/ premises where the founding is proved by EU or the federal government. In the interviews, these policy instruments are characterized as “standard programs”.

[176] http://www.optonet-jena.de/optonet?set_language=en

companies need each other for various purposes and have a mutual interest in having a platform in order to develop their network and share information and in some cases even initiate collaborative R&D-projects.

OptoNet does also facilitate international and national partnering in order to widen up the network and to support internationalisation of the industry especially the smaller companies. In a national perspective, OptoNet is also member of the German Competence Networks for Optical Technologies sponsored by the Federal Ministry of Education and Research within the national funding program for Optical Technologies.
However, making business is a matter of the industry and not the network. Therefore, the Jena-companies are not only solely technology oriented companies, but also actively evaluating the market potential of new technologies and products. For that purpose, methods such as business cases, technology road-mapping and IPR are used to analyse the market potential.

Furthermore, OptoNet does also play a role in encouraging training and further education having in mind that shortage of qualified people is a potential threat as an increased demand is foreseen within the photonic industry. Focus is both on engineers, other academic skills and skilled workers[177].

All in all, OptoNet brings itself into position in the knowledge chain of critical importance for the Jena photonic industry.

CoOPTICS[178]is an example of a large cluster initiative in Jena. The cluster counts about 250 members including companies, universities and research and educational facilities. The initiative is funded by the Free State of Thuringia (20 million Euro) in order "to push innovation into the growth markets ecology and energy, security and mobility as well as life sciences and medicine".

The objective of the cluster is to make a technological hub for optical technologies in Europe. The main instrument – and success of the cluster - is to facilitate that all kinds of partners have the opportunity to meet and allow economic and scientific challenges to develop. Focus is not only on encouraging innovation but also on strengthening Jena as a centre for education and training in optical technologies.

JenaWirtschaft Business Development[179] is a local business promoting organisation taking care of general marketing but with a dedicated focus at the technological (R&D) and industrial specialisation of Jena. Furthermore, they are responsible for location marketing. JenaWirtschaft also plays an important role in marketing or in attracting companies, employees and students from other regions and countries and in facilitating contacts.

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[177] See: http://www.bmwi.de/BMWi/Navigation/Technologie-und-Innovation/Technologiepolitik/Rahmenbedingungen-fuer-Forschung-Innovation/fachkraefte,did=377356.html
[178] http://www.cooptics.de/
[179] http://www.jenawirtschaft.de/en/business/

Results

Today, Jena is a very strong R&D and deployment centre within photonics, but also other emerging technologies. Jena has a long tradition with photonics, both in terms of R&D and industrial deployment, which can be traced back to the mid-19th century when the still existing company Carl Zeiss was founded. The case of Jena represents a technological and industrial path dependency, which has become a unique platform for further development and deployment of photonics.

However, the success of Jena is certainly not only based on passed and revitalised competitive advantages in terms of developing the research and technological infrastructure, but also on a dedicated effort to facilitate technology transfer as an interactive way of knowledge management and transformation. Focus is not only on facilitating knowledge creation and transfer but also on encouraging the collaboration, on the absorption capacity (e.g. training) of the employees/ companies as well as on the informal communication. Such competences have been vital knowledge for successful deployment and are characterised as tacit and intangible knowledge which sticks to all actors involved in the deployment process[180]. Besides scientific and technological knowledge, a key success factor of Jena is that sticky knowledge is recognized and initiatives have been made to facilitate development and maintenance of sticky knowledge in the entire knowledge chain.

The local actors especially the industrial representatives/companies and the research institutes have been a driven force in the bottom up process to develop initiatives to strengthen a well-functioning knowledge chain.

List of persons interviewed

- Managing director, Wilfried Röpke, JenaWirtschaft, Business Development
- CEO, Dr. Klaus Schindler, OptoNet e.V.
- Innovation manager Dr. Stefan Wiechmann, Jenoptik AG
- Scientific Director Prof. Dr. Jürgen Popp , Institut of Photonic Technology

[180] Gabriel Szulanski (2008): Sticky knowledge - barriers to knowing in the firm

Case Study Poland – Advanced materials

Introduction

Poland has experienced an annual GDP per capita growth every year since 1992 and the Polish economy has handled the global economic crisis well. The response of the authorities was, according to the World Bank, timely and adequate. Poland entered the crisis with relatively strong economic fundamentals and a sound financial system. The Polish authorities have taken a number of measures, including liquidity support and bank confidence restoring measures. While the EU10 contracted by 3.6 per cent, and the EU15 by 4 per cent, in Poland real GDP *increased* by 1.7 per cent in 2009. According to the World Bank, this was driven by private consumption and net exports. The global financial crisis in Poland has been muted for a number of reasons: the relatively solid initial macroeconomic situation (robust growth and manageable internal and external imbalances); the large size of the domestic market; the flexible exchange rate; and appropriate policy responses[181]. Although Poland is performing well, there several challenges for industrial deployment of Key Enabling Technologies (KETs) and innovation.

The latest Innovation Union Scoreboard report[182] from 2010 shows that Poland is lacking behind in innovation performance; Poland is ranked 22nd out of the 27 Member States. The only innovation category, where Poland scores above the EU average is *Human Resources* (ranked 12th), whereas they are ranked 26th in the *Innovators* category and 24th in *Linkages and Entrepreneurship*.

There are several explanations for the fact that Poland is lacking behind in terms of innovation. One reason is that Poland has experienced a large structural change since the fall of the 'iron curtain'. The strong state-driven R&D collapsed and the free market occurred. This provided many opportunities for entrepreneurs, mainly because it was very easy to set up a company and very little regulation. This lasted until regulation came in place and competition from abroad started to have an impact, so the entrepreneurial activity dropped. The universities became a good and safe place to work. Today there is a strong degree of 'scientists for science', where engaging with businesses is *generally* not seen as positive as it interrupts with the scientific goal. Also, many companies lost the R&D base, and many are still struggling with creating the capacity to absorb the results from R&D projects or even engaging on R&D projects.

[181] World Bank (October 2010): Country brief 2010 – Poland.

[182] http://www.proinno-europe.eu/inno-metrics/page/innovation-union-scoreboard-2010

This said, Poland has experienced strong growth and Poland naturally have strengths in both traditional sectors and in key enabling technologies, for example advanced materials. Examples of these are the aerospace industry and companies producing laser diodes. These will be highlighted in this case study.

Poland received a significant amount of funding from the Structural Funds for the period 2007-2013. Related to innovation is the 'Innovative economy' Operational Programme, with a total budget of just under €10 billion, with just over €8.2 billion from ERDF and the rest through national funding. This represents approximately 12 per cent of the total EU investment earmarked for Poland under the Cohesion Policy for 2007-13. A lot of the current initiatives related to innovation have been supported through the Structural Funds, but according to several of the interviewees, the funds are *not* being used for national initiatives for industrial deployment of *high technology research,* such as the KETs. This said, some of the companies interviewed have received funding through funding schemes supported by Structural Funds.

Why is Poland interesting to look at?
Poland is experiencing some challenges which have implications for successful industrial deployment of key enabling technologies (KETs). Poland has a low number of high-tech companies and little collaboration between universities/research organisations and companies. The importance of high-tech sectors, including the KET related sectors, is recognized as important for the future and progress are being made, especially in trying to make incentives for spin-offs from universities. However, many challenges exist, especially related to access to finance and industry-research collaboration.
This case study will introduce some of the initiatives in place in Poland and the challenges these initiatives are facing in terms of successful industrial deployment. It will also look at the challenges facing some of the successful spin-off companies, especially challenges related to access to finance. The Polish case is interesting as it describes some of challenges for industrial deployment of KETs common for especially some of the New Member States, with low innovation activity and a weak high-tech industry compared to the European average.

Policy initiatives and their challenges

Policy initiatives aimed at existing companies wanting to engage in R&D activities with universities or research institutions are rare at national level. There are several aimed at collaboration between scientific researchers through funding from the Ministry of Science and Higher Education and funding for entrepreneurial activities through the Ministry of Economy. A lot of funding is available at the regional level through the Structural Funds, but there is no particular focus on neither key enabling technologies, such as advanced materials, or industrial deployment in general.

However, some initiatives support collaboration between existing companies and universities with the aim of commercialization in focus.

A Bridge between Science and Business Measures 1.4 and 4.1 OP IE
Two of the measures in the Innovation Economy Operational Programme have proved very popular amongst the Polish companies. The measures *A Bridge between Science and*

Business Measures 1.4 and 4.1 OP IE is intended to address the fact the R&D level in Polish companies is low and that the R&D carried out at research institutes often does not match the needs of the companies.[183] The two measures are aimed at industrial deployment through *Support for goal-oriented projects* and *Support for the implementation of R&D results.* One interesting aspect of these measures is that companies only have to submit one application for the two stages, *research* and its *implementation*. The condition for obtaining investment support for the second part of the project is to successfully complete the research stage, which offers funding up to the development of a prototype, and this should offer a chance of market success for the new product.

The budget allocation for these two measures amount to €780 million, of which 60% is allocated to SMEs. Industrial research for the research phase is support up to 70% for micro/small companies and 50% for large companies and development work from 45% to 35%. At the implementation stage companies can receive funding for investments up to 70% for micro/small companies and 50% for large companies. Finally 50% of cost for consultants can be funded through measure 4.1. The upper limit for funding is €7.5 million for the research stage and €5 million for the implementation stage.

These measures have been so popular, that the funds for the two measures have almost been exhausted.

Importance of large foreign companies – the role of the Technology Partners Foundation

The Technology Partners Foundation[184] dates back to 1995 where the main objective was to carry out projects consisting of research and consultancy work related to the restructuring of Poland's research and development sector and adapting it to market economy requirements. The foundation took its current name in 2003 and today it is a scientific research and implementation organization specialized in research and development and innovation management and the performance of large-scale interdisciplinary national and international research projects. The foundation matches the needs of industrial clients (mainly international) and the Polish R&D institutions from identifying partners to quality assurance of the project. The services include:

- Identifying appropriate R&D potential partners
- Assistance to R&D Institutes in formulating appropriate proposals
- Contract negotiation and signing
- Project management
- Quality assurance.

The foundation has strong insight into and connections to the Polish universities and research organisations. One important role of the foundation has been to find R&D partners for major international companies with strong linkages to key industry sectors in Poland, such as the aerospace industry. The foundation also plays a major role in contract negotiation and project management. One example is the collaboration with Airbus.

[183] http://en.parp.gov.pl/files/214/3568.pdf
[184] http://www.technologypartners.pl/index.php/homepage.html

Collaboration with Airbus - Airbus has been working with Polish sub-contractors for more than a decade. This is due to the Polish long-standing expertise in aircraft production. In 2006 Airbus signed a strategic research framework agreement between Airbus and Technology Partners. It is a five-year cooperation agreement aimed at creating innovative aeronautic solutions using the latest technology. In April and May of 2007, three research contracts were signed with Technology Partners for an 18-month project which amounted to €650,000 directly financed by Airbus. These research programmes represent key technologies needed for the aircraft of tomorrow. Airbus and EADS are the largest investors and customers for the Polish aerospace industry with an estimated US$143 million worth of investment and purchase in Poland between 2005 and 2015. Together, they will continue to operate widely with Polish industry, currently actively involved in all Airbus programmes.

Source:http://www.airbus.com/myairbus/myairbus-single/detail/industrial-cooperation-polish-industry-contributes-to-all-airbus-programmes/archived-features/news-browse/10/news-period/1296557450/

The investment of Airbus and other large international companies (for example Solvay Group[185]) are important for Polish companies in order to be able to increase R&D, not at least due to the large investments from these companies in sector.

According to Mr. Kosmider, President of Technology Partnership Foundation, there are some general obstacles currently not being addressed in order to increase R&D in Polish companies. There is a visible separation and no natural linkages between Polish industry and research organisations and there is a very low R&D capacity in the companies, which means that companies either are unable to participate in R&D projects and if they can they are not able to absorb the results. This means that the successful development in direct transfer of knowledge from abroad, as highlighted in the Airbus case above, is a case of adopting existing technologies and not new technologies.

Technology platforms

In many Member States technology platforms are focused on industry/university collaboration. This is also true for some Polish technology platforms, but the vast majority of the Polish technology platforms only receive very limited funding and often none at all. Mr. Witold Łojkowski from the Institute of High Pressure Physics, Polish Academy of Sciences, is also coordinator of the Polish Nanotechnology Platform. Mr. Łojkowski pointed out that the technology platforms have had an impact in terms of bringing the scientific community together, but very little has been done to engage with industry.

This is not due to a lack of commitment from the people behind the technology platforms, but the fact that the vast majority of the work is done voluntarily. Also, the cultural difference between scientists and industry is a barrier and not a lot is done to change this. Recently the Nanotechnology Platform arranged an event where half of the participants were from the industry and it is the aim of the platform to build on this. However, without funding for these activities, the effect will be very limited.

[185] http://www.solvay.com/

Tech-transfer centres

There are several spin-off initiatives in Poland, such as technology transfer centres and national initiatives providing funding for entrepreneurial activity and spin-offs.

One example of this is the Centre for Technology Transfer and Entrepreneurship Development[186] at the Warsaw University of Technology. The Centre has several initiatives, such as incubators and cross-border programmes on tech-transfer methods and courses related to IP. One specific initiative is the national initiative, Innovation Factory OP IE 3.1[187] aimed at transforming ideas into companies. There are 20 projects within this initiative, where one of them is managed by the Centre for Technology Transfer and Entrepreneurship Development. The overall model, for each project, is that 100 ideas from the university is collected and reviewed by a panel, and off these 100 ideas, 30 will receive a small amount of funding towards IPR and incubators. Finally, three ideas will get €200,000 for towards creating a spin-off company.

However, according to Helena Korolewsk-Mróz and Andrzej Rabczenko (Director) from the Centre for Technology Transfer and Entrepreneurship Development, there are several obstacles for the initiative to be a success. One is the high level of bureaucracy in order to deal with the IPR and a second is that in order to get the €200,000 match-funding is required. This is very difficult to get and even more so if it is a high-tech company. Finally, there is an issue regarding who should manage the company, a young researcher or the professor with the idea. The scientists often lack management skills and the skills to make a solid business plan. Basically, in many cases, the scientist needs support from idea to market launch in order to be successful. Also, when it comes to high-risk technologies, such as advanced materials, it is difficult to get funding in the first place.
Another, well-known problem is related to cultural issues. Scientists are meant to do science and companies therefore don't see opportunities in collaborating. One suggestion from the interviewees from both industry and academia is that the first very important step has to be to focus on changing this perception.

Scientists not interested in collaborating with industry

One of several examples showing the barriers mentioned above is from Warsaw Technical University. The Association for Automotive Parts contacted the university in order to get help to solve a problem. They suggested that a master thesis could be done on the project. However, this was declined but the professors in charge of the technical area. According to the university's tech transfer center this shows the main problem, that the scientists are not interested in engaging with industry.

Although there seems to be cultural and economic barriers for creating spin-off companies from universities and the fact that there are few initiatives to support collaboration between industry and universities, there are examples of spin-off companies creating benefits for the university the people behind the spin-off company come from,

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[186] http://www.ctt.pw.edu.pl/en/aboutUs/

[187] Funded through the Structural Funds

their own spin-off company and industry in general. The text box[188] below shows how service innovation can lead to such benefits.

ME Group – a service spin-off company

In 2003 four colleagues from the Material Science Department at the Technical University of Warszawa decided to start a service company implementing knowledge of material research into industrial practice. The people behind the company saw a gap for smaller contracts, which were often turned away by the university because of the heavy bureaucracy. The four founders made a bilateral agreement with the university to use the specialized equipment at the university, which meant they could offer state-of-the-art services without heavy investments. Since then they have opened their own laboratory and today employ 22 people. The founders are still working at the university as scientists and in ME Group where they have managerial roles. The rest are employed directly by the company. http://www.megroup.pl/en/home.html

The business model used by ME Group provides mutual benefits for the university, company and industry:

- *University:* Increased income from the fees paid by the spin-off company for the use of their equipment in order to help the companies the university has previously turned away because of high bureaucracy (smaller contracts)
- *Spin-off company:* Can offer state-of-the-art equipment through the university and because they are still working for the university they have access to latest knowledge and developments on material science. The spin-off company can offer cheaper rates for smaller projects because of lower overhead costs
- *Industry:* The industry can get quick access to service and avoid bureaucracy for smaller projects, and also save costs because they don't have to pay large amounts for overheads.

Barriers to industrial deployment in Poland

Some of the barriers to industrial deployment of key enabling technologies are mentioned above, but in Poland one barrier stands out. The problem of access to funding for companies operating in high-tech sectors, and in this case advanced materials, is a major issue for the companies. European Venture Capital Funds are reluctant to invest in technology as the return of investment can be 4-5 years away or more. The tendency is for VC's to support companies with a shorter time to market. Loan from banks are according to the interviewees out of the question simply because the risks are too high.

[188] Based on interview with the Vice President of ME Group Lukasz Cibienski.

The company *Ammono*[189], a world leader in truly bulk Gallium Nitride (GaN) manufacturing used for lasers, needed €22 million to start production of GaN crystals used for lasers. They managed to get €5 million from grants from European Structural Funds and Polish funding. The remaining €17 million came from the large Japanese company Nichia[190]. Without this funding the company would not have existed. One of the down sides of getting funding through major companies outside Europe is that as a return they have ownership of the patents.

The product they have now is ahead of competitors, but in order to develop their product and stay ahead of competition from outside Europe (especially Japan and Korea), relatively large investments are needed. Even though Ammono is performing well, they do not have the capital for this investment, so they need to find funding, in order to stay competitive on the market.

According to the company there are three ways of getting the funding. The *first* is through European VC funds, but it is difficult and it comes with major demands, which could easily result in loss of management power. A *second* option is to enter the stock market, which is also risky and will need investors. The *third* solution is to move to company outside Europe, where the funding opportunities, according to the interviews, are much better. Ammono has been offered VC grants from the US (California), where there are many opportunities for companies at the stage where Ammono is now, but it came with the condition to move the company to the US. *Source: Interview with Robert Dwilinski, President of Ammono.*

The interview with the spin-off company TopGan[191], a manufacturer of blue/violet GaN laser diodes, showed that another major obstacle with European and national funding is to obtain match-funding. There are several European funding schemes, but the vast majority requires match-funding and this is, as mentioned above, very difficult in a high-tech sector because of the uncertainty and associated risks. Until now TopGan have mainly provided R&D services, but are hoping to enter the commercial market and start mass production, but this requires investments and even though they are close to the market, this is extremely difficult to obtain. The company are now trying to team up with a Scottish company in order to bid for funding through the Eurostars programme[192].

Another issue mentioned by the companies in relation to EU and national funding is that the time it takes to get funding is simply too long. The money is often received when the project is near the end and the funding available is not sufficient for many high-tech R&D projects.

Lessons to be learned and recommendations

It is important to mention that Poland has been and is performing well in economic terms. However, Poland is lacking behind in many areas in relation to innovation, which in itself is a major obstacle to industrial deployment of key enabling technologies.

Many companies lack R&D capacities and the ability to absorb the results of R&D projects, but the major obstacle is to get access to funding for high-risk investments. The

[189] http://www.ammono.com/
[190] http://www.nichia.co.jp/en/about_nichia/index.html
[191] http://www.topgan.fr.pl/
[192] http://www.eurostars-eureka.eu/

difficulty of obtaining funding for high-tech companies, should be investigated in detail at both national and European level as there is a major risk that these companies will either close down or move out of the EU to regions where funding is available.
Bureaucracy both within the universities and public organisations (for example IPR) is an obstacle for creating incentives for collaboration between industry and universities/research organisations and when initiatives, such as the technology platforms are not funded properly, then the effect is limited. There is larger focus on creating collaboration between scientists than transfer of knowledge to companies. Also, there is also a great divide between scientists at universities and industry. This is creating a very serious barrier for industrial deployment of KETs and transfer of knowledge in general in Poland. However, there are good examples of companies being successful spin-off companies, but there is a lack of support for these companies to grow at both national and European level.

Interviewees

Name	Title	Association/company
Robert Dwilinski	President	Ammono Sp. z.o.o
Witold Lojkowski	Head of Nanostrucures Laboratory and Coordinator (platform)	Unipress (Polish Academy of Science) and Nanotechology Platform
Krzysztof Jan Kurzydłowski	Director	National Centre for Research and Development (and Warsaw University of Technology)
Tomasz Kosminder	President	Technology Partners Foundation
Helena Korolewska-Mroz	Director	Center for Technology Transfer and Entrepreneurship Development
Andrzej Rabczenko	Director	Center for Technology Transfer and Entrepreneurship Development
Piotr Perlin	Head of Laser department	TopGan
Lukasz Ciupinski	Director	MEG

Case study Slovenia – Advanced Manufacturing

Introduction

Slovenia is a small, open and export-oriented economy with an estimated population of 2 million people in 2010. Approximately a quarter of the people employed in Slovenia work in manufacturing (2009 figures).[193] The Gross Value Added from the manufacturing industry in Slovenia is 23%, compared 18% average in the EU27[194], so the manufacturing industry is of major importance to the Slovenian economy.

Slovenia's ranking in the innovation scoreboard (Innovation Scoreboard, 2010) is relatively high, and Slovenia is now being recognized as innovation follower, one level up from the previous scoreboard. Improvement is mainly due to the increased investment in R&D and innovation system. But on the other hand, a major weakness and drawback is recognized on the output side, on industrial deployment and commercialization of the results of R&D investment.

Slovenia has a strong automotive sector consisting of 85 companies with direct supply to car manufacturers (tier 1) and 600 sub-contractors to these 85 companies (tier 2 and 3). Investment in R&D, especially advanced manufacturing and new materials has been important for the sector in the last decade. Today, the sector employs 24,000 people and the annual turnover is approximately €2.3 billion. 80% of the sales are export[195].
Slovenia's economic history is rather unique, especially after the post-Yugoslavia period.

A large part of the customer base disappeared in the early 1990's, for the automotive industry it was in the region of 80%. This left Slovenia with two choices, either to compete on low price labour or to invest in R&D. From both political and industry side it was quickly decided to focus on R&D as competing on price was seen as a short-term and non-sustainable solution. One of the downsides of losing the wider Yugoslavian market, except from income, was that the R&D departments were closed down in many companies.

Why is Slovenia interesting to look at?

The automotive sector is one of the sectors in Slovenia that has managed to rise to the challenge. The sector has created a strong network between suppliers and across all three

[193] Statistical Yearbook 2010, Statistical office of the republic of Slovenia
[194] Eurostat: Gross value added - Industry, including Energy - [tec00004]
[195] Interview with Director DusanBusen from the AutomotiveCluster.

tiers; in other words, the whole value-chain has been included in building up critical R&D mass and skills. The companies have managed to define niche areas in high-technology areas, where they can compete with the major companies in the sector. This case study will investigate the role of industrial innovation policy and initiatives on this journey and also find out what the companies have done. It will also look at some of the challenges the sector face and how this is addressed by policy, or not.

Also, the position of Slovenia in terms of being situated somewhere between cheap labour costs and high-tech intensive countries is true for all New Member States and some of the EU-15, so this case represent challenges seen in many of the Member States. Finally, Slovenia has been open in regards to their weaknesses in terms of economic competitiveness and lack of results from previous initiatives. The policymakers have responded through some interesting initiatives based on these challenges, both research led initiatives with focus on basic research with market orientation and industry led initiatives focus on applied research.

Background

As mentioned in the introduction, Slovenia lost a great share of R&D during the restructuring in the early 1990's and since then a large amount of public funding has been earmarked to re-establish a strong R&D base in Slovenia. The aim of industrial innovation policy in Slovenia has therefore first of all been to strengthen to R&D base within the key sectors and technologies of national importance. These sectors have been identified through different research projects carried out for the Government in the 1990's involving both industry and academia.

Several initiatives were launched in order to increase R&D and uptake of R&D in companies. National innovation policy at the time was focused on supporting clusters through regional clusters, technology networks and technology parks. In the period from 1999 to 2004 a total of 17 clusters and later in 2005 4 technology networks were establish, mainly with the goal to increase collaboration between industry and academia, but also to create strong links within the value chain of the sectors of national importance.

However, the clusters and technology networks were formed using a top-down approach and funding was limited both in terms of money and time. Active policy support for clusters and networks was cancelled in 2005. Many of the clusters had limited success, not at least due to the short time the clusters received funding. This was also pointed out in the Annual Innovation Policy Trends and Appraisal Report on Slovenia[196] from 2006 '*Funding has often been insufficient and irregular and several institutions spend much of their energy on survival instead of on carrying out the tasks they were established for*'.

As a result of this change in industrial policy orientation the Chamber of Commerce took the initiative and started the process of identification of the long-term needs for R&D investments in industry. This was inspired by the European Technology Platforms[197] approach. All together 22 technology platforms were organized, bringing together

[196] http://www.arrs.gov.si/en/agencija/inc/Country_Report_Slovenia_2006.pdf
[197] http://cordis.europa.eu/technology-platforms/individual_en.html

innovation leaders from industry and research groups from public sectors to discuss jointly technology trends and challenges for different sectors. As a result they developed strategic research agendas and defined priority technology areas for future investments.

One of the major successes of the clusters and technology platforms were that several key topics for R&D with market potential were identified by both industry and academia. These topics have been used by the Government to define major strategic areas, which are now used in the latest and largest R&D initiatives in Slovenian history, the Centres of Excellence and Competence Centres. These two initiatives are described in the section below.

Automotive Cluster of Slovenia

One of the first clusters to be established was the Automotive Cluster, which was formed in 2001.This cluster has played a vital role facilitating the process in forming a strong cluster where the whole value chain is active. The role and set-up of the Automotive Cluster, which is one of the few 'survivors' is presented in the next section. http://www.acs-giz.si/

Initiatives - importance the value chain and increased focus

As mentioned above, the first clusters and technology networks had limited success in achieving industrial deployment and according to the interviewees this is due to the fact that funding was only available for a short time period (four years) and the initiatives were led by the public sector. For some of the clusters this meant that the industry lacked incentives due to a mismatch between industry needs and content of the initiatives.

However, according to the Ministry of Education, Science and Technology, the aim of the initial initiatives was to stimulate networking and cooperation, bring together industry and academia to explore new opportunities. In some of the clusters where the industry took initiative, like the automotive cluster, the work continued and the clusters continued as non-for-profit organisations.

The Automotive Cluster

The role of the Automotive Cluster is to facilitate R&D through bringing together the whole Slovenian value-chain in the automotive industry. Building up relations was especially important at the start in 2001 and today, this is a benefit to the sector, both in terms of finding partners for public R&D projects, but even more important, it has created a cluster where personal relations provide easy access to vital information without cost.

The automotive cluster has set up working groups, consisting of people from all levels of the value-chain and research organisations. These groups are working on identifying synergies for R&D projects across the value chain and have also been very active in promoting the sector in the market and also politically. The latter has helped to establish funding for R&D projects which is based on what the automotive industry needs in order to increase quality and business excellence. One key aspect has been to identify the key strengths of the industry. Niche areas have been identified and also service innovation was a key aspect to deliver unique full circle products. There has also been a focus on finding generic topics for the future, such as creating products that increase safety and environmental performance in the automotive industry. Again this focus helped to strengthen and integrate this is the whole value chain.

The establishment of a strong value chain has improved the automotive sector greatly. Especially two areas have been improved. The first is that it is easy for the companies to find relevant partners both within the industry, but also academia for national or EU public R&D projects.

Mr. Nardin from Gorenje Orodjarna d.o.o.[198] mentioned that one of the major benefits of a strong value-chain is that partners from the value-chain, who are not direct competitors as they are at a different level in the value chain, can join up in R&D projects. This is especially true in R&D projects in advanced manufacturing and advanced materials where the results and technologies can be applied easily across different subsectors. This has increased the willingness to share knowledge.

The second area is the fact that collaboration and knowledge sharing often takes place without the involvement of any type of public initiatives. At the interview with Hidria d.o.o.[199]it was mentioned that when they get a new idea for an R&D project, they know who to contact, and if they don't, somebody else within the cluster will, also if the partner needs to be found outside Slovenia.

Another interesting example mentioned at the interview with Gorenje Orodjarna d.o.o. shows how close the Slovenian Automotive Cluster is. When Gorenje Orodjarna has a portfolio of projects exceeding their capacity, they often give the orders to another company within the cluster. According to Mr. Nardin, this is only possible because they have developed personal relations and trust over time.

Centres of Excellence (CoE) and Competence Centres (CC)

The first round of the Centres of Excellence programmes took place in the period from 2004-2008, mainly financed from the EU Structural Funds. Ten such centres were financed with about €15 million (for all 10 centres) for a duration of three years[200].
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After the first Centres of Excellence period the following reasons for lagging behind in competitiveness in Slovenia were identified as[201]:

- Low private R&D investments
- Weak cooperation between companies and knowledge institutions
- Weak networking and clustering
- Insufficient investment in applied and development research
- Dispersed financing – lack of focus.

[198] http://www.gorenje-orodjarna.si/en/
[199] http://www.hidria.com/
[200] http://www.centriodl.si
[201] http://www.centriodl.si/index.php?option=com_content&view=article&id=16&Itemid=32&lang=en

Two of the most recent research initiatives in Slovenia aim to address the above challenges by bringing together the strengths in research and industry, is the second round of Centres of Excellence and the Competence Centres. These are particular interesting as they distinguish between basic research (*research led*) and applied research (*industry led*).

Centres of Excellence

The aim of the Centres of Excellence is to bring together a high quality multidisciplinary group of researchers both from academic and business spheres, combining critical mass of knowledge and adequate research infrastructure for potential breakthrough of the Centres[202]. Therefore the focus is on basic research in order to achieve breakthroughs at a global scale in selected interdisciplinary fields.

The Centres determines R&D priorities and supports concentration of resources on technology areas that are crucial for the competitiveness of the Slovenian economy. The aim is to contribute to the efficient flow of knowledge and applications into products and services and is focused on reaching different goals and indicators, closely aligned to the indicators set out in the Operational Programme for strengthening regional development.
In the period from 2009-2013 the Slovenian Government published a call for eight new Centres of Excellence, with 100% funding for the R&D projects – the largest and most concentrated investment in R&D to date with €77.5 million awarded to the eight Centres of Excellence, selected amongst 60 applications on the basic criteria of the research competences and excellence, quality of partnership and relevance.

The Centres cover the following fields:

- Nano-science and nanotechnology
- Biosensors, instrumentation and process control,
- Chemistry and biology of proteins,
- Low-carbon technologies (hydrogen and lithium batteries),
- Non-metallic materials (ceramics),
- Plastic materials,
- Space science and
- Nuclear magnetic resonance studies[203].

Each project has to establish a new legal entity managed by the partners, and in the Centres of Excellence this entity is led by a research organization.

Below is an example of a consortium established through the Centres of Excellence:

[202] Internal document from the Slovenian Ministry of Education, Science and Technology
[203] Internal document from the Slovenian Ministry of Education, Science and Technology

Advanced Materials and Technologies for the Future; CE: NAMASTE is a multidisciplinary and trans-disciplinary consortium of research institutions and industry, who have decided to merge academic, technological and business expertise, skills, and equipment, with the aim to reach crucial technological advancement in selected areas, related to inorganic non-metallic materials and their implementation in electronics, optoelectronics, photonics, medicine, and by that to markedly increase the added value, the relevance of research and scientific excellence in accord with the strategy of the development of Slovenia. The activities of the consortium include research, development, education, and promotion. The consortium consists of three research partners with ten groups, three non-profit organisations, four large companies and eight SMEs.

Competence Centres

Whereas the Centres of Excellence are led by universities and research institutions and focused on basic research, the Competence Centres are led by industry partners and focused on applied research. The aim of the Competence Centres is strengthening development capability and the use of new technologies for the development of new competitive products, services and processes in the priority areas of technological development.

In the projects, the integration of knowledge and competences of companies and research organisations in certain technological areas is encouraged, namely the areas that show a critical mass of knowledge and capability for development and the use of new technologies. The scheme is considered as state aid.

In the framework of the scientific and technological policy of Slovenia, the Competence Centres are a measure, intended for the encouragement of knowledge concentration on the priority technological areas, and for horizontal agreement in the entire chain of knowledge development, carried out on the basis of strategic partnership between the industry and academic spheres. It involves an integrated research development programme from industrial research to demonstration and validation with the stress on the horizontal goal of encouraging transition to an energy efficient economy and low carbon society in the priority areas of technological development, namely:

- User Platforms and Interfaces
- Network systems and services
- Food and Health Biotechnological research and innovation
- Biomedical engineering
- Process Technologies
- Sustainable Building Industry;
- Effective use of energy (smart grids).

The calls for Competence Centres for the period 2010-2013 were launched in summer of 2010. The funding available for the calls was around €45 million. 7 CCs were eligible for funding and each of them was awarded €6.4 million. Competence Centres combines 46 companies, highly focused on new technologies and 16 universities and/or research institutions. The selection criteria stressed highly the competence of industrial partners (added value, R&D and innovation performance), relevance and implementation capabilities.

Some of the CC's funded were identified in the CoE selected process. They had received a positive evaluation, but did not receive funding for the CoE programme. Instead the international and national experts reviewing the applications encouraged them to submit an application for the CC programme as they the topics were more suited for applied research.

Below is an example of a consortium established through the Competence Centre:

Competence Centre BRIN
Competence Centre for Research and Innovation in Biotechnology »KC-BRIN« will operate in the priority area »Food and health« The aim of the Centre is to increase competence of Slovenian companies and academic research institutions in this field. The proposed activities of the Centre include research in the fields of probiotics, functional foods and dietary supplements as well as naturally produced active ingredients used to improve human and animal health. The goal of the proposed research is to generate new knowledge and use it for development of novel products with higher added value which will further strengthen the partners' competence. The CC is led by 6 industrial partners covering the whole value chain. Two national leading public institutes (Institute Jozes Stefan and National Institute of Biology) and University of Ljubljana are participating.

Access to finance

Access to finance for the most critical and high risk part of the experimental research and commercialization is recognized as an important gap. Research and innovation policy in last three years is putting strong emphasis on development of efficient financial mechanisms to complement research (grant) funding with the accessible loan or equity financing opportunities.

Financial engineering was introduced as new financial instrument in 2009. The Holding fund was established, managed by the Public Small Business Fund and €35 million from the ERDF Operational Program invested to stimulate development of the venture capital market in Slovenia. The Holding fund is investing in private, venture capital and seed capital funds, operating in the country to increase the overall size of the equity financing for innovative companies in early stages of development.

Additional to that financial engineering instruments are also developed to improve access to loan financing for industrial research and commercialisation. €100 mill public funds was invested in 2010-2011to stimulate private financial institutions to support R&D and innovation projects with special guarantee and interest rate subsidies. Initiative has high leverage effect; all together there are €300 mill additional funds available on the market[204]. Mr. Busan from the Automotive Cluster mentioned the funding from especially the Holding fund has created many opportunities for the companies in the cluster, a point also made by some of the companies.

[204] Information from the Slovenian Ministry of Education, Science and Technology.

Barriers to Industrial deployment in Slovenia

Three major barriers for industrial deployment were mentioned by the companies interviewed; *access to qualified labour (engineers)*, *access to funding for companies with more than 250 employees* and *lack of interest from universities to engage with industry*.

Access to qualified labour

In order to engage in R&D activities it is vital for the companies to have access to engineers, but in Slovenia this is extremely difficult. A high proportion of engineers and researchers are choosing to work at universities or other state institutions due to higher wages (starting wage is lower in private sector) and job stability. Mr. Savšek from TPV d.o.o.[205]mentioned that TPV along with other companies from the automotive industry created a list with competences needed in the industry and asked a university faculty if they could provide a course, but the faculty they approached were not interested. There are currently talks with another faculty to provide a training course based on industry needs.As a result of the lack of engineers in Slovenia Hidria d.o.o. provide scholarships for 100 people every year.

Access to funding

All companies interviewed have more than 250 employees and are in Europe considered as large companies. However, many of their foreign competitors have very large R&D departments (some of them with more than 1000 employees in R&D departments). The major issue mentioned by the companies is that there is a funding gap for companies to grow. Some of the companies have participated in the European Framework Programmes (FP's) and this has helped the companies with ideas, but not in terms of growing their business and commercialise the research. This has according to the companies interviewed large complications for sustaining the value chain in the automotive industry in Slovenia, where there are no car manufacturers, only suppliers. The results of the FP's are often far away from the market and for 'large' companies with for example 500 employees there are very limited funding opportunities to take the research results forward. Also, sector and technology focus on projects funded often change along with new funding periods.

Another issue pointed out as a barrier is that the FPs often creates good relations with companies in other Member States. However, further collaboration funded by national funding schemes is often not possible, as many national funded projects do not allow foreign companies to participate. This is a particular problem for smaller Member States like Slovenia and creates a lack of critical mass. CoE and CC thus devoted particular importance to this issue. While partners from other countries are eligible in CoE, costs of R&D services are eligible regardless of the country of origin. One European Programme was pointed out as very positive. *Factories of the Future*[206], an FP7 programme of Public-Private Partnership included in the Commission's recovery package was seen as having a positive impact towards industrial deployment with more focus on industry needs and faster time to market.

[205] http://www.tpv.si/en/

[206] http://ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html

Universities not interested in industry projects

The well-known ‘scientist for science’ is also a major issue in Slovenia. The university culture is not encouraging collaboration with research and this is a large issue as a relatively high proportion of engineers and researchers are working at the universities or state institutions. In the automotive industry in Slovenia this is an issue, but the strong value chain and network means that the industry has created strong linkages with *individuals* at universities, not *faculties*, but this does not cover all research areas.

Interviewees

Name	Title	Association/company
Simona Rataj	Technology Development Director	Slovenian Chamber of Commerce
Mag. MatejaMesl	Secretary, Cabinet of the Minister	Ministry of Higher Education, Science and Technology
Dusan Busen	Director	Automotive Cluster of Slovenia
Dr.Blaž Nardin	Director	Gorenje Orodjarna Former head of Manufuture Slovenia
Tomaž Savšek	Assistant General Director	TPV d.d
ZivkoKavs	Vice-president of Management Board	Hidria d.o.o.

We would like to say thank you to all participants and a special thanks to Dusan Busen from the Automotive Cluster for identifying relevant interviewees and Masa Repez for letting us use the facilities at the Chamber of Commerce and identify relevant interviewees.

Case study Cambridge, UK – Industrial biotechnology

Introduction

The UK is the second largest economy of the EU, behind Germany. It comprised 14.4%[207] of total EU27 GDP in 2008. The dynamics of real GDP growth in the UK over the last 10 years can be divided into two time periods; between 2000 and 2007, real UK GDP growth hovered between 2% and 3%[208]. From 2008 onwards, when the global economic and financial crisis struck, UK real GDP growth turned negative with a dip of -4.9% in 2009[209]. In 2010, GDP recovered, growing by an estimate 1.7%.

With regard to the economic structure of the UK economy, Eurostat data for 2008 indicate that three quarters of the gross value added in the UK was created in the services sector[210] [211] whereas industry and construction made up a little less than 24% of the gross value added in 2008. The fourth sector, the agricultural sector, accounted for less than 1% of the UK Gross Value Added. In comparison to 1998, the share of the services sector has increased by 6 percentage points whereas the importance of industry & construction decreased by nearly 5 percentage points.

In terms of spending on R&D, overall, in 2007, the UK spent €36.7 billion. R&D intensity, (measured as R&D expenditure as a percentage of GDP) was 1.79%, falling just below the EU average of 1.85%[212]. R&D intensity in the UK has fluctuated around this level for more than a decade although in 2007 all classes of R&D expenditure had registered a considerable increase.

Why is the UK interesting to look at?

The UK is in a good position to compete with European countries and the USA regarding underpinning research in industrial biotechnology[213.] The UK is acknowledged as having a bioscience base second only to the US[214]. It is well-placed to lead Europe in areas such as biocatalysis, biotransformations for low to medium volume, biocatalytic manufacture, and high added value products such as speciality chemicals, nutraceuticals, flavour and

[207] Measured in terms of PPS (purchasing power standards); source: Eurostat Yearbook 2010.
[208] OECD statistics
[209] http://www.parliament.uk/briefingpapers/commons/lib/research/briefings/snep-02783.pdf
[210] Services are defined as (a) Trade, transport &communication services; (b) Business activities & financial services and (c) Other services. Source: Eurostat Yearbook 2010.
[211] The three groups of services identified above accounted for 71.6 % of total gross value added in the EU-27 in 2008.
[212] Erawatch research inventory report for the UK
[213] http://www.berr.gov.uk/files/file51237.pdf
[214] Paper IB-IGT [SG-08]:6, Mapping UK Industrial Biotechnology

fragrances. Knowledge and experience of applied biotechnology are growing and advancing rapidly. Historically the UK's biotechnology activities have been focused on the life science sector and on medical biotechnology; for example the majority of clinical programs in development (71%) of British companies are in Phase II or later[215]. However, the use of biotechnology for the production of energy, chemicals and materials from renewable resources has created significant interest in the last years[216].

Although the UK has an excellent research base in biotechnology, they struggle to commercialize their biotechnology research. The UK has a lack of interdisciplinary research and possesses few demonstration facilities. Moreover, the UK does not have the chemical industry with a strong interest in industrial biotechnology that other countries have[217]. What makes the UK interesting to look at is the fact that the UK developed two strategies to support Industrial Biotechnology:

- **'A Strategy for non-food crops and uses – creating value from renewable materials'** has been produced by the Department for Environment, Food and Rural Affairs (DEFRA) and DTI (now BERR[218]) in 2004. This strategy includes areas such as tackling climate change, funding scientific research and increased use of sustainable products.
- **'The UK Life Science Strategy'** was published in 2007, and covers amongst others the use of biotechnology to produce more sustainable products[219]. The UK also has a few dedicated funding programmes to support industrial biotechnology.

Background

Importance of Industrial Biotech for the UK

The UK has a very strong bioscience base. In particular Cambridge has a strong science base that comprises not just the University of Cambridge, but also Addenbrooke's Hospital, the Medical Research Council Laboratory of Molecular Biology, the Sanger Centre, the Babraham Institute, and the European Bioinformatics Institute, along with over 250 biotechnology companies[220]. The formation of the Cambridge cluster began in 1960 with Cambridge Consultants Ltd, a spin-off from the University of Cambridge[221]. It comprises a biotechnology cluster that is known for its healthcare and medical technology developments. Seen the global environmental concerns (low carbon economy) together with the energy and fuel security, there is an increasing interest in industrial biotechnology. Industrial Biotechnology (IB) is the modern use and application of biotechnology for the sustainable processing and production of chemicals, materials and

[215] http://www.ey.com/Publication/vwLUAssets/Beyond_borders_2010/$File/Beyond_borders_2010.pdf
[216] http://www.berr.gov.uk/files/file51144.pdf
[217] http://www.berr.gov.uk/files/file51237.pdf
[218] DTI is the Department of Trade and Industry; BERR is the Department for Business, Enterprise and Regulatory Reform
[219] http://www.berr.gov.uk/files/file51237.pdf
[220] http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2003_08_29/noDOI.14178992370365584642
[221] http://www.insme.org/documents/cambridgeStruct.pdf

fuels. It is also called ‘white biotechnology’ as it involves the use of microorganisms, biochemistry, biocatalysts, biochemical engineering and fermentation[222].

The estimates for the global IB market by 2025 range from £150 billion to £360 billion and similar estimates for the UK IB market range from £4 billion to £12 billion[223]. The potential of IB for the UK is particularly important with regard to applications in the chemical and pharmaceutical sector as these are key UK sectors. The chemical sector alone is one of the most successful, with sales of £60 billion per annum, exporting £43 billion and contributing a £6.5 billion surplus to the UK’s trade balance, mostly in high value chemicals[224]. However, as IB 2025[225] has identified, the take-up of this promising technology in the chemical sector has been modest to-date (£1.8 billion), in contrast to its well established and highly successful use in pharmaceuticals. On the other hand, IB is well established in the UK pharmaceutical industry due to its contribution to high-value, high-speed drug development. This is due to the fact that in the past, biotechnology research was often focussed on non-renewable chemicals, for example the development of pharmaceuticals[226].

This trend is changing at a number of UK academic centres which have recently developed active research programmes encompassing the use of biomass-based chemicals such as the Green Chemistry Centre of Excellence in York, the Satake Centre for Grain Process Engineering in Manchester, the BioComposites Centre of Excellence in Bangor, and the Centre for Sustainable Chemical Technologies in Bath. This enables the UK to build significant expertise in the development of enzymatic catalysts for manufacturing processes, fermentation technologies, bio-prospecting, utilizing the functionality of molecules, and chemical transformations.

UK strategy for Industrial Biotechnology

The **Biotechnology and Biological Sciences Research Council (BBSRC),** a UK funding agency, annually invests around £450 million in a wide range of research that makes a significant contribution to the quality of life for UK citizens and supports a number of important industrial stakeholders including the agriculture, food, chemical, healthcare and pharmaceutical sectors[227]. It has created the Integrated Biorefinery Research and Technology Club (IBTI Club) which is a £6M, 5-year partnership between BBSRC, the Engineering and Physical Sciences Research Council, and a consortium of leading companies aimed at developing biological processes and feedstocks to reduce our current dependence on fossil fuels as a source of chemicals, materials and fuel[228] (see also box below). It has also set up the BBSRC Sustainable Bioenergy Institute which is an innovative academic-industry research partnership to underpin development in the important and emerging bioenergy sector[229]. This Centre represents a £24M investment to increase the UK bioenergy research capacity.

[222] http://www.berr.gov.uk/files/file51236.pdf
[223] http://www.berr.gov.uk/files/file51891.pdf
[224] http://www.berr.gov.uk/files/file51891.pdf
[225] http://www.berr.gov.uk/files/file51144.pdf
[226] http://www.berr.gov.uk/files/file51237.pdf
[227] Cambridge network.co.uk/news
[228] http://www.bbsrc.ac.uk/business/collaborative-research/industry-clubs/ibti/ibti-index.aspx
[229] http://www.bbsrc.ac.uk/organisation/institutes/sustainable-bioenergy-centre.aspx

Another interesting actor is the **Technology Strategy Board**. This is an executive non-departmental public body, established by the Government in 2007 and sponsored by the Department for Business, Innovation and Skills (BIS)[230]. Their mission is to "Connect and Catalyse" to ensure that the UK is in the forefront of innovation enabled by technology. They have defined bioscience as a key technology and coordinate the Knowledge Transfer Networks (KTN) such as the chemistry innovation knowledge transfer network and the bioscience for business knowledge transfer network. Also the **Engineering and Physical Sciences Research Council (EPSRC)** and the **Department for Environment, Food and Rural Affairs (DEFRA)** have an interest in biotechnology.

The Cambridge Cluster

The Cambridge cluster houses several initiatives that contribute to the success of the cluster. It is a unique interplay between universities, incubators, companies and network initiatives. Initiatives like Cambridge Science Park, Cambridge Network and One Nucleus are essential elements to create an ecosystem as they facilitate the transfer of knowledge between different companies and universities. To create a vibrant ecosystem, you need these facilitators to let knowledge flow between the different actors.

University of Cambridge

The University of Cambridge entails several departments that perform research in the area of industrial biotechnology. The department of chemical engineering & biotechnology for example has the aim to play a key role in global issues such as the environment, sustainability and healthcare. They want to advance their knowledge in chemical engineering and biotechnology through working at the interfaces with the underpinning science disciplines of chemistry, biology and physics[231]. One example is presented in the textbox below[232]. The university also houses the department of clinical biochemistry that has the aim to conduct high quality biomedical research.

Institute of Biotechnology, University of Cambridge

In 1988, Professor Chris Lowe set up the Institute of Biotechnology as a center of excellence for biotechnology research, training and entrepreneurship. Since then, the Institute has grown to a staff of 135, including PhD students, post-doctoral research associates, academic and support staff, with expertise in areas including molecular biology, **microbiology**, biopharmaceuticals, anhydrobiotechnology as well as chemical and biological sensors.

Professor Chris Lowe won the Most Entrepreneurial Scientist Award in UK in 2006 as he has a very strong interest in creating a seamless interface between academia and industry. He has been responsible for spinning out 8 companies employing over 200 people which were estimated to be worth in excess of £500M in 2006. He holds a number of non-executive directorships and actively promotes the entrepreneurial ethos within the University and wider community. He has overall responsibility for and teaches on the unique and highly over-subscribed Master's in Bioscience Enterprise course at the Institute of Biotechnology.

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[230] IB 2025 "Maximising UK Opportunities from Industrial Biotechnology in a Low Carbon Economy", 2009, Report to government by the Industrial Biotechnology Innovation and Growth Team. http://www.innovateuk.org/aboutus.ashx

[231] http://www.ceb.cam.ac.uk

[232] http://www.ukti.gov.uk/uktihome/aboutukti/successStory/107772.html

Cambridge Science Park

Cambridge Science Park provides high-quality, flexible laboratory and office buildings to a mixture of spin-outs, new ventures from the Cambridge area and elsewhere in the UK, and UK subsidiaries of multinational companies. Cambridge Science Park focuses on high-tech sectors and opened an Innovation Centre in 2005 with the aim to support early-stage companies to flourish and grow. The Park houses several companies active in the bio-medical industry, but few companies active in industrial biotechnology[233].

Babraham Institute

The Babraham Institute has the aim to undertake innovative, life sciences research to generate new knowledge of biological mechanisms underpinning lifelong health and wellbeing. It is supported by the BBSRC and located in Cambridge, UK and currently employs around 750 people. It houses the Babraham Research Campus which is one of the leading centres for bioscience innovation in the UK and the Babraham Bioscience Technologies Ltd. The latter institute is the commercial arm of the Babraham Institute that promotes, supports and encourages academic and commercial biomedical research locally, regionally and nationally. They are also responsible for managing the Bioincubator buildings which provide around 70,000 sq ft lab space to 30 early-stage biomedical companies. The institute is renowned for its knowledge in monoclonal antibody development and antibody technology complements[234].

Granta Park

Granta Park is one of eight Business Estates managed by the UK business estate agency MEPC located in the heart of the Cambridge Science Cluster. The park was launched in 1997 and houses several companies such as MedImmune, Pfizer, PPD and TWI. They offer smaller office and R&D/laboratory space with the aim to attract leading companies of the future[235].

Cambridge Network

Cambridge Network is a network organisation that has the aim “to link like-minded people from business and academia to each other and to the global high technology community for the benefit of the Cambridge region” [236]. They offer an efficient web platform to academics and businesses which allows them to post events, news and jobs. A non-profit subsidiary of the Cambridge network is The Learning Collaboration which helps companies find staff and improve their skills by pooling recruitment and training for small organizations with some of the largest companies in the region. The networking activities in combination with recruitment and training offers unique value to strengthen the Cambridge cluster.

One Nucleus

One Nucleus is a membership organisation for international life science and healthcare companies, based in Cambridge and London UK. One Nucleus was formed in April 2010 by the merger of two regional life science networks – Cambridge-based ERBI and the

[233] http://www.cambridgesciencepark.co.uk
[234] http://www.babraham.ac.uk
[235] http://www.mepc.com/grantapark
[236] http://www.cambridgenetwork.co.uk

London Biotechnology Network (LBN). They claim that London and Cambridge are home to at least 60% of the UK's life science industry base, four of the UK's five Academic Health Science Centres and three of the world's top six universities[237]. Therefore, their aim is to create an international life science "super cluster". In that regard, they have set up a collaboration called "The Golden Triangle Partnership" with Oxfordshire Bioscience Network (OBN) to combine the knowledge in life sciences and healthcare present in Cambridge, London and Oxford. This partnership wants to provide its member's access to potential partners and investors. Therefore, several Memoranda of Understandings were signed with different partners such as Massachusetts Biotechnology Council, Massachusetts Medical Device Industry Council, and BioCom in San Diego. One Nucleus facilitates the transfer of knowledge between several global centres of excellence.

Lessons to be learned from the UK

UK strengths and weaknesses in industrial biotechnology

The Bioscience for Business KTN made an analysis of the UK capabilities in Industrial Biotechnology in 2009, which is summarized in the table below[238].

UK Strengths	UK Weaknesses
• Strong history of research in underpinning areas: microbiology, molecular and structural enzymology, biochemical engineering • Strong expertise in biomass feedstock research; both in plant and marine sciences • UK well placed in systems biology particularly as mathematics and biology links are being established • Consolidation of activities by Bioscience for Business and Chemistry Innovation KTNs resulting in a core community comprising both academics and industrialists, with good relationships amongst its members • Established Centre of Excellence for Biocatalysis, Biotransformation and Biomanufacturing, including close contact with industry and access to scale-up facility • Centre for Process Innovation at Wilton providing consultation and scale-up facilities • Genuine commercial interest evidenced by company financial commitment to industrial biotechnology research (e.g. IBTI) • Close contacts with European and US groups through CoEBio3 and KTN infrastructure • Governmental support of sustainable products and technologies	• Lack of dedicated funding programmes for industrial biotechnology research • Grants for interdisciplinary research are difficult to obtain • Lack of chemists with biotransformation experience and know-how • Not enough spin-out activity and capitalisation on expertise/discoveries • No dedicated funds to reduce industry's risk in developing novel bio-processes and products • Scale-up and demonstration facilities are limited • Chemical industry is less advanced in industrial biotechnology than their continental European counterparts • Almost no capability in contract manufacturing in industrial biotechnology • Lack of governmental incentives for the development of bio-based products • Limited arable land will make the development of sustainable supply chains of biomass feedstocks more difficult

[237] http://www.onenucleus.com
[238] http://www.berr.gov.uk/files/file51237.pdf

Lack of dedicated funding programmes

One of the weaknesses that were identified is the lack of dedicated funding programmes. Several industrial biotechnology companies experience difficulties in getting access to finance. INEOS Bio for example has so far found it easier and faster to get financing in the US for its first industrial scale plant than in the EU. This is due to the fact that the US department of energy (DoE) and the US department of agriculture (USDA) have quickly established respectively grant programs and loan guarantee programs with streamlined selection processes. INEOS Bio has received a $50 million grant from the DoE and a conditional commitment for a $75 million loan guarantee from the USDA for its plant in Florida. In the UK and in the EU, there are so many opportunities to get funding that it is very difficult to identify the most appropriate fund. The amount of funding however is often limited, while the process of getting funding takes quite long and the administration is quite heavy. As a result, Ineos Bio has been able to secure financing in the US, and not in the UK or the EU although it is fully aligned with the Europe 2020 strategy and in particular the objectives of the flagship initiative; 'Resource Efficient Europe' through its process technology to convert waste into bioethanol and renewable power.

It is also difficult to obtain funds to finance the growth of companies. Producing industrial biotechnology products on a small scale can be realized, but customers often demand production on a large scale. For small companies, it is however quite difficult to bridge the leap from small scale production to large scale production. There are multiple funds available in the UK like the Technology Strategy Board and the Carbon Trust to develop new technologies in the area of industrial biotechnology that result in small scale production. The amount of funding usually amounts up to £1 million. However, there is no money available to invest in scaling up the production and demonstration of the new technologies/products.

In order for a company to grow, it is often also necessary to test new materials on a large scale. Testing new materials give rise to huge costs as trials often demand a significant amount of tonnage of material. Next to the difficulties in getting financing to bridge the product registration, is the fact that the rules to get products and new materials registered are stricter in the UK than compared to the rest of Europe. This creates an additional barrier for UK companies to commercialize their technology. An interesting UK initiative to help companies grow is Solutions for Business[239].

Solutions for Business, is the Government's streamlined package of support products to help businesses start and grow. Solutions for Business has emerged from the Business Support Simplification Programme and responds to the request from business for a simpler framework that provides a quick, easy and direct route to effective support. Previously, it was estimated that over 3,000 publicly funded business support schemes existed. Business said they were confused and discouraged from applying for support. Now, for the first time, the range of support offered by Government Departments, their agencies and local authorities has been brought together in a single portfolio, easily recognisable and accessible via Business Link.

[239] http://www.berr.gov.uk/files/file51891.pdf

Grants for interdisciplinary research

A second weakness is the fact that grants for interdisciplinary research are difficult to obtain. As a result, large companies set up partnerships to bridge the lack of knowledge they experience. British Sugar for example, has set up a joint venture with BP and Dupont to convert a variety of feedstock, from wheat and sugar beet to ethanol. British Sugar has a lot of knowledge in the area of sugar beets but they do not have the in-house capabilities to produce bioethanol. Therefore, they looked for a partner that has these capabilities. For small companies however, it is more difficult to create these partnerships. An interdisciplinary grant could help these companies to set up a consortium that allows them to commercialize their technology. As industrial biotechnology is a new industry, no industrial partner has all knowledge in-house. Therefore, partnerships are important to merge old and new value chains like the agricultural and energy value chain[240]. One example of collaborative funding is the Integrated Biorefinery Technologies Initiative Research and Technology Club (IBTI Club) launched by BBSRC in 2008[241].

Integrated Biorefinery Technologies Initiative Research and Technology Club

This is a £5 million, 5 year partnership between BBSRC, a consortium of leading companies, and the Bioscience KTN aimed at developing biological processes and feedstocks to reduce our current dependence on fossil fuels as a source of chemicals, materials and fuel. The Club will provide a way for appropriate academic researchers to work on innovative, multidisciplinary, scientific areas of relevance to industry. EPSRC is committing £200,000 to IBTI in 2009 and will commit an additional £1 million in 2010, raising the total Club budget to £6 million over five years. This further demonstrates the Research Councils' commitment to support excellent multi-disciplinary research with significant industrial relevance.

Knowledge on various parts of the value chain can often be found in different countries. Therefore, the migration of people that possess the relevant knowledge might be very interesting. In industrial biotechnology, knowledge on feedstock for example is much appreciated. This knowledge often resides in countries such as China, India, and Brazil as these countries have large feed stocks. Due to the new immigration policy in the UK, it has become more difficult for companies to recruit people from outside the EU. This hinders the exchange of valuable knowledge.

Lack of spin-out activity and capitalisation on expertise/discoveries

A third weakness is the lack of spin-out activity and capitalisation on expertise/discoveries. The Biotechnology Exploitation Platform (BEP) Challenge that was created to stimulate the exploitation of publicly funded bioscience intellectual property, made an evaluation of the programme in 2007. They found that the main barrier to commercialize scientific knowledge is intellectual property. Patents are known to be expensive. However, if universities want to transfer technology in the area of bioscience, they need to apply, prosecute and maintain patents until the technology can be transferred. Most universities and technology transfer offices do not have the financial means to sustain a large patent portfolio. Therefore it is important to make educated choices in the portfolio. The expertise and experience of the technology transfer office (TTO) staff is crucial to value the related intellectual property and recognize its potential.

[240] Beyond Borders, Global biotechnology report 2010, Ernst & Young

[241] http://www.berr.gov.uk/files/file51891.pdf

Moreover, senior TTO people often have a good network which allows them to attract venture capital for their spin-offs or to set up a license with an existing company.

A vibrant ecosystem can also play a major role to capitalise on scientific expertise and discoveries. The ideas that are not picked up at university or by technology transfer officers, could find a way to companies through network events organized in these ecosystems. During these targeted network events, idea owners, small, medium and large companies come together to exchange ideas and look for opportunities. Consequently, the chances that an idea is picked up and commercialised, increase significantly.

What can be learned from the UK case?

Funding should be more focused

The EU and the UK should set up funds that are dedicated around certain technologies. It is hereby important that the financing rules are focused on criteria and requirements for the development and deployment of the technology rather than choosing the particular technology itself. These funding programs can allow companies to find out how they can master the techniques to produce at a large scale if they are more oriented towards early commercialization. A clarification of European rules that are simple and straightforward would be really helpful. It is important that Europe finds a way to streamline its own support programs for 'key enabling technologies' in the emerging bio-economy in order to remain competitive in the global race. To quote Peter Williams: *"The EU seems to be the leader in "what to do" whereas the US seems to be leading in "how to do it".*

The UK Government recognises that in order for industrial biotechnology to be fully exploited in the UK there is a need for practical, operational means to enable that to happen[242]. The UK lacks sufficient demonstration facilities. As it is difficult for SMEs to acquire the necessary capital to invest before proving the technology at large scale, the UK Government plans to establish national capability centres to provide funding and promote the commercialisation of industrial biotechnology. This could also attract larger industrial companies in IB to the UK and EU, making it possible to create a complete value chain in industrial biotechnology in the UK and EU.

A vision towards industrial biotechnology

In the UK, industrial biotechnology deals represent only a small fraction of all biotechnology investment (e.g. 48 deals for IB companies worth a total £194m worldwide last year out of a total of 584 investment deals, worth £3bn, in all biotech companies)[243]. Currently, IB is being impeded from delivering this prize in the UK – primarily because of low awareness of the potential of the technology, a lack of the necessary facilities to demonstrate its commercial feasibility, and insufficient connectivity between the key players[244]. The UK government has therefore been very active in the recent years to assess the possibilities of industrial biotechnology. The Industrial Biotechnology Innovation and Growth Team have formulated several recommendations to the UK government[245]. The Government has welcomed these recommendations and has

[242] http://www.berr.gov.uk/files/file51891.pdf
[243] Thompson
[244] http://www.berr.gov.uk/files/file51144.pdf
[245] http://www.berr.gov.uk/files/file51144.pdf

formulated a response as to how they intend to respond to these challenges to ensure that the UK capitalises on the economic and environmental benefits of industrial biotechnology[246]. They should now take that vision forward and translate this vision into concrete actions. For example, the industrial biotechnology industry would benefit from investment tax credits in their industry.

Legislation to stimulate the commercialization of industrial biotechnology
The UK government recognizes that scaling up of IB processes is more difficult than comparable chemical routes. Currently, industrial biotechnology companies compete on price. As this is a relatively new technology, the scale is not as large yet, which makes it difficult to compete on price especially with regard to the chemical processes. In analogy with the legislation on renewable biofuels, a legislation that would oblige chemicals companies to use a certain percentage of renewable chemicals in their products and processes would really support the market expansion of industrial biotechnology companies. Several chemical companies currently engage in industrial biotechnology mainly driven by public relation motivations, legislation could create a different dynamic.

List of persons interviewed

Association/Company	*Name*	*Title*
Cambridge Biopolymers	Nick Layton	CEO
TSB	Merlin Goldman	Lead Technologist – Biosciences
BEP programme	Gordon Malan	BEP programme manager
Ineos Bio	Peter Williams	CEO
Quinvita	Henk Joos	CEO
Green Biologics	Edward Green	CTO
British Sugar	Richard Stark	Business Manager - Commercial

[246] http://www.berr.gov.uk/files/file51891.pdf

9 Annex 3: National innovation policy profiles

The Innovation policy profiles present a *snap-shot* of some of the main policies and initiatives related to or having an impact on successful deployment of Key Enabling Technologies.

The majority of profiles are based on interviews with policy experts and a literature review of the key policy documents and other relevant literature. However, the Japanese, Indian, and Taiwanese innovation policy profiles have only been based on contact and information exchange via email correspondence with policy makers and experts, plus literature reviews. The level of detail will therefore differ in some of the profiles.

One reason for the lack of willingness to engage in this study has been the fact that it is a highly political topic, and only high level experts and policy makers have been willing to provide information, but not been willing or having the time for an interview. For Taiwan, which was chosen as an case region late in the process, it was simply time restrictions.

China

Introduction

China is already a major world player in Science and technology (S&T) in terms of funding and human resources for R&D. Still, China is playing S&T catch-up; policy focus is not on the far end of the innovation value chain – rather China is focusing on gradually building its research base, starting from policy incentives to enhance the overall innovation capacity of the country by focusing on basic research.[247]

The status of the Chinese innovation system is evident in the national innovation policy, which springs from the comprehensive five-year plans (FYPs) within which the future strategic direction of the Chinese society and economy is developed.[248] Currently, China is at the end of 11th FYP and commencing the 12th FYP in March 2011. The overarching goal of the 11th FYP (2006-2010) has been to promote a sustainable, people-centred growth and development and thereby creating a more "harmonious society".[249] This has been done in several ways, one of them being an increased focus of moving China up the value chain from being an economy based mainly on exports to one based on domestic demand – from 'Made in China' to 'Designed in China'.[250] One of the measures taken to bring about this change is by heavily investing in science and technology education and R&D; consequently, R&D spending has increased significantly – from EUR 9 billion in 2000 to EUR 46 billion in 2008.[251]

Under the commencing 12th FYP, seven major sectors have been turned into strategic emerging industries (SEIs) under the overall themes of healthcare, energy, and technology:

1) Alternative energy
2) Biotechnology
3) New-generation information technology
4) High-end equipment manufacturing
5) Advanced materials
6) Alternative-fuel cars

[247] OECD (2008) Reviews of Innovation Policy: CHINA
[248] The FYPs are formulated through a process from the State Council's draft plan, then discussed and adopted by the Central Committee and presented as a proposal to, and decided by, the National People's Congress.
[249] World Bank (2008) Mid-term Evaluation of China's 11th Five Year Plan (http://siteresources.worldbank.org/CHINAEXTN/Resources/318949-1121421890573/China_11th_Five_Year_Plan_overview_en.pdf)
[250] APCO (2010) China's 12th Five-Year Plan: How It Actually Works And What's In Store For The Next Five Years (http://www.apcoworldwide.com/content/PDFs/Chinas_12th_Five-Year_Plan.pdf)
[251] James McGregor (2010) China's Drive for 'Indigenous Innovation': A Web of Industrial Policies (http://www.uschamber.com/sites/default/files/reports/100728chinareport_0.pdf)

7) Energy-saving and environmental protection

All of these industries are objects to preferential tax-, fiscal-, and procurement policies.[252] In terms of funding, professor Xiao Guangling explains that up to EUR 200 billion yearly is considered by the state council (China's Cabinet) for these seven industries. Furthermore, the value-added output from these industries is expected to account for 8 per cent of the country's GDP by 2015[253] (an expected EUR 580 billion).[254]

To reach the strategic objectives outlined in the 11th FYP, the Medium- and Long-Term Plan of Science and Technology Development 2006-2020 (MLP) was developed as a key promoter of innovation-driven economic development. The MLP illustrates the main objectives of Chinese innovation policy – *to make China an innovation-oriented society by 2020 and to become a leader in emerging S&T fields.*[255] The general objective is to push economic development and to make the strategy more focused and people-oriented. The MLP specifically calls for[256]:

- Enhancement of indigenous innovation to strengthen global competitiveness, increase Chinese IP, and enhancing national security and prosperity.
- Increasing R&D spending – up from 1,7% of GDP in 2010 (EUR 40 billion)[257] to more than 2,5% by 2020 (EUR 228 billion).[258]
- To boost contribution of science and technology from 39% of GDP to 60% while lowering the dependence on foreign technology to 30%.
- To rank China among the top five countries holding patents and science citation (SCI) papers.

These goals also support the previous statement that China is still in the process of building its research base, which naturally influences policy focus. At the same time it stresses the fact that China is aiming at moving up the production value chain and at enhancing indigenous innovation as a means of ensuring the future of Chinese development.

Key Enabling Technologies

In China, no particular policies are formulated explicitly at the identified KETs within this study; however, as a result of the strong focus on technology-based economic growth, the six KETs are all embedded in the FYPs and the Medium- and Long-Term Plan of Science and Technology Development 2006-2020 (MLP) in some form.[259] For instance, development in information technology (IT), new materials and advanced manufacturing technology are highlighted as important for strengthening China's industrial base.[260]

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[252] Interview with Prof. Chen Jin, Zhejiang University
[253] APCO (2010) China's 12th Five-Year Plan: How It Actually Works And What's In Store For The Next Five Years (http://www.apcoworldwide.com/content/PDFs/Chinas_12th_Five-Year_Plan.pdf)
[254] Own calculations based on IMFs projections of the Chinese economy and current USD-EUR exchange rates.
[255] DG Enterprise (2009) INNO-Policy TrendChart – Innovation Policy Progress Reports: China
[256] OECD (2008) *Reviews of Innovation Policy: CHINA*
[257] Own calculations based on Goldman Sachs' projections the Chinese GDP and current USD-EUR exchange rates.
[258] Own calculations based on Goldman Sachs' projections the Chinese GDP and current USD-EUR exchange rates.
[259] Interview with Prof. Xiao Guangling, Tsinghua University; Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, European Union Chamber of Commerce in China (EUCCC)
[260] DG Enterprise (2009) INNO-Policy TrendChart – Innovation Policy Progress Reports: China

China Mega Projects
One of the China Mega Projects is the **New Generation Broadband Wireless Mobile Communication Networks**. It aims at developing a new generation of wireless mobile networks combined with low cost and wide coverage communication access systems. By this measure, China aims at increasing the number of Chinese patents in international technology standards and widening the application of these technologies.

Source: James McGregor (2010) China's Drive for 'Indigenous Innovation': A Web of Industrial Policies

Furthermore, under the MLP, the development of nanotechnology is given priority status as it is identified as one of the *China Mega Projects*. 16 projects (of which 10 has begun) have been planned as 'Mega Projects'. They are characterised by strategic priority and receives up to EUR 10 billion in direct funding each.[261] This funding is provided by four different sources:

- Central government financing serving as"orientation" fund for core technologies
- Financing from enterprises focusing on certain projects with clear production targets
- Supplementary fund from local governments and institutes
- Funding from existing S&T programmes such as 863 Programme[262].

Chinese intensity of purpose

In general, Chinese industrial policy is very goal-oriented and aims at long-term accomplishments within strategic sectors chosen by the government. State aid is provided from both the national and regional governments, where the local government invests a little more than half.[263] Within the central government, different ministries are responsible for the development of policy guidelines and the subsequent materialisation of policies. For instance, Ministry of Science and Technology (MOST) allocates around 20% of the total investment budget.[264] MOST is also the most prominent creator of policy outlines within the state organ. The National Development and Reform Commission (NDRC) plays a large role in the making of policy guidelines and funding as well.

Chinese industrial policy employs several support instruments; for instance will enterprises that establish themselves within one of the strategic emerging industries (SEIs) receive financial subsidies, fast and easy accesses to funding and overall enjoy government support. In theory, these sectors should be open to all companies, yet it is unclear whether this is actually the case.[265] Every year, the NDRC publishes three catalogues guiding foreign Investment in industry. Here all industries in China are ranked in three categories; 1) FDI encouraged, 2) FDI restricted, and 3) FDI prohibited. One of the targeted sectors of the FYP, biotechnology (especially stem cell and life sciences), is seen as key to the development of an innovation-driven economy, restricted for FDI.[266][267]

261 (Prof. Xiao Guangling, Tsinghua University)
262 http://www.access4.eu/_img/article/MoST_4_-_National_ST_Major_Projects.pdf
263 Interview with Prof. Xiao Guangling, Tsinghua University
264 Interview with Prof. Xiao Guangling, Tsinghua University
265 Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, European Union Chamber of Commerce in China (EUCCC)
266 http://www.fdi.gov.cn/pub/FDI_EN/default.htm

The exact public support measures vary on a case-by-case basis, yet one example from one of the SEIs (the development of energy-efficient technologies) in the construction sector is given below:

> **Going green**
> In order to encourage the development of new, energy-efficient R&D and products within the construction sector, the government of Haerbin (a city in Northern China) creates calls for China-made technology for energy-saving buildings; here enterprises can apply for state-funded pilot projects. This means that if the company can develop a technology and prove that it fits within the government project, direct funding will be given through the entire process – from idea to end-product. Furthermore, if the pilot project is successful, the company will be certified to construct similar buildings around China – they become ratified as builders of green buildings.
>
> Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, EUCCC

Another SEI is 'alternative fuel cars', which has become increasingly important as a consequence of the increasing urbanisation in China. Within production of batteries used for these electric cars, China has now overtaken the leading world position from Germany by establishing their own development facilities.[268] This shows how the Chinese strategy is based on increasing indigenous R&D development and production.

One way of illustrating the Chinese intensity of purpose in reaching its long-term goals is the case of tax incentives for export companies; for the Chinese policy-makers to direct its companies in the 'right' direction is to gradually remove the tax rebates previously available to export companies. This shift in business model forces these enterprises to try to focus efforts on growing a home-market.[269]

Indigenous Innovation

To reach the goals of the Medium- and Long-Term Plan of Science and Technology Development 2006-2020 (MLP), two main priorities were put forward:

- promoting S&T development in selected fields and,
- enhancing innovation capacity through indigenous innovation activities[270]

Especially the indigenous innovation policies have created a stir in countries outside of China. Basically, this measure of the MLP states that China needs to create its own intellectual property and proprietary product lines. One of the means is by changing foreign technology, e.g. "enhancing original innovation through co-innovation and re-innovation based on the assimilation of imported technologies"[271]. It also raises one of the points of the 12th FYP to reduce dependency of foreign technology and the solution

[267] Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, European Union Chamber of Commerce in China (EUCCC)
[268] Interview with Prof. Jon Sigurdson, Stockholm School of Economics
[269] Interview with Adele B. Wang, Senior Business Manager & Government Affairs Manager, European Union Chamber of Commerce in China (EUCCC)
[270] DG Enterprise (2009) INNO-Policy TrendChart – Innovation Policy Progress Reports: China
[271] James McGregor (2010) China's Drive for 'Indigenous Innovation': A Web of Industrial Policies (p.4) (http://www.uschamber.com/sites/default/files/reports/100728chinareport_0.pdf)

proposed is that Chinese enterprises should not blindly import foreign technology without clear plans of how to transform it into *Chinese* technology.

Below, some examples of how the indigenous innovation policy unfolds in practice are given. In 2007, the Ministry of Public Security published the Multi-Level Protection Scheme (MLPS), a technical policy, which in short prohibits the usage of foreign technology in 'critical infrastructure' such as bank, ports, and utilities. This means that the core intellectual property in products and systems for these sectors must be Chinese[272] and thus gives mandate to replace all foreign technology within this field.

The Certification and Accreditation Administration of China (CNCA) has established a certification system that is geared to slow down the introduction of foreign products to China. This allows for studying product design and production processes before the products enter China. Furthermore, in 2002, Chinese authorities formulated the Government Procurement Law, which stated that government procurements shall (besides a few exceptions) be limited to domestically produced goods.

Challenges to China's innovation-driven growth

As mentioned in the beginning, the Chinese innovation system is world-class in terms of funding and number of scientists, which also proves significant for the development of an innovation-driven economic growth. Especially is the focus on ensuring the human resources needed for the long-term development.

Nursing talent

The Chinese government on both local and national level has intensified its focus on educating the scientists of tomorrow. Special focus is on basic research (such as math, physics, chemistry, computer science, and biotech). As a result, every year 1.000 students are hand-picked from middle school when displaying particular skills within a scientific area. The government then provides a stimulating environment for the students and encourages them to spend 1/2-1 year in Europe or US on recognized universities and business schools.

Interview with Chen Jin, Professor at Zhejiang University; Vice Chairman, China Association of Science of Science and S&T Policy.

The grand investments in S&T have however yet to translate into a proportionate increase in the innovation performance; the national innovation framework still needs to be developed to absorb the skills and knowledge produced in universities. The product outcome is still below that of countries that spend an equal proportion of GDP on R&D as China (e.g. Japan and Korea). The amount of patent applications has increased significantly, yet the number of market-ready products is comparatively low. This implies that China is facing similar challenges as Europe in the commercialisation of technology; however, it must also be taken into consideration that China is not on the same level of technological development as Europe is.[273]

[272] It defines an indigenous innovation product as one with IPR owned by a Chinese company *and* a commercial trademark initially registered in China.

[273] DG Enterprise (2009) INNO-Policy TrendChart – Innovation Policy Progress Reports: China

France

Introduction

France is a major player with regard to key enabling technologies (KETs) and is very active in taking patents in all six KETs areas. France has several research institutes that are actively transferring knowledge from university to small and large companies. Policy makers in France have recently devoted a lot of attention to the need to transfer excellent research to industry. As the French president Sarkozy stated: “too often there have been walls between research and the economy”.

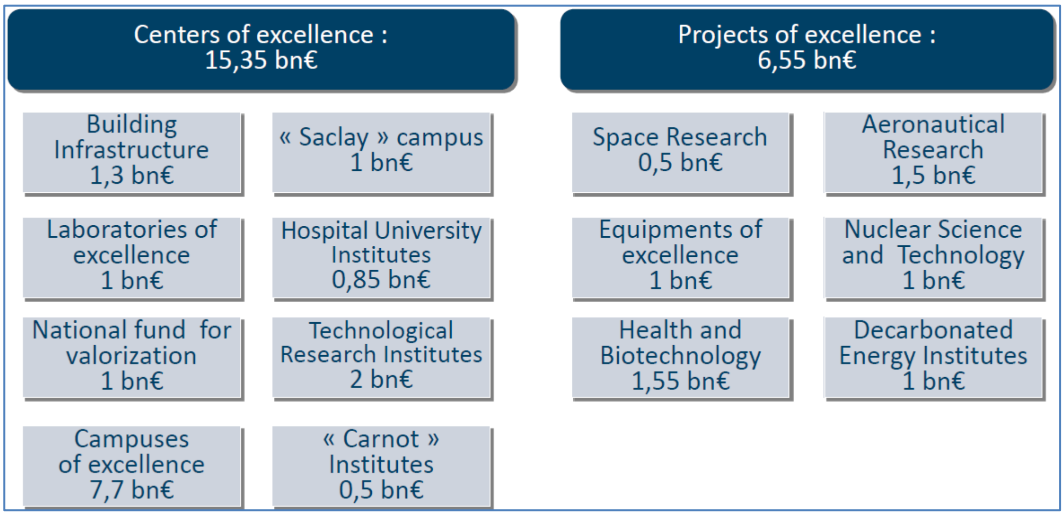
France has developed several policy measures to stimulate the transfer of knowledge from universities to industry. The efforts are driven by the Ministry of Higher Education and Research (le Ministère de l'enseignement supérieur et de la recherché), and the Ministry for Economy, Finances and Industry (le Ministère de l’Economie, des Finances et de l’Industrie).

The Ministry of Higher Education and Research (MESR) is active in the field of research and innovation, professional and higher education. It houses two Directorate Generals namely the Directorate General for Research and Innovation and the Directorate General for Higher Education. The mission of the Directorate General for Research and Innovation is to define strategic orientations, to identify key economic sectors and technologies, and to promote and disseminate science to all citizens[274]. They have developed a national research and innovation strategy (SNRI) in close collaboration with the other ministries and directorates in which they define 3 priority areas namely:

1. Health, care, nutrition and biotechnology
2. Environmental urgency and eco-technology
3. Information, communication and nanotechnology

To roll out this strategy, a special investment plan has been advanced totaling €35 billion of which €21.9 billion are supervised by the Ministry of Higher Education and Research (see Figure 1)[275].

[274] http://www.ktconference.com/pdf/Dr.%20Ronan%20Stephan.pdf
[275] http://www.ktconference.com/pdf/Dr.%20Ronan%20Stephan.pdf



The Ministry for Economy, Finances and Industry (MINEFI) is responsible for the financial and economic system, the development and regulation of the economy, taxation, employment policies and career education. They prepare and implement policies related to economy, foreign trade, SMEs and micro companies, industrial policies, information and communication technologies, energy, bank insurance, fiscal policies, etc[276]. They support the development, promotion and diffusion of new technologies; and define strategies with regard to industrial orientation and competitiveness of the French economy. The Directorate General for Competitiveness, Industry and Services (DGCIS) is a directorate of the Ministry for the Economy, Finance and Industry which is responsible for improving the overall framework in which businesses operate. The DGCIS provides stimulus for both innovation and R&D by creating a legislative framework that favors the creation, transmission and continuation of businesses[277]. It develops programs to boost companies' competitiveness through the development of clusters and ecosystems.

National policies aimed at industrial deployment of KETs

France has developed several initiatives with the aim to transfer knowledge in order to help companies innovate and grow. The following will present two interesting initiatives namely the National Research Agency and OSEO.

National Research Agency (L'Agence Nationale de la Recherche)
The National Agency for Research (ANR) was created in 2005 to provide support to basic and applied research, innovation, partnerships between public and private sectors and to contribute to the technological transfer of public research results towards the economic sector. In particular it supports the funding of projects that are selected according to scientific and technical excellence criteria[278]. The agency operates under the authority of the Ministry of Research and Higher Education. The role of the Agency is to

[276] http://www.economie.gouv.fr/ministere_finances/index.php
[277] http://www.pme.gouv.fr/presentation/dgcis-english.pdf
[278] http://cordis.europa.eu/erawatch/index.cfm?fuseaction=org.document&uuid=7D87CE1C-03B0-A058-E5948DED1A418175

bring more flexibility to the French research system, foster new dynamics and devise cutting edge-strategies for acquiring new knowledge. By identifying priority areas and fostering public-private collaborations, the ANR also aims at enhancing the general level of competitiveness of both the French research system and the French economy[279]. As the research programme orientations for 2011 demonstrate (see the textbox below[280]), the agency reflects the priorities that have been laid out by the different ministries in the National Research and Innovation Strategy. This strengthens France in its mission to pull down the walls between research and the economy. A clear and coherent view at all levels can reinforce this mission.

Research Programme Orientations for 2011

For its research programme of 2011, ANR aims to follows the priorities of the National Research and Innovation Strategy (SNRI). This implies that the proposed research orientations and structuring aids must in particular underpin the universities and consolidate the "innovation ecosystems" (companies in particular). The sectors identifiable as priorities from this viewpoint are those likely to rapidly increase company productivity, those that are firmly rooted in society and difficult to relocate, and which moreover correspond to fundamental needs (for example: aging, "decarbonizing", raw material scarcities, etc.), and those which at the same time constitute competitive exports. Sectors particularly concerned are therefore "green growth", health and ICSTs. The necessary transformations could result in profound changes in the behaviour of households and economic players. This is why all the ANR Strategy and Planning Boards pushed for research into technological innovation, new social behaviours and new economic models.

Thematic programme planning strongly encourages scientific innovation through the convergence of disciplines, particularly physics, ICSTs and biology, on nano scale and other scales (with bioinspiration, for example). Hybridization between themes (as is the case in the Contaminants, Ecosystems and Health programme, for example) also invites the invention of new inter-theme and interdisciplinary spaces (in this case between chemistry, ecology and biology). Special funding is proposed for scientific instrumentation (within certain programmes). This field that has been the subject of repeated requests and represents a bold application area of engineering and an area of innovation vital for the productivity and efficiency of science and technology.

OSEO

OSEO was created in 2005, bringing together ANVAR (French innovation agency) and BDPME (SME development bank). Its mission is to provide assistance and financial support to French SMEs and very small enterprises (VSEs) in the most decisive phases of their life cycle: start up, innovation, development, business transfer / buy out.[281] OSEO offers expertise in three key areas[282]:

1. Support for innovation
2. Guarantees to back bank financing and equity contributions
3. Financing for investments and the business operating cycle.

[279] http://www.agence-nationale-recherche.fr/en/about-us/missions/
[280] http://www.agence-nationale-recherche.fr/en/research-programmes/programme-planning/research-programme-orientations-for-2011/
[281] http://www.oseo.fr/oseo/oseo_in_english
[282] OSEO and international – Supporting growth and innovation for SMEs

In 2009, OSEO has conducted more than 100 000 interventions that allowed companies to get €25 billion of financing[283]. They make a distinction between innovative projects that have the aim to support innovation (up to 3M€ per single or collaborating project) and projects that contribute to industrial strategic innovation (from 3 to 10M€ per project)[284]. In 2009, they invested €410,61 million in a total of 3778 projects[285]. OSEO covers all areas of France, through its network of 37 regional branches[286]. It makes its competences and networks available to local communities and regional agencies, acts on their behalf and in accordance with their economic development priorities[287]. Companies can participate in calls for project through the regional agencies.

Policy measures towards industrial deployment and their impact

Access to talent: Law on career security

The "Article 47 Chapitre premier de la Loi n°2006-1770 du 30 décembre 2006 pour le développement de la participation et de l'actionnariat salarié et portant diverses dispositions d'ordre économique et social (1)"[288] allows members of competitiveness clusters to exchange employees. This legal disposition was an experimental legislation which ended on 31 December 2010. The organizations targeted by the article are companies, research centers, and higher education institutions that are located in the same competitiveness cluster. A major condition was that the contracting organizations could not make profits thanks to the exchange. The exchange itself was formalized by an agreement specifying the conditions of the provision. By stating the time and financial dimensions of the exchange, the non-profit practices became legal and were not considered to be an illegal lucrative or simple exclusive loan[289]. As can be seen in the example mentioned below, technology transfer between research centers and industry is supported by this exchange. This implies that the law has a positive effect on the exchange of knowledge.

[283] http://www.oseo.fr/notre_mission/qui_sommes_nous/organisation

[284] http://www.oseo.fr/votre_projet/innovation/aides_et_financements/aides/aide_aux_projets_d_innovation_strategique_industrielle_isi

[285] http://media.enseignementsup-recherche.gouv.fr/file/inov_et_rech_techno_-_rapports/89/9/SETTAR_2009_159899.pdf

[286] http://www.oseo.fr/notre_mission/nos_equipes_en_region

[287] http://www.oseo.fr/oseo/oseo_in_english

[288] http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000458333

[289] http://lesrapports.ladocumentationfrancaise.fr/BRP/104000363/0000.pdf

An application of the law: the experience of Minalogic

The competitiveness cluster Minalogic is based on micro-nanotechnologies and embedded software and located in Grenoble. Minalogic has launched an initiative to apply the law with the aim to secure careers and to prevent brain drain from the Grenoble area[290].

Nicolas Leterrier commented: "What is interesting here is to place the employee at the center of the value creation so that he or she can fully leverage his/her competencies in a company or a research institute and, once he or she is back to his/her original structure, he or she can promote his/her accomplishments and experiences. Exchanges work in all ways, from public to private, from private to private, from private to public and from public to public[291]."

Since 2009, 52 employees have been moving in the cluster involving 7 companies and 3 research institutes. Soitec, the international leading company specialized in silicium and silicon-on insulator, exchanged 20 engineers and technicians to the Centre d'Energie Atomique (CEA) during a period of 18 months[292]. The employees from Soitec at the CEA stayed linked with their company, through the intranet and internal meetings. Corinne Margot (Soitec) commented: "This measure is adapted to help people remain in their professional domain and enlarge their experience. It is thus very efficient for their career security. This innovative agreement launched by the Grenoble Cluster under the December 2006 law on career security helps to thin the labor market within the Grenoble region and encourage innovation within SMEs[293]."

Access to finance: Crédit impôt Recherche

Crédit d'impôt Recherche (CIR) is a research tax credit measure which is aimed at supporting corporate R&D investments through tax incentives[294]. This fiscal measure was created in 1983 and extended by the "Loi de finances" of 2004 and again by the "Loi de finances" of 2008. It aims to promote Research and Development activities in companies by lowering the R&D costs for the companies. The CIR is based on the claimed volume of R&D expenditures[295]. It is equal to 30 % of R&D expenditures up to EUR 100million; beyond this threshold, the rate comes down to 5 %. For companies entering the scheme for the first time, the applicable rate used to be 50 % the first year, and 40 % the second year. The rate has now come down to 45% in the first year while 40% in the second year. The attractiveness of this measure is demonstrated in the graph below which shows the number of companies that register for this measure[296]. The new entrants are mostly small and micro companies. The R&D tax credit rose from €1.6 bn in 2007 to €4.8 bn in 2010[297].

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290 http://www.minalogic.com/Actualites/149%23%26Minalogic+lance+la+1%C3%A8re+Convention+de+mise+%C3%A0+disposition+de+salari%C3%A9s/17-les-actualites.htm?utm_source=RSS&utm_medium=rss&utm_campaign=Ressources+Humaines+//

291 http://www.eetimes.com/general/displayprintviewcontent?contentItemId=4085015

292 http://www.wk-rh.fr/actualites/detail/23508/le-pret-de-main-d-uvre-sans-doute-perennise.html

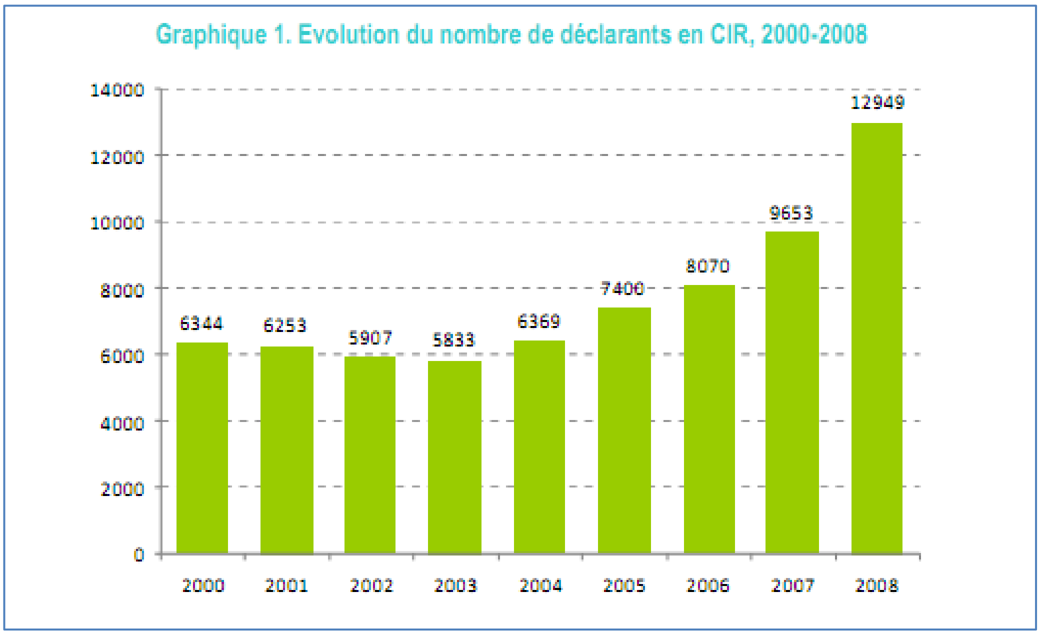
293 http://www.eetimes.com/general/displayprintviewcontent?contentItemId=4085015

294 ERAWATCH Country Report 2009 France

295 http://www.greater-paris-investment-agency.com/pdf/Research%20tax%20credit.pdf

296 http://media.enseignementsup-recherche.gouv.fr/file/inov_et_rech_techno_-_rapports/89/9/SETTAR_2009_159899.pdf

297 http://www.ktconference.com/pdf/Dr.%20Ronan%20Stephan.pdf



Access to knowledge: Pôle des compétitivity

Pôle des compétitivity or competitiveness clusters were launched in 2004 by the French Government. The logic of Competitiveness Clusters is to create regional poles of excellence in accordance with regional strengths[298]. It brings together companies, research centers and educational institutions in order to develop synergies and cooperative efforts[299]. 71 competitiveness clusters have been labialized which consist of around 80% of SMEs. In 2007, 5,000 companies were member of the different clusters, while 14,000 researchers took part in funded R&D projects[300].

France has launched its national competitive cluster policy to make businesses more competitive, to stimulate employment in promising markets and to strengthen the local regions. The French government has launched the second phase of this policy for a further three-year period (2009-2011), with a total budget of €1.5bn, similar to the appropriation for the period from 2006 to 2008[301]. In addition to providing continued support for R&D – the essential part of the competitiveness clusters' activities – the funds will be used in three specific areas[302]:

1. Strengthening leadership and strategic steering for competitiveness clusters (performance contracts)
2. New means of financing (innovation platforms)
3. Developing a growth and innovation ecosystem in each competitiveness cluster (including private financing and better regional synergies)

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[298] ERAWATCH Country Report 2009 France
[299] Competitiveness clusters in France, Direction Générale des Entreprises
[300] http://media.enseignementsup-recherche.gouv.fr/file/inov_et_rech_techno_-_rapports/89/9/SETTAR_2009_159899.pdf
[301] ERAWATCH Country Report 2009 France
[302] http://www.industrie.gouv.fr/poles-competitivite/brochure-en.html

France intends to increase their support for R&D of companies and innovation as they are convinced that R&D departments of companies, public-private partnerships, creation and development of innovative companies are powerful engines of competitiveness and development[303].

Conclusion

In recent years France has launched several initiatives and policies aiming at closing the gap between research and industry. They have developed a national research and innovation strategy that formulates their vision with regard to the development and competitiveness of research and innovation in France. As Valérie Pécresse, Minister of Higher Education and Research, states[304]:

> *'At the core of the National Research and Innovation Strategy there is an ambition: to put back research and innovation at the heart of French society and economy.*
> *It is a truly National strategy: its priorities will therefore be defined on the basis of the country's most pressing needs in order to reassert the social value of research and innovation and re-establish dialogue between science and society'*

In order to reinforce this vision, France has developed and is continuing to develop measures to ensure access to talent, finance and knowledge. The access to talent and knowledge should further be enhanced and stimulated to allow a successful deployment of KETs. Elaborate access to talent, finance and knowledge can boost the industrial structure and allows bridging the Valley of Death.

[303] http://media.enseignementsup-recherche.gouv.fr/file/Innovation,_recherche_et_developpement_economique/02/1/recherche-innovation-plaquette-2010-traduction-english_140021.pdf
[304] National Research and Innovation Strategy, Ministry for Higher Education and Research, 2010

Germany

Introduction

Patent analysis shows that Germany is leading the way in Europe in the individual KETs with strong performance of both RTOs and large companies[305]. The Jena case study (see Annex 2) also provides an example of a strong cluster in photonics, which is a major strength in Germany.

The main comparative advantage of the German innovation system is its specialisation on high and medium-high technology combined with efficient production and innovative products and services. Germany has a large and diversified science and technology (S&T) base, it is one of the nations in the world with the biggest R&D capital stock, and the output of RD&I activities in terms of patents, new products and high productivity is significant in a European context.[306] Germany has a mature national innovation system, which includes a number of large, well-established research institutions and companies; it has a large and growing share in total OECD high- and medium-high-technology exports, and is the fourth most intensive in applying for patents in the OECD area (adjusted for population).[307] Germany has a large advantage when it comes to generating innovative outputs and new technology, which leads to a strong innovation performance. This is evident in a high share of innovators (both technological and non-technological), a high share of patent applications per inhabitant, and the employment and export shares of medium and high-tech manufacturing.[308]

The backbone of the German innovation system is within the automotive sector, mechanical engineering, chemicals and electronic equipment and these are also those branches with a strong innovation performance and high R&D investment.[309] Every KET plays a significant role in these sectors and in the German innovation system and therefore also receives policy attention.

The main national innovation policy making bodies in Germany are the Ministry of Education & Research (federal level) and the Ministry of Economics & Technology (innovation-oriented programs). As Germany is a strong player within high technology

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[305] European Commission (2010): European Competitiveness in Key Enabling Technologies

[306] INNO-Policy TrendChart (2009) Innovation Policy Progress Report Germany http://www.proinno-europe.eu/page/innovation-and-innovation-policy-germany

[307] OECD (2010) SCIENCE AND INNOVATION: COUNTRY NOTES Germany http://www.oecd.org/dataoecd/17/40/41559102.pdf

[308] INNO-Policy TrendChart (2009) Innovation Policy Progress Report Germany http://www.proinno-europe.eu/page/innovation-and-innovation-policy-germany

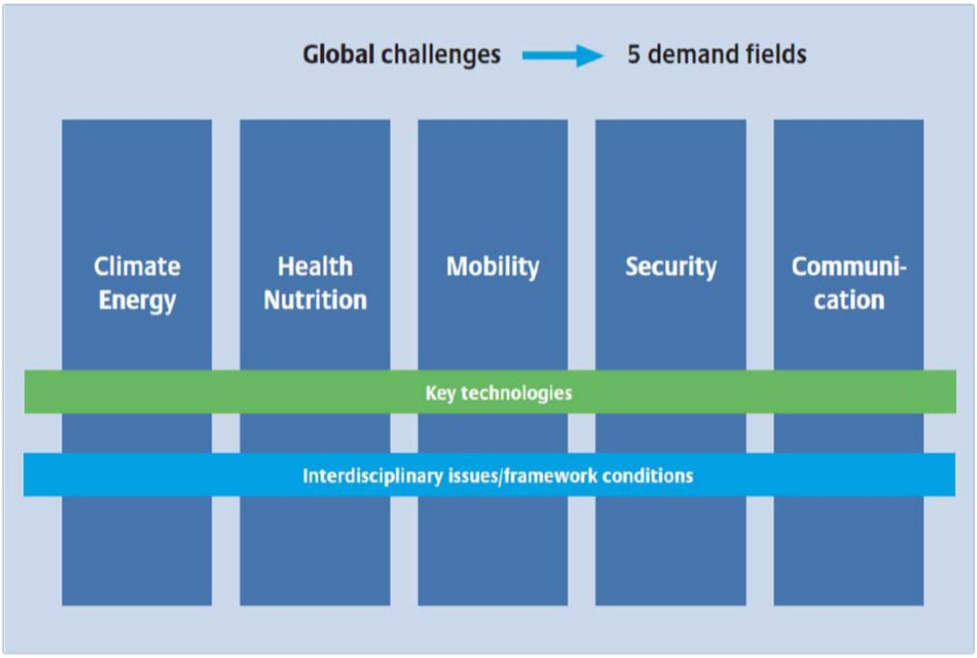
[309] INNO-Policy TrendChart (2009) Innovation Policy Progress Report Germany http://www.proinno-europe.eu/page/innovation-and-innovation-policy-germany

and has a strong innovation performance and solid S&T base, policy focus is on establishing better conditions for innovation and technological progress and facilitating commercialisation. In practice, this policy focus aims:

- To improve the innovative capacities of SMEs and to increase collaboration with research establishments (supported by programmes like the *ZIM* (Central Innovation Programme for SMEs) and the introduction of *vouchers for innovation advice* is planned)
- To increase the number of knowledge-based business start-ups in the future (supported by programmes like the *High-tech Start-up Fund* and *EXIST*)
- To strengthen key industrial technologies (energy, transport, aviation, shipbuilding, space research) and cross-sectoral technologies (information technologies, multimedia) (supported by technology-specific programmes)
- To strengthen the linkages between industry and research (supported for example by regional economic assistance and programmes to promote networks/clusters).
- To improve the climate for investment and consumption (supported by policies aiming at innovation in public procurement, innovation-friendly standards, and lower taxes).

The innovation policy focus is increasingly directed at the global challenges of protecting the climate and resources, health, mobility and safety/security that Germany is currently facing.[310]

Figure 7: Fields of Action (Source: Engelbert Beyer (2010) The German Perspective on Innovation Policy) [311]



[310] BMWi (Federal Ministry of Economics and Technology) (2011) Policies for innovation and technology http://www.bmwi.de/English/Navigation/technology-policy.html
http://www.bmwi.de/English/Navigation/technology-policy.html
[311] Engelbert Beyer (2010) The German Perspective on Innovation Policy
http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/EuroCase_Annual_Conference_2010/Keynote_Papers/Beyer.pdf

As seen in the figure, all KETs (nanotechnologies, biotechnologies, optical technologies, micro technologies, and ICT) are included cross-sectorally in the German government's policy focus. Furthermore it illustrates that emphasis is on how these technologies can be integrated into *fields of application* such as automotive/mechanical engineering or environmental/energy technology rather than developing the technology in its own right.[312]

National policies aimed at industrial deployment of KETs - The High-Tech Strategy

In 2006, Germany launched its High-Tech Strategy (with a planned end-point in 2009 and hereafter continued and *adapted to cope with new challenges* by the new administration taking office in 2008). The High-Tech strategy is the first comprehensive national innovation strategy developed to include all ministries in Germany. It aims at a incorporating all aspects of research and innovation and therefore is a cross-cutting strategy that argues that *innovation policy is more than just research policy*. The aim of this strategy is to strengthen Germany's position in the field of technology and promote the transfer of "research results into business applications"[313]. The initiative identifies 17 priority fields of technology development (in which KETs play a significant role) that are a direct response to the challenge of keeping pace with high-tech technological change and will receive preferential funding.

The High-tech Strategy had a total volume of EUR 14.6 billion in the period from 2006 to 2009. EUR 12 billion of this amount was earmarked for research and the diffusion of new technologies in 17 high-tech sectors. Another EUR 2.7 billion went to technology-spanning, cross-cutting measures.[314] The funding for the technology-policy measures in 2010 from the Federal Ministry of Economics and Technology (which accounts for approx. half of the High-Tech Strategy's funding) amounts to a total of EUR 2.3 billion, or € 2.8 billion including the measures of the stimulus package. Below, the total funding is divided on 17 high tech "future fields" and cross-technology measures for the initial period.[315]

[312] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[313] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[314] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[315] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php

Figure 8: Funding for the High-tech Strategy 2006-2009 (source: Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy)

Funding for the High-Tech Strategy 2006 – 2009 (millions of €)	
17 High-tech sectors	**11,940**
Nanotechnologies	640
Biotechnology	430
Microsystems technology	220
Optical technologies	310
Materials technologies	420
Space technologies	3,650
Information and communications technologies	1,180
Production technologies	250
Energy technologies	2,000
Environmental technologies	420
Automotive and traffic technologies	770
Aviation and aeronautical technologies	270
Maritime technologies	150
Health research and medical technology	800
Plants	300
Security research	80
Services	50
Cross-technology measures (selection)	**2,660**
Bundle the forces of science and industry: Research grants, cluster competition, Exchanges Between Science and Industry competition, Entrepreneurial Regions, Science Meets Industry competition	600
Improve conditions for innovative SMEs: Non-thematic innovation funding for SMEs (PRO INNO, IGF, INNO-WATT, Innonet, NEMO, ERP innovation programme)	1,840
Support technology start-ups: High-Tech Gründerfonds seed fund, the EXIST University-Based Start-Ups programme, best practice models in non-university research organisations	220

The High-tech Strategy was built upon well-established activities and programmes yet the amount of funding has been increased. Funding for the 17 priority fields of technology takes place within the structure of thematic R&D programmes. Generic actions rest on on-going programmes as well as newly implemented instruments while simultaneously placing emphasis on improving framework conditions for innovation, for example by means of regulation. Subsequently, a number of new research and innovation policy measures have been introduced, including the Research Bonus, Industrial Initial

Research, SME Innovative, the ZIM, Top Cluster Competition and Innovation Alliances.[316]

In this strategy, the main goal is to incorporate all aspects of research and innovation, meaning that the improvement of framework conditions is considered when policies are designed as well as for instance considerations about human resources.

Innovation strategies

The High-Tech Strategy is divided into *innovation strategies* that are aimed at:[317]

- Innovation for a safe and healthy life (Medical technologies, Security technologies, Agricultural technologies, Energy technologies, and Environmental technologies).
- Innovation for communication and mobility (ICT technologies, Automotive and transport technologies, Aviation technologies, Space technology, Maritime technologies, and Services)
- Innovation through *cross-cutting technologies*: Nanotechnologies, biotechnology, microsystems technology, optical technologies, materials technologies, and production technologies

Nanotechnology

A governmental aim is to speed up the translation of nanotechnology research findings into a variety of innovations. It is working to introduce more sectors and enterprises to nanotechnology and eliminate obstacles to innovation by co-ordinating the relevant policy fields at an early stage. This has resulted in the formulation of the Nanoinitiative 2010. The Ministry of Education and Research is consequently concentrating its R&D project funding on lead innovations and giving strategic focus to collaborative research activities that are geared to add value and using nanotechnology to aid the solution of future national challenges.[318]

Photonics

Optical technologies are a part of the 17 strategic areas of the high-tech strategy. The "*Optical Technologies - Made in Germany*" funding programme was launched in spring 2002. The BMBF initially provided EUR 280 million under this programme up to the year 2006 and nine competence networks on optical technologies have developed so far.[319]

The programme is aimed primarily at collaborative R&D projects between companies and institutions. The overall aim of this program is to grow the number of jobs in this sector by more than 40 per cent by 2020[320].

[316] INNO-Policy TrendChart (2009) Innovation Policy Progress Report Germany http://www.proinno-europe.eu/page/innovation-and-innovation-policy-germany
[317] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[318] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[319] Federal Ministry of Education and Research (BMBF) (2011) Optical Technologies - With Light into the Future http://www.bmbf.de/en/3591.php
[320] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php

OLEDs

Organic light-emitting diodes (OLED) are extremely efficient in converting electricity into light, are flexible and flat and can be produced in large sheets ('OLED wallpaper'). In light of these advantages, OLED products are predicted to have billions of euros in market potential. The Federal Ministry of Education and Research is allocating EUR 100 million for research through its *OLED initiative*. German companies have committed themselves to investing an additional EUR 500 million in R&D funding when the initiative is successful. This funding will target the establishment of an OLED manufacturing operation in Germany.

Federal Ministry of Education and Research (BMBF) (2011) Optical Technologies - With Light into the Future http://www.bmbf.de/en/3591.php

The Technology Offensive

In January 2011, the Ministry of Economics and Technology launched the Technology Offensive[321], which have three main focus areas:

- Improving innovation framework conditions
- Raising the innovation performance of the German SMEs; and
- Support the key technologies.

Under the three headlines, several measures are taken, among others to increase options for funding, e.g. via the High-Tech Gründerfonds that provides venture capital for innovative enterprises.[322] In the key technologies, focus is on developing energy-efficient solutions as the German government aims at cutting its energy usage in half by the year 2050. Furthermore, focus is on developing the electrical cars industry, aerospace industry, and aviation via several research programmes.

Policy measures towards industrial deployment and their impact

Under the High-Tech Strategy, numerous initiatives have been launched/reshaped. In this section, the Cluster Strategy is briefly presented.

The Cluster Strategy

The aim of this strategy is to enhance research and industry collaboration. The strategy consists of several programmes illustrated below:

[321] Technologieoffensive (2011) http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/Technologie-und-Innovation/technologieoffensive-des-bmwi,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf

[322] High-Tech Gründerfonds (2011) http://www.en.high-tech-gruenderfonds.de/

Figure 9: The German Cluster Strategy (Source: Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy)

An example is the aim of making exchanges between science and industry visible. The Donors' Association for the Promotion of Sciences and Humanities in Germany and the Federal Ministry of Education and Research created a competition titled “Exchanges Between Industry and Research”. The aim of this competition is to identify particularly successful exchanges, present them to the public, and nurture the development of the concept behind such relationships. The contest is designed to mobilise broad segments of science and industry.[323]

Measures to foster the development of clusters and expand the non-technological co-operation funding for SMEs include *The Collaborative Industrial Research Programme* under the Federal Ministry of Economics and Technology. It funds sector-based projects conducted by members of the German Federation of Industrial Research Associations "Otto von Guernicke". Funding for cross-industry projects which is provided through the ZUTECH (Future Technologies for Small and Medium-Sized Enterprises) programme will be increased. In addition, cluster projects that cover the entire innovation process (from basic research and extending to the translation of research findings into new products) will also receive support. The basic research part of such projects will be financed by, for example, the Deutsche Forschungsgemeinschaft (German Research Foundation), while the application-oriented research part will be financed through the

[323] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php

Collaborative Industrial Research programme, and product development activities through the private sector.[324]

The German government wishes to aid the start-up process not only in research-intensive industries but in knowledge-based services sectors as well. The aim is to step up the start-up rate, improve access to financing vehicles and establish attractive conditions for private venture capital investments on the part of venture capital lenders and business angels.[325]

An example is the EXIST University-Based Start-Ups programme by the Federal Ministry of Economics and Technology, which funds individual start-up projects at German universities. EXIST-SEED covers the research and development needs all the way up until the business idea has reached technological maturity and will also facilitate the individual project's transition to assistance from the High-Tech Gründerfonds seed fund. The Federal Ministry of Education and Research will engage in dialogue with non-university research institutes regarding the development of new instruments to facilitate spin-offs.[326]

Challenges to the German innovation system

One of the challenges for the innovative German companies is product piracy, which has led to the launch of *Put a stop to product piracy***.** In the High Tech Strategy it is mentioned that approximately two-thirds of the companies in the capital goods industry are victims of product piracy or trademark counterfeiting. These counterfeit products are made mainly in Asia (70 per cent) – and foremostly in China – where they are also primarily marketed. However, goods that infringe intellectual property rights are also being produced in Europe and the USA.

For this reason, the development of ways for the German capital goods industry to better protect itself again product piracy is a funding priority in the Research for Production of the Future programme being conducted by the Federal Ministry of Education and Research. These efforts are aimed at improving the copy protection field such as product authentication at the time of manufacture (using, for example, holograms, laser techniques, chemical or RFID methods) or through a method that is incorporated into the actual production process as part of the design and production phase (for example, the targeted development of copy-protected key components)”[327]

[324] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[325] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[326] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php
[327] Federal Ministry of Education and Research (BMBF) (2011) High-Tech Strategy http://www.hightech-strategie.de/en/350.php

India

Introduction

India has the aim to become the ***"Global Innovation Leader"*** in all science and technology (S&T) areas[328]. India is currently spending around 1.14% of GDP for R&D, its national aggregate gross expenditure on research and development (GERD) is about €5.5 billion in 2005[329]. The XIth Plan approach paper highlights the objectives and challenges for achieving a broad based higher economic growth rate in agriculture, industry and services, as also the initiatives needed to be taken for a more inclusive development that includes better health, clean drinking water, rural infrastructure, etc[330].

In India, **the Ministry of Science and Technology** is responsible for the promotion of new areas of S&T. It plays the role of a nodal department for organising, coordinating and promoting S&T activities in the country. With regard to KET domains, one of the responsibilities of the Ministry is the "*promotion of new areas of Science and Technology with special emphasis on emerging areas. This includes Research and Development through its research institutions or laboratories for the development of indigenous technologies concerning bio-fuel production, processing, standardization and applications"*[331].

The **Department of Scientific & Industrial Research (DSIR)[332],** a part of the Ministry of Science and Technology, has a wide mandate to support projects, which promote trade in technologies, showcase Indian R&D and technology capabilities in the country or abroad, promote collaborative R&D and technology development. The primary endeavour of DSIR is to promote R&D by the industries, support a larger cross section of SMEs to develop state-of-the art globally competitive technologies of high commercial potential, catalyse faster commercialization of lab-scale R&D, enhance the share of technology intensive exports in overall exports, strengthen industrial consultancy & technology management capabilities and establish user friendly information networks to facilitate scientific and industrial research in the country. It also provides a link between scientific laboratories and industrial establishments for transfer of technologies through the National Research Development Corporation (NRDC) and facilitates investment in R&D through Central Electronics Limited (CEL).

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[328] Report of the Steering Committee on Science and Technology for Eleventh Five Year Plan (2007-2012)
[329] ERAWATCH Research Inventory Report: INDIA
[330] Report of the Steering Committee on Science and Technology for Eleventh Five Year Plan (2007-2012)
[331] http://www.dst.gov.in/about_us/intro_DST.htm
[332] http://www.ableindia.org/html/about/about_index.html
http://www.dsir.gov.in/

India is a large country and its technology requirements also correspondingly span a wide range from nuclear to rural[333]. It wants to continue to develop strategic technologies that are nuclear, space and defence related. Technologies related to energy security, food and nutritional security, health and water security, environmental security, advanced manufacturing and processing, advanced materials, etc., are also important as are the so-called "knowledge-based" technologies (Information Technology, particularly hardware; Nanotechnology, particularly Nanoelectronics; Biotechnology; and convergence of these technologies like Nanobiotechnology for drug delivery).

The Ministry of Science and Technology has created the **Department of Biotechnology (DBT)** in 1986 specifically devoted to boost the development of biotechnology in India[334]. This is considered to be an important area as biotechnology is related to developments in agriculture, health care, environment and industry. The Department of Biotechnology has the aim to[335]:

- Promote large scale use of biotechnology
- Promote university and industry interaction
- Identify and set up centres of excellence for R&D
- Integrated programme for human resource development
- To serve as nodal point for specific international collaborations
- Establishment of infrastructure facilities to support R&D and production
- Serve as nodal point for the collection and dissemination of information relating to biotechnology.

Biotechnology is ranked second as a growth sector after multimedia industry with a tremendous employment potential[336]. The Indian biotech industry in 2009-10 registered 17 % growth, with an estimated revenues of US$ 3.14 billion while the BioIndustrial market (mainly comprising industrial enzymes) is estimated to be US$ 124.65 million in the year 2009-10 as against US$ 105.64 million in 2008-09[337].

National policies aimed at industrial deployment of KETs

India recognizes the importance of R&D in order to keep up and be at the forefront of new technological developments and innovations. They are also committed to reserve substantial budget to make this happen. The budget estimates for XIth Plan (2007-2012) issued by the Planning Commission indicated a fivefold increase to education and a threefold increase to science and technology budgets for the plan period compared to the 2005-06 figures[338].

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[333] Report of the Steering Committee on Science and Technology for Eleventh Five Year Plan (2007-2012)
[334] http://dbtindia.nic.in/uniquepage.asp?id_pk=4
[335] http://dbtindia.nic.in
[336] http://www.indiaeduinfo.co.in/careers/biotech.htm
[337] http://www.indiainbusiness.nic.in/industry-infrastructure/industrial-sectors/Biotechnology.htm
[338] Report of the Steering Committee on Science and Technology for Eleventh Five Year Plan (2007-2012)

Funding programs

The Department of Science & Technology (DST), the Department of Biotechnology (DBT), and the Department of Scientific & Industrial Research (DSIR) have established several funding programs such as[339]:

- Technology Development Board
- Technology Information Forecasting & Assessment Council
- Program aimed at Technological Self Reliance
- Technopreneur Promotion Program
- Industrial Research & Development Promotion Program
- Scheme to Enhance the Efficacy of Transfer of Technology
- Small Business Innovation Research Initiative Scheme
- Biotechnology Industry Partnership Programme.

These programs are briefly discussed in table 1[340, 341] while the small business innovation research initiative scheme and the biotechnology industry partnership programme are discussed in more detail in the next paragraph.

Table 1: Overview of funding programs

Funding programs	
Technology Development Board	In order to promote the commercialization of technology, the Government of India constituted the Technology Development Board (TDB) in September 1996, to promote development and commercialization of indigenous technology and adaptation of imported technology for wider application. The TDB is the first organization of its kind within the government framework with the sole objective of commercializing indigenous research. The Board plays a pro-active role by encouraging enterprises to take up technology oriented products. To achieve this objective, the TDB provides equity capital or loans to industrial concerns and financial assistance to research and development institutions. The loans carry a interest rate of 5% per annum.
Technology Information Forecasting & Assessment Council	Technology Information Forecasting & Assessment Council (TIFAC) is an autonomous organization that operates under the Department of Science & Technology. It aims to keep a technology watch on global trends, formulate preferred technology options for India, promote key technologies and provide information on technologies.
Program aimed at Technological Self Reliance	The aim of PATSER is to support industry for technology absorption, development and demonstration. It helps building indigenous capabilities for development and commercialization of contemporary products and processes of high impact. PATSER also attracts the involvement of national research organizations in joint projects with industry.
Technopreneur Promotion Program	The Technopreneur Promotion Program, jointly operated by DSIR and DST, has the aim to assist individual innovators to become technology based entrepreneurs

339 http://ableindia.in/govt_support.php
340 http://www.tdb.gov.in/WebContent.aspx?id=6&type=homemore
341 http://www.ableindia.org/html/about/about_index.html

	and to assist in networking and forging links for the commercialization of their developments.
Industrial Research & Development Promotion Program	The main area of focus of the Industrial Research & Development Promotion program is the recognition of in-house R&D units in industries, the recognition of Scientific & Industrial Research Organizations and to give fiscal incentives for Scientific Research.
Scheme to Enhance the Efficacy of Transfer of Technology	The Scheme to Enhance the Efficacy of Transfer of Technology gives support to technology acquisition and management. It has two important programs namely the National Register of Foreign Collaborations and the Transfer and Trading in Technology. The objective of the first program is to facilitate the acquisition and management of technology in the country more efficiently. The objective of the second program is to catalyze technology intensive export efforts of industry/R&D through grants & technical assistance.

National Strategy for biotechnology

Seen the importance of biotechnology, a National Biotechnology Development Strategy has been approved by the government in 2007. The strategy includes the following key elements[342]:

- Setting up a national biotechnology regulatory framework
- Promotion of the biotechnology industry through the following measures:
    - 30% of the Department for Biotechnology will be invested in public-private partnerships
    - Launch of the Biotechnology Industry Partnership Programme for advanced technologies to achieve competitiveness in frontier biotechnologies
    - Expand the existing Small Business Innovation Research Industry scheme
    - Launch of the Biotechnology Industry Research Assistance Council (a) to act as an interface between the private and public sector; (b) to nurture and catalyze R&D and innovation in biotechnology in the private sector and (c) to promote public-private partnerships
- The Indian government focuses on building human capital in biotechnology by organizing several initiatives such as:
    - Support for colleges that specialize in undergraduate education in biotechnology.
    - Expansion of PhD and postdoctoral programmes
    - Attracting scientists from Indian origin from overseas (reverting the brain drain)
    - Creating centres of excellence in biotechnology
    - Build further capacity for technology transfer and IPR
- Promotion of innovation and product development, by the following measures:
    - Implementation of biotechnology clusters

[342] http://dbtindia.nic.in/biotechstrategy/National%20Biotechnology%20Development%20Strategy.pdf

- Improving the biotech infrastructure through the development of e.g. biotech incubators
- New Legislation to protect IPR of publicly funded R&D
- Leveraging international partnerships

The funding provided for the development of this strategy is approximately €1 billion.

Policy measures towards industrial deployment and their impact

The next paragraphs will highlight a few interesting initiatives with regard to biotechnology.

Financial support initiatives for biotechnology

The Small Business Innovation Research Initiative (SBIRI)[343] is a new scheme launched by the DBT to boost public-private-partnership effort in the country. The distinctive feature of SBIRI is that it supports the high-risk pre-proof-of-concept research and later stage development in small and medium sized companies. The SBIRI scheme operates in two phases. Phase I for the establishment of pre-proof of concepts of innovations and Phase II for product and process development. In both phases, projects are to be implemented at the industry site. The table below provides an overview of the background, type of support and target group of the SBIRI Scheme[344].

Table 2: Overview of SBIRI programme

SBIRI	
Objective	Seeks to meet the ESTD funding needs of private biotechnology entreprises
Background	Competitive programme that provides matching grants to entreprises with fewer than 500 employees to stimulate technology development – modelled on the US Small Business Innovation Research Programme
Support	Supports start-ups phase I with 80% grant support Supports phase II development-for-commercialization-potential with soft loans for enterprises and grants for public partners
Target	Restricted to biotechnology and covers all biotech areas related to health care, agriculture, industrial processes, environmental biotechnology, and biomdecial devices and instruments Open to individual entreprises, groups of entreprises, and public private partnerships

Source: World Bank, 2007, "Unleashing India's innovation: towards sustainable and inclusive growth".

Biotechnology Industry Research Assistance Programme (BIRAP)[345], is a programme initiated by Department of Biotechnology in partnership with the Association of Biotechnology Led Enterprises (ABLE) and Biotech Consortium India Limited (BCIL) with an objective to assist and promote emerging biotechnology entrepreneurs and

[343] www.bcil.nic.in and http://sbiri.nic.in/

[344] World Bank, 2007, "Unleashing India's innovation: towards sustainable and inclusive growth".

[345] http://www.birapdbt.nic.in/programmes.php

facilitate innovative research and development in existing small, medium as well as large industries. The **Biotechnology Industry Partnership Programme** (BIPP) has been initiated under BIRAP to nurture R&D and innovation in biotechnology industry. The BIPP[346,347] is a Government partnership with industry with the objective to support, on a cost-sharing basis, the development of novel and high risk futuristic technologies. The goal is to develop appropriate technologies in the context of recognized national priorities in the area of agriculture, health, bioenergy, green manufacturing, when the scale of the problem has serious consequences for social and economic development. They also aim to support path-breaking research in frontier futuristic technology areas that have major economic potential to make the Indian industry globally competitive and that is focused on IP creation with ownerships by Indian industry and where relevant, collaborating scientists.

A cluster initiative for biotechnology: Genome Valley

The Genome Valley is a dynamic biotech cluster, in and around Hyderabad[348]. IKP Knowledge Park, SP Biotech Park, Bharat Biotech, Shanta Biotech, and various academic institutions such as the Indian Institute of Chemical Technology, the Centre for Cellular and Molecular Biology, the University of Hyderabad, and the International Crops Research Institute for the Semi-Arid Tropics form important nodes of the cluster[349]. The IKP Knowledge Park, established in 2003, is an excellent example of a public-private partnership providing facilities for life sciences and pharmaceutical research[350]. Currently, the 140,000 square feet Innovation Corridor 1 with 84,000 sft of wet laboratory space is operational and around 35 acres of land has been developed with utilities for customised R&D centres[351].

Sales Tax initiative in Genome Valley[352]

Keeping in view the special difficulties and risks involved in commercialising cutting-edge technologies in the field of biotechnology, Government of Andhra Pradesh has fixed a nominal sales tax of 1% for “high-end” biotech products manufactured by units located in the Biotech Park in Turkapalli village, Shamirpet mandal, Ranga Reddy district. This sales tax rate will be applicable only for a period of 7 years from the date of commencement of commercial production of a biotech unit, and will be extended only to those units which go into commercial production on or before March 31st, 2006. The cut-off date for this concessional rate is 31st March, 2010, beyond which date no new unit in this Park will be extended this incentive. The Department of Science and Technology, Government of India will notify products which do not fall in the category of ‘high end’ from time to time.

[346] www.bcil.nic.in
[347] http://www.birapdbt.nic.in/downloads/About%20BIPP.pdf
[348] dbtindia.nic.in
[349] http://www.genomevalley.in
[350] World Bank, 2007, “Unleashing India’s innovation: towards sustainable and inclusive growth”
[351] www.iciciknowledgepark.com
[352] http://www.genomevalley.in/policy.htm

Networking initiatives for biotechnology

The Department of Biotechnology (DBT) is also involved in networking—through **Biogrid,** a virtual private network designed to connect DBT's bioinformatics centers[353]. The principal aim of the bioinformatics programme is to ensure that India emerges as a key international player in the field of bioinformatics; enabling a greater access to wealth of information created during the post-genomic era and catalyse the country's attainment of lead position in medical, agricultural, animal and environmental biotechnology[354]. The BIOGRID allows exchange of database & softwares which have been created/acquired by the individual centers/nodes of Biotechnology Information System[355]. The DBT has also the intention to use BIOGRID to share teaching materials, to deliver lectures through video conferencing-virtual classrooms besides synergizing research in biotechnology and bioinformatics[356].

The Association of Biotechnology Led Enterprises (ABLE) is a not-for-profit pan-India forum launched in April 2003 that represents the Indian Biotechnology Sector. The primary focus of ABLE is to accelerate the pace of growth of the Biotechnology sector in India, through partnering with the Government in their biotechnology initiatives to deliver optimal policies and create a positive regulatory environment, encouraging entrepreneurship and investment in the sector, providing a platform for domestic and overseas companies to explore collaboration and partnerships, forging stronger links between academia and industry and showcasing the strengths of the Indian biotech sector[357].

An education initiative: Biotech Industrial Training Programme

The objective of the Biotech Industrial Training programme (BITP) is to provide industry-specific training to Biotech students for skill development and enhancing their job opportunities in biotech industry[358]. The programme is being implemented by Biotech Consortium India Limited (BCIL) since 1993 and many leading companies have found it to be an effective mechanism to select suitable prospective manpower[359]. The training period is for six months during which a trainee is paid stipend of Rs.8000/- per month and the trainer company is paid a bench fee to cover the expenses for providing training.

Conclusion

India is increasingly becoming a top global innovator for high-tech products and services[360]. Over the last decade, India has launched a number of interesting initiatives with regard to KETs as the small business innovation research initiative or the sales tax initiative in Genome Valley. It aims to invest in strategic and knowledge-based

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[353] World Bank, 2007, "Unleashing India's innovation: towards sustainable and inclusive growth"
[354] http://dbtindia.nic.in/btisnet.htm
[355] http://dbtindia.nic.in/uniquepage.asp?id_pk=38
[356] http://dbtindia.nic.in/uniquepage.asp?id_pk=38
[357] http://ableindia.in/about_able.php
[358] http://www.bcil.nic.in/biotech_industrial-training.htm
[359] http://www.scholarshipsinindia.com/biotech_industrial_training_programme_BITP.html
[360] World Bank, 2007, "Unleashing India's innovation: towards sustainable and inclusive growth"

technologies. The New Millennium Indian Technology Leadership Initiative (NMITLI) for example is the largest public-private-partnership R&D Programme that looks beyond today's technology and seeks to build, capture and retain for India a leadership position by synergizing the best competencies of publicly funded R&D institutions, academia and private industry[361].

They focus on high risk technology areas with global leadership potential in the domain of biotechnology, chemistry, pharmaceuticals, information and communication technology, energy, and materials. India has the benefit of a dynamic young population as more than half of the country's population is less than 25 years old[362].

[361] http://www.csir.res.in/external/heads/collaborations/nmitli.htm

[362] World Bank, 2007, "Unleashing India's innovation: towards sustainable and inclusive growth"

Italy

Introduction

Italy's economy is dominated by small and medium-sized firms (SMEs)[363]. Italy's R&D expenditure is underdeveloped compared to its economic profile. In 2006 GERD/GDP was 1.14% and BERD/GDP was 0.56% with a trend that for both measures during 2000s has remained more or less stable. Private funding of GERD is even lower, 0.40%[364]. President Giorgio Napolitano made a call to the government to do more for the economy in September 2010. He said[365]: *"Italy needs a serious industrial policy within a European framework. We need this for employment and for the young people who are our main cause for concern".*

To address these issues, the Interministerial Committee for Economic Planning (CIPE) has designed the National Strategic Framework[366]. The Italian National Strategic Reference Framework (NSRF) includes guidelines for the country's comprehensive regional development policy to improve productivity, competitiveness and innovation[367]. CIPE is is a collective governmental body headed by the President of the Council of Ministers and composed of the so-called economic ministers. It examines the general socio-economic situation with a view to the adoption of cyclical measures; identifies the guidelines and actions needed to achieve the objectives of economic policy; allocates financial resources to development programmes and projects; and approves the country's principal public investment plans[368].

The government of Prime Minister Silvio Berlusconi that took office in April 2008 has taken only modest steps toward structural economic reform that could increase investment, business creation, production and employment[369]. According to Eurofound, Italy lacks a genuine industrial policy, that is, one which is not based on short-term or generic measures[370]. Italy faces a weakness with regard to the productive and technological specialisation of the country (traditional sectors and medium low technologies)[371]. Moreover, Italy has a small number of researchers, especially in the

363 http://www.eubusiness.com/europe/italy/invest
364 ERAWATCH Country Report 2009, Italy
365 http://www.lifeinitaly.com/news/napolitano-calls-serious-industrial-policy
366 http://www.cipecomitato.it/en/highlights/national_strategic_framework.html
367 http://ec.europa.eu/regional_policy/atlas2007/fiche/it_en.pdf
368 http://www.cipecomitato.it/en/the_cipe/role.html
369 http://www.eubusiness.com/europe/italy/invest
370 http://www.eurofound.europa.eu/emire/ITALY/INDUSTRIALPOLICY-IT.htm
371 ERAWATCH Country Report 2009, Italy

private sector, that generally earn low wages[372]. In 2009, the Italian government implemented some tax benefits for start-ups and some fiscal incentives for companies. However, significant stumbling blocks to investment remain, such as rigid labor laws, high input costs and taxes, a muddled commercial law system, the large role of Italy's public sector, and the perception of corruption and latent economic nationalism[373].

National policies aimed at industrial deployment of KETs

To address some of the major economic challenges Italy is facing, it has created several policies and initiatives. No particular policies are formulated explicitly towards the development and deployment of KETs. However, several KETs might be deployed in pursuing the general economic, research and innovation targets the Italian government has formulated.

The National Agency for Innovation is the operative tool of the Ministry for Innovation which, together with the Ministry for the Economic Development, defines the policies and strategies at national level[374]. The mission of the Agency is[375]:

- To promote the application of research results to products and processes in the productive sector and in the national and regional public administration;
- To develop the competitiveness of SMEs through the diffusion of innovative technologies;
- To increase the availability of financing of innovative companies by venture capital funds and private equity.
- To promote worldwide Italian innovation.

The Agency aims to promote the dissemination of innovation and strengthen the exchange between the actors that produce innovation in Italy. One mechanism to do this is through the creation of competence centers.

Competence centers

The competence centers are promoted and coordinated by the universities and Italians research institutions to establish close cooperation with companies on issues of major interest for innovation in public administration[376]. The goal is to gain experience on the innovative technologies and to build technological know-how to research, to market development and to its use by the public administration. The existing centers are focused on:

- dematerialization of documents
- cloud computing
- energy efficiency
- smart services for citizens.

[372] http://www.observa.it/view_page.aspx?ID=635&LAN=ENG
[373] http://www.eubusiness.com/europe/italy/invest
[374] http://www.taftie.org/taftie.content.asp?ContentId=132
[375] Presentation Agency for the Promotion of Technologies for Innovations
[376] Presentation Agency for the Promotion of Technologies for Innovations

There is no explicit focus on key enabling technologies.

The Italian government creates an open source competence center[377]
The Italian Center of Competence for the Open Source initiative is a joint effort between Engineering Ingegneria Informatica, the Univeristy of Sannio, the University of Insubria and the University of Bolzano. The resource center is meant to assist schools, colleges, hospitals, and other adopters of open source technology.
The center's primary goal is to provide user support to publicly funded institutions and small and medium enterprises that use open source software regularly. In addition, the center will promote the adoption of open source in Italy, a country that has been slow to embrace open source solutions, at least by European standards.

The purpose of the competence centers is to gain experience on enabling technologies and organizational arrangements to make it available to the government concerned to achieve a virtuous circle[378]:

- SMEs and large companies examine the value of their technology proposals before making investments, receiving information on innovative applications of interest to the public administration;
- Universities and research institutions can set their own research on innovative technologies that have high probability of engineering and development of market;
- Public Administrations find a partner that require solutions and to receive proposals from technology enablers to develop new services and innovative organizations.

INDUSTRIA 2015
The Italian Ministry for Economic Development has established strategic priorities for the growth and future competitiveness of Italy’s production system through the Industria 2015 programme[379]. INDUSTRIA 2015 is the plan for New Industrial Politics in Italy enacting the EU Directive 2006/32/EC of April 5th, 2006[380].

[377] http://www.linux-magazine.com/Online/News/Italian-government-to-create-open-source-competence-center
[378] Presentation Agency for the Promotion of Technologies for Innovations
[379] http://sostenibilita.fiatgroup.com/en-US/sustInn/Pages/industria2015.aspx
[380] http://www.azonano.com/news.asp?newsID=9756

FIAT Group, Industria 2015[381]

Projects for industrial innovation forming part of this programme create new, cross sector chains of production (integrating manufacturing, advanced services and new technologies) to foster the development of specific types of highly innovative products and services in areas which are strategic for Italy: **energy efficiency, sustainable mobility and new technologies for traditional Italian products**. In addition to manufacturers, contributors to the programme include local and national government, universities and research organisations and the financial system.

The Fiat Group has taken part in many initiatives and projects, most notably in the strategic area of sustainable mobility, with six proposals considered eligible for co-financing. Iveco coordinates three of these projects: LIVE (ecocompatible light commercial vehicles), VECTOR (optimised multi-role medium commercial vehicles), and AUTOBUS (innovative buses for urban mobility). Magneti Marelli is coordinator for the Easy Rider project on telematic services for mobility and safety. Finally, in the area of energy efficiency, the Group was awarded the contract for the Target Fluff project, which centres on recovering energy from residual materials generated by the end-of-lifevehicle recycling process.

RIDITT

RIDITT is an initiative sponsored by the Ministry of Economic Development (MSE) and implemented by the Institute for Industrial Promotion (IPI) aimed at promoting innovation in SMEs[382]. RIDITT aims to[383]:

- Analysing enterprises technology needs and identifying emerging technologies;
- Stimulating partnerships between research organisations, SMEs, enterprise associations, chambers of commerce;
- Funding technology transfer projects to the benefit of SMEs by exploiting innovative technologies developed by state-of-the-art research centres;
- Fostering specialisation of the national innovation system in selected priority technology areas (e.g. advanced materials, micro and nano technologies, biotechnology, automation, energy, and environment).

RIDITT has carried out a study to identify 126 technologies and 1,400 industrial applications which can play a pivotal role for the development of the Italian production system. The resources available for implementing the RIDITT Program (2003-2012) are approximately €23 million[384].

Expo 2015

The Expo 2015 Company and the National Agency for Innovation intend to develop a systematic and comprehensive collaboration on the themes of Expo Milano 2015, aimed in particular at the exploitation of scientific and technological expertise of the Italian system of public and private research[385].

[381] http://sostenibilita.fiatgroup.com/en-US/sustInn/Pages/industria2015.aspx
[382] http://www.riditt.it/site/about-riditt
[383] http://www.riditt.it/themes/technologies
[384] http://www.riditt.it/site/about-riditt
[385] Presentation Agency for the Promotion of Technologies for Innovations

Policy measures towards industrial deployment and their impact

Although there are no specific policy measures that target the development and deployment of KETs, there are several interesting initiatives in Italy that stimulate the development and deployment of KETs. Some initiatives are highlighted in the next paragraphs.

The Institute for Microelectronics and Microsystems (IMM)

The Institute for Microelectronics and Microsystems (IMM) is the largest institute in the field of microelectronics in Italy. Its headquarters are in Catania, driven by the presence of some large companies in that area like STMicroelectronics. IMM is engaged in the development of innovative solutions for microelectronics (materials and processing for sub-32 nm CMOS and non-volatile memory technologies; materials, processes and devices for advanced power electronics; large area and plastic-based electronics; novel photovoltaic applications, etc.), sensing technology, optoelectronic microsystems, and microfluidics[386]. It is an interdisciplinary organization that has the aim to develop competencies in the area of microelectronics. The institute has developed strong linkages and collaborates with industry in order to share costs and to be close to industrial applications. As there is no general national strategy with regard to microelectronics, they focus on regional initiatives which have been created in response to the formation of districts (microelectronics has been assigned to Catania)[387].

Enel Green Power, Sharp and STMicroelectronics signed an agreement for the largest PV manufacturing plant in Italy[388]

Enel Green Power, Sharp and STMicroelectronics have signed a binding letter of commitment for a project financing agreement for €150m for the development of a PV panel factory, 3Sun in Italy. With the signing of the agreement, the Catania factory enters into its operational phase for the production of PV cells and panels. The factory's initial PV panel production capacity of 160MW per year will be financed through a combination of self-financing, €49m in funding from the CIPE (the Italian Joint Ministerial Committee for Economic planning) and project financing provided by banks[389].

The factory will be located in Catania in the existing M6 facility to be contributed by STMicroelectronics. **Catania represents an ideal location** as it takes full advantage of an existing semiconductor plant and related facilities as well as of very important workforce skilled in silicon-based manufacturing. In addition, Catania hosts Conphoebus, an Enel research center fully dedicated to renewable sources, solar in particular, and energy savings. Moreover, Sicily is one of the key regions in the Mediterranean area for the development of solar farms and provides a unique location for all logistics necessary to reach the neighbouring markets[390].

Association Microelectronics Electronics Semiconductors (AMES)

AMES is a disciplinary group of AEIT (Italian Federation of Electrical, Electronic, Automation, Information and Communication Technology) that focuses on

[386] http://www.imm.cnr.it/en
[387] Interview with Vito Raineri, IMM
[388] http://gotpowered.com/2010/enel-green-power-sharp-and-stmicroelect/
[389] http://solar.energy-business-review.com/news/enel_sharp_stmicroelectronics_partner_to_develop_pv_panel_plant_in_italy_100802
[390] http://gotpowered.com/2010/enel-green-power-sharp-and-stmicroelect/

microelectronics and semiconductors. It aims to support the development of these areas, by promoting education, training, and dissemination of knowledge[391]. In Italy, there are many groups present in universities and research institutions that are engaged in microelectronics and semiconductors activities. These groups are however very scattered across Italy and usually only consist out of a few people[392]. AMES has the mission to bundle the activities of these people in order to create a critical mass.

Veneto Nanotech

Veneto Nanotech was created in 2003 after careful valuation and analysis of the Italian business reality regarding innovation and technology transfer, and has grown to coordinate the activities of the high tech cluster of nanotechnology applied to materials[393]. It was established with the objective to build international excellence in research, to foster the application of nanotechnology, and to support the development of start-ups in the focus sector.

Nanofab[394] is one of the first European laboratories applying nanotechnology to industrial production.

Created to promote interaction between the nanotechnology and business communities, it places at the disposal of businesses laboratories in the forefront in order to support technology and scientific expertise transfer. The Nanofabrication Facility is a 2,500 sqm R&D lab to be utilized by both Universities and innovative companies. NanoFab proposes itself as a reference point for scientific consultancy through its own facilities as well as through its links with national and international academic institutions. It offers a wide variety of high tech products and services aimed at satisfying the specific demands of its clients. In fact, companies can place orders for R&D projects availing from the company's team of researchers or can merely use the laboratories with their own technical staff. The Nanofabrication Facility is managed by Nanofab scarl, a non-profit organization created by the Park of Science and Technology VEGA and by the CIVEN Association. The Region of Veneto has invested 14mn euros in order to create the laboratories that cover an area of 2500sq m and employ 12 fulltime researchers.

Conclusion

Italy has an industrial landscape in which many SMEs are present, and a limited amount of large companies. To strengthen its industrial landscape, the Italian government has launched several policy measures and initiatives. These measures and initiatives have a tendency to cover many topics and broad areas, while in general the amount of money that is available for the specific measure or initiative is limited. The Italian economy would benefit from a clear strategy that sets out some clear goals, backed with sufficient financing. Recently, some interesting initiatives have been set up that focus on addressing the 'Valley of Death' issues, such as the Nanofab and the Competence centres, but it is too early to assess their success.

[391] http://www.aei.it/index.php?option=com_content&view=article&id=51&Itemid=12
[392] Interview with Vito Raineri, IMM
[393] http://www.venetonanotech.it/en/about-us/,61
[394] http://www.venetonanotech.it/en/industry/nanofab/,76

Japan

Introduction[395]

Since World War II factors such as government-industry cooperation, a strong work ethic and mastery of high technology helped Japan develop a technologically advanced economy. Two important characteristics of the post-war boom, which lasted nearly three decades, were the close interlocking structures of manufacturers, suppliers, and distributors, also known as keiretsu, and the guarantee of lifetime employment for a large part of the urban workforce[396].

The Japanese economy slowed down considerably following a Tokyo Stock Exchange crash in 1990-92. During the last 20 years the Japanese economy has struggled to regain the growth levels of the 1960s, 70s and 80s, which averaged around 6 per cent. A sharp downturn in business investment and global demand for Japan's exports in late 2008 pushed Japan further into recession. Government stimulus spending helped the economy recover in late 2009 and 2010.[397] Today, Japan has the third largest economy in the world after the United States and China.

The Global Competitiveness Index 2010-2011, published by the World Economic Forum, places Japan 6th in terms of competitiveness compared with 133 countries. Moreover, Japan is ranked 1st in terms of innovation and sophistication factors.[398]

According to recent data from the OECD, Japan has a very high expenditure on research and development. In recent years Japan has consistently allocated over three per cent of its own GDP to investment on R&D annually. By 2008 this number was at 3.42 per cent – only superseded by Israel, Sweden and Finland.[399]

Japan is a resource poor country and is therefore heavily dependent on imports of goods and raw materials. Consequently, Japan has formed its growth strategies around sustainability and development of state-of-the-art science and technology (S&T).

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[395] This innovation policy profile has not taken into account the possible economic impact of the tragic event in Japan March 2011. The profile is based on literature review only, but the consultants had email correspondence with Mr. Koji Takimoto, Counsellor, Bureau of STI Policy, Cabinet Office, Japan.

[396] https://www.cia.gov/library/publications/the-world-factbook/geos/ja.html

[397] https://www.cia.gov/library/publications/the-world-factbook/geos/ja.html

[398] http://www3.weforum.org/docs/WEF_GCR_Highlights_2010-11.pdf

[399] http://www.oecd-ilibrary.org.esc-web.lib.cbs.dk/docserver/download/fulltext/191000011e1t002.pdf?expires=1301563329&id=0000&accname=freeContent&checksum=58F41C15BDC751FCA83F55223AE131FB

In relation to KETs, Japan play a significant role in all six KETs, but particularly in nanotechnology, micro- & nanoelectronics and photonics (especially LED)[400].

Innovation policy in Japan

Science and Technology Basic Law[401]

In 1995, the Japanese government established the "Science and Technology Basic Law". One of the objectives was to achieve a higher standard of S&T through prescribing the basic policy requirements for the promotion of S&T and comprehensively and systematically promoting policies for the progress of S&T.

Promotion of R&D is an important element towards industrial deployment in the Law. It has a number of recommendations for the factors which should be included in future policies. These include:

- *Balanced Promotion of various levels of R&D*
    - Balanced promotion of various levels of R&D in comprehensive fields, including taking necessary measures for the planning and implementation of R&D in the specific fields of S&T of national importance.
- *Securing Researchers*
    - Improve education and research in graduate schools, to secure and train Researchers and to improve their quality in order to promote R&D corresponding to the progress of S&T.
    - Implement necessary policy measures to improve the occupational conditions of researchers in order for their positions to be attractive.
- *Improvement of Facilities*
    - Implement necessary policy measures to improve research facilities of R&D institutions (national research institutes and institutions for R&D in Universities, private sector) in order to promote R&D corresponding to the progress of S&T.
- *Promotion of Information Intensive R&D*
    - Promote information intensive R&D, including databases on S&T and the construction of information networks among R&D institutions in order to promote R&D effectively.
- *Promotion of Exchange in R&D*
    - Implement policy measures for the promotion of R&D to enhance various exchanges such as the exchange of Researchers, joint R&D of R&D institutions and joint use of Facilities of R&D institutions, in consideration of the fact that promoting the fusion of various Researchers' knowledge through exchanges between R&D institutions and/or Researchers is the source of new R&D progress and that this exchange is essential for the effective promotion of R&D.

[400] See main report.
[401] http://www8.cao.go.jp/cstp/english/law/law.html

- *Making public the results of R&D*
    - Implement policy measures to diffuse the results of R&D, such as the publication of the results of R&D and the provision of the information on R&D and measures to promote appropriate practical applications of them.
- *Support of efforts by private enterprises*
    - Implement necessary policy measures to promote private sector R&D by encouraging initiatives in the private sector[402].

Based on the *Science and Technology Basic Law* the Japanese Government sets the "Science and Technology Basic Plan" and shows implementing policy for 5 years in the Five Year Plans (FYP).

Science and Technology Basic Plan

Since the Science and Technology Basic Law, three *Science & Technology Basic Plans* has been published the latest for the period 2006-2010.

The first two basic plans were formulated and carried out during a long period of economic stagnation in Japan following the collapse of the 'bubble economy'. However, Governmental R&D expenditure increased, and a broad range of structural reforms were conducted, including strategic priority setting in S&T through promotion of basic research and prioritization of R&D on national/social issues; development of a competitive R&D environment by increasing competitive funds and reforming existing systems; and the reorganization of national research institutes and national universities into corporations[403].

In the preparation phase for the 3rd basic plan, the economy was no longer in decline and the aim of the 3rd basic plan was to build on the two previous plans through:

- Development of world-class researchers who can produce excellent research findings
- Creation of a competitive environment, promotion of science, and creation of persistent innovations through strategic investment
- Removal of systematic or operational obstacles to return the R&D benefits back to society.

The Governmental R&D expenditure for the Basic Plan in the 5-year period was set to approximately €212 billion (25 trillion yen), slightly higher than the two previous basic plans (17 trillion yen and 24 trillion yen). This is equal to approximately 1% of the GDP[404].

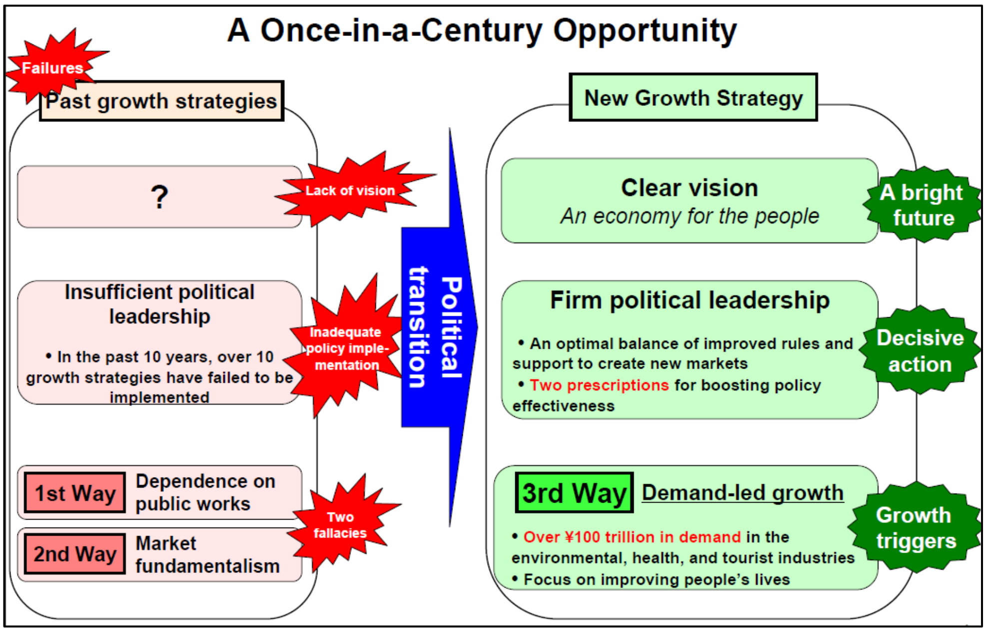
The focus in the Basic Plan is very much reflecting the recommendations of the Basic Law as highlighted above.

[402] http://www8.cao.go.jp/cstp/english/law/law.html
[403] http://www8.cao.go.jp/cstp/english/basic/3rd-Basic-Plan-rev.pdf
[404] 404 http://www8.cao.go.jp/cstp/english/basic/3rd-Basic-Plan-rev.pdf

New growth strategy - Towards a Radiant Japan[405]

In 2009, Japan's Cabinet issued the *New Growth Strategy* to change 20 years of economic downturn. The strategy seeks to move Japan past its traditional emphasis on export-oriented manufacturing in favour of demand-led growth and domestic consumption. A Growth Strategy Implementation Plan is under development and the outcomes are to be realised in 2020.

Figure 10: The New growth Strategy, Japan (Dec. 2009)



Source: http://www.kantei.go.jp/foreign/topics/2009/1230strategy_image_e.pdf

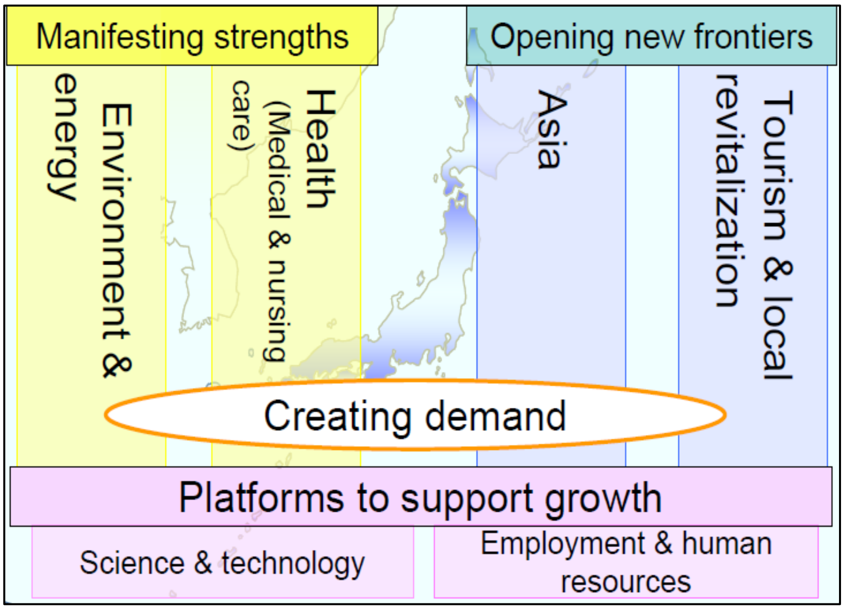
According to the New Growth Strategy document, previous growth strategies had lacked focus and vision, which has led to an inadequate policy implementation of the Basic plans and Basic Law. Previous growth strategies have either been based on public works and market fundamentalism[406].

The New Growth Strategy aims to create a clear long-term vision with political leadership based a thorough analysis of the national goals and policies. The aim is to realise the "selection and focus" on those things that are truly necessary for Japan. Finally, the 3rd way is based on a demand led growth driven by Japans strengths aimed at improving citizen's lifestyles, generating employment by creating over ¥100 trillion (approximately €850 billion) in new demand from the environmental, health, and tourism industries by 2020.

Four focus areas has been pointed out, of which two are based on Science and Technology as illustrated in the figure below.

[405] http://www.rio.br.emb-japan.go.jp/NewGrowth.pdf
[406] http://www.rio.br.emb-japan.go.jp/NewGrowth.pdf

Figure 11: Demand-led growth in the New Growth Strategy, Japan (Dec. 2009)[407]



The aim of the S&T areas is to lead the world in *green innovation* and *life innovation* and increase the number of universities and research institutions that lead the world in the respective fields.

Energy & Environment

The first focus area comprises global warming (energy) measures with the aim to move Japan towards becoming a world leading low carbon society, by creating over ¥50 trillion (approximately €425billion) in new markets and 1.4 million jobs and reduce worldwide greenhouse gasses by 1.3 billion ton CO2 using Japanese technology. The following measures will be implemented in order to achieve this:

- Support for increasing renewable energy by measures such as expanding feed-in tariffs[408] etc.
- Focus on zero-emission structures in buildings
- Speed up development of innovative technology
- Concentrate investment for creating an eco-friendly society.

As it is the case in for example Europe and the US, the KETs are seen as a key to enable the targets.

Health

The second area based on S&T intervention, *health*, comprises measures that respond to the aging of society with a goal to make Japan a healthcare superpower. The aim is to address this challenge and thereby make Japan a model country that leads the world in solving problems and thereby create a large market for the Japanese companies.

407 *Source: http://www.kantei.go.jp/foreign/topics/2009/1230strategy_image_e.pdf*

408 Policy mechanism designed to encourage the adoption of renewable energy sources.

Generating a virtuous cycle of demand creation and strengthen the supply capacity is seen as essential in order to break away from deflation. The role of Japanese government in creating such a system is a key to the Growth Strategy.

Two of the measures are directed towards industrial deployment:

- Promote R&D and application of innovative health technology, pharmaceuticals and devices; and
- Promote expansion to Asian and overseas markets.

The New Growth Strategy show how Japan has based its growth strategy on creating demand, based on the challenges and key strengths in Japan with an aim to become a leader in the related technologies, of which the KETs play a key role. Furthermore, the societal challenges in Japan are mirrored in many other parts of the world, which could create a large market.

Promotion of Science and Technology – Japan Science & Technology Agency (JST[409])

The Japan Science and Technology Agency (JST) is one of the core institutions responsible for the *implementation* of science and technology policy in Japan, including the government's Science and Technology Basic Plan.

One of the main features is the *Technology Transfer Program from academia to the private sector*, which combines two approaches to achieve effective results. The program offer support from the basic research stage until industrial deployment. In some cases JST support R&D projects lasting up to 10 years.

There are two major approaches, which is supported by a long range of different support measures.

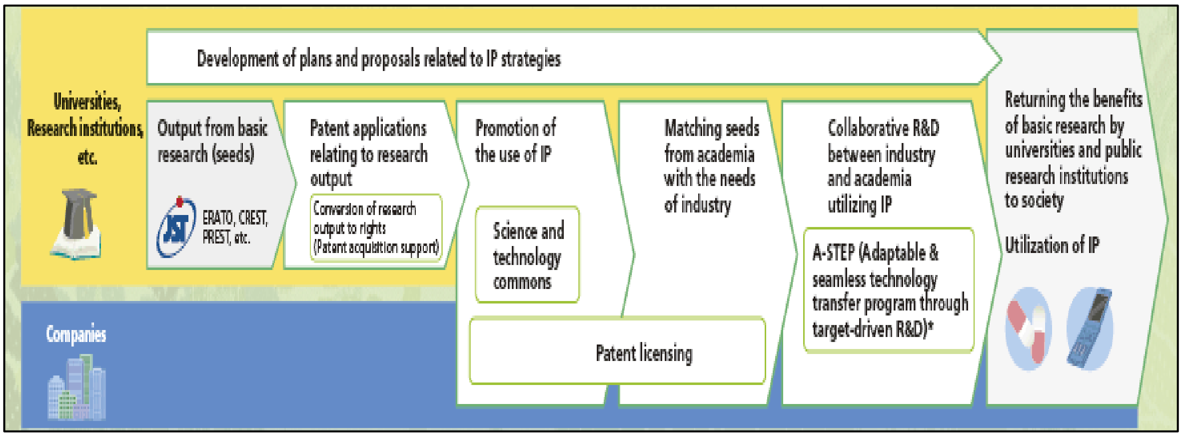
Utilizing University IP to drive innovation

The figure below shows the long range of support measures provided by JST for improving the utilization of university IP.

The aim of the first approach is to utilize University IP through collaboration between the universities, public sector research institutions and the private sector. The approach includes a long range of financial and non-financial support mechanisms from promoting the pursuit of patents which match the need of industry and society.

[409] http://www.jst.go.jp/tt/EN/index.html

Figure 12: Support measures for utilizing University IP



JST have senior patent investigators with extensive industry and R&D experience, to support these institutions to file and promote patents. Also, JST is supporting collaborative R&D between industry and academia based on the IP and seeds held by universities through two stages:

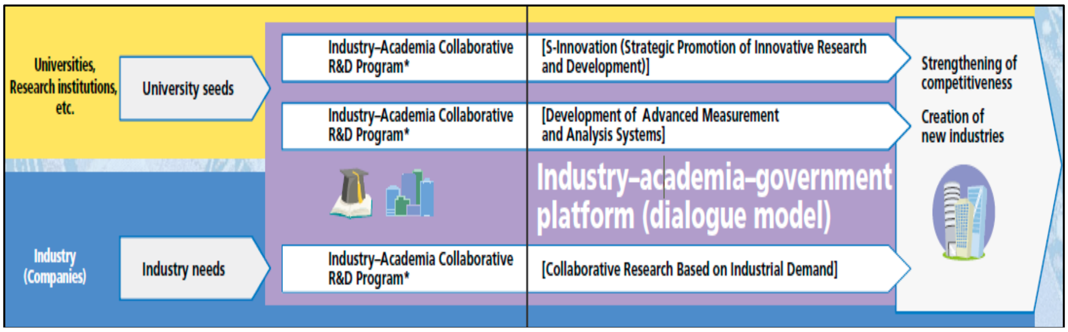
- *Feasibility stage:* Investigation of technology transfer potential; validation of potential as a technology seed that will meet the needs of companies; and validation of potential to become the technology seed for a university-launched start-up company.

- *Full-scale R&D stage:* R&D in preparation for the establishment of a university-launched start-up venture that aims for the practical application of technology seeds; and R&D during the practical *verification and testing phase* through joint R&D by an industry–academia partnership.

Platform for dialogue to drive innovation

The second approach aims to accelerate innovation driven by close collaboration between industry, academia and government, and facilitated by a platform for dialogue between all three sectors. This ultimate aim is to create new industries and assist existing industries in increasing their competitiveness.

Figure 13: Support measures to accelerate innovation driven by close collaboration between industry, academia and government.



The idea behind this approach is to strengthening the basic research and R&D infrastructure through dialogue between industry and academia, as well as by implementing large-scale R&D projects through industry–academia consortia. There are three programs within this approach.

The first two programs (S-Innovation and Development of Advanced Measurement and Analysis Systems) provide support for long-term research projects (up to 10 years) from basic research to testing of prototypes. It is envisaged that the innovation resulting from such technologies will form the foundations of future industries. Below is a description of the S-Innovation program.

The S-Innovation Program is based on long-term pursuit of R&D toward the practical application of novel technologies. The initial R&D themes are selected from other R&D programs in Japan and the final selections of R&D themes are selected after a workshop with leading experts from industry and academia. One of the themes for 2010 is *R&D for aged society*, one of the four focus areas of the New Growth Strategy.

The table below provides an overview of the different stages in the S-innovation program:

Figure 14: S-Innovation process overview[410]

Number of projects approved	Approximately five projects per R&D theme		
R&D period	Maximum period of 10 years (comprising three stages)		
R&D phase	Stage I	Stage II	Stage III
	Basic and foundational R&D aiming to establish component technology	R&D of component technology	R&D of applications (verification testing aimed at commercialization of product)
R&D period by stage (approximate)	2–3 years	3–4 years	2–3 years
R&D funding (including indirect costs)	Up to ¥70 million per project team		
	Contract fund	Contract fund	Matching fund
R&D system	Industry–academia collaborative R&D teams are formed through partnerships between companies and universities, etc. The project manager (PM), who is responsible for team coordination, is chosen at the time a proposal is submitted. Centering on the PO, each PM works to share information among teams as R&D proceeds.		

Conclusion

Japan is leading the way in innovation and is leading the way in several KETs. After two decades of downturn in the economy, Japan has changed its innovation policy. Focus is now on creating demand for key technologies through addressing national societal challenges. The aim is to become world leader to address these challenges, which are similar to the challenges seen in many parts of the world.

The R&D investments in Japan are high, and there is a clear long-term focus. This is mirrored in the R&D projects, which are funded and support in up to 10 years, from basic research to testing of prototypes.

[410] http://www.jst.go.jp/tt/EN/platform/s-innova.html

Korea

Introduction

Over the past 40 years, Korea has shown remarkable economic growth. Furthermore, Korea has changed technology strategy from R&D investments and attracting FDI towards a focus on technology transfer and technology commercialization. One of the most important driving forces of the growth has been the investment in large-scale facilities, development of infrastructure, and aggressive acquisition of the most advanced technology in the global marketplace.

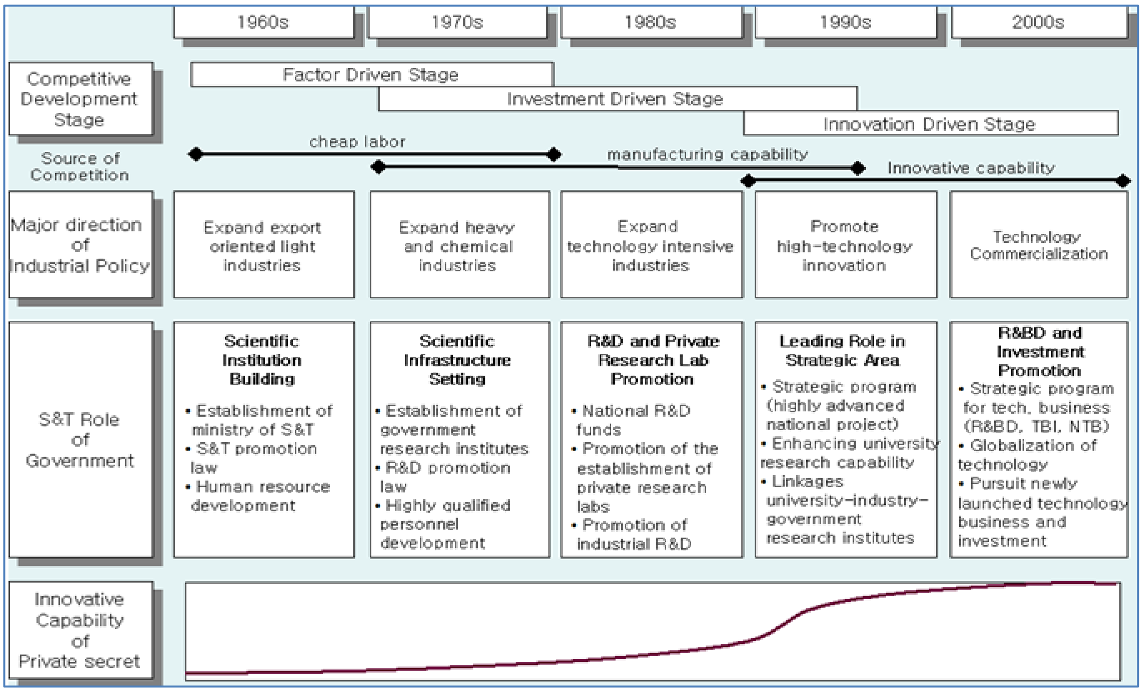
This is also highlighted by ERAWATCH, who state that R&D policies in Korea has been known to use a variety of direct instruments for the promotion of national R&D activities and industrial development, including tax credits, tax exemptions, R&D grants and subsidies.

The national R&D approach is, however, increasingly focusing on indirect instruments, such as establishment of clusters, incubators and networks for the promotion of private companies' innovations as well as S&T infrastructure-service development such as establishment of technology intermediaries, intensifying technology certification programmes and building-up of systematic IPR structures.[411]

The figure below show the different stages of Korean industrial policy from factor- driven stage based on cheap labour, investment-driven improving the manufacturing capability and for the last two decades innovation-driven, by firstly promotes high-tech innovation and in the last decade focus on tech-transfer and commercialisation.

[411] ERAWATCH, http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=14&parentID=12&countryCode=KR

Figure 15: Science and technology roadmap of the Korean Government[412]



This innovation policy profile will first present of how Korea is attracting FDI in high-tech sectors and support indigenous high-tech companies through financial support, and then look at the role of the different organisations set up to promote technology transfer and commercialisation and finally gives provide of KET specific initiatives.

Attracting high-tech FDI and support of indigenous high-tech companies

Attracting FDI has been a priority since the introduction of the Foreign Investment Promotion Act, which was enacted in 1988 to promote foreign investment by providing support for and enhancing the convenience of foreign investment. FDI-related foreign exchange and external transactions must be governed by the Foreign Exchange Transaction Act unless otherwise specified in the Act.

Korea offers two kinds of support for FDI and high-tech companies, *Tax breaks and Cash/location support.*

Tax breaks on FDI are governed by the Special Taxation Restriction Act, which implements a system of tax breaks designed to facilitate the transfer of cutting-edge technologies and to promote foreign investment. The tax breaks include both corporate and income tax for up to seven years for foreign companies and high-tech businesses, five years full tax break and two years with 50% tax breaks. According to some of the large European companies interviewed for this projects, this means that there is enough time to go from R&D to commercialize the technology. The Korean Government has created different types of zones[413] where companies will be eligible to different types of tax

[412] Dr. Young Roak Kim, Korea Technology Transfer Center (KTTC): Technology Commercialization in Korea

[413] Examples include complex-type foreign investment zones, individual-type foreign investment zones, free economic zones, and free trade zones.

breaks, such as the one mentioned above. Also, the Korean government provides free or low-cost industrial complexes exclusively for foreign-invested companies according to specific criteria for eligibility[414].

Cash and location support is offered to companies with an FDI ratio of over 30% and they should build or expand factories for businesses requiring highly advanced technologies or for industrial support services with an investment amount of US$ 10 million; or should newly install or expand research facilities to conduct R&D activities relating to the businesses requiring highly advanced technologies.

The cash support can be used for land purchase costs or rental costs for installing factory facilities or research facilities, plus as employment subsidies and education and training subsidies.

The amount of cash support is determined through negotiations between the government and the investor, but range from between 5 and 15% of the FDI amount[415].

Support for tech-transfer and commercialisation

According to the OECD, Korean innovation policy has recently changed from 'catch-up' to a 'creative innovations system, where the policy attempt to improve knowledge flows and technology transfer across the innovation system.

The focus of industrial innovation policy in Korea has previously been to boost R&D and increase the number of patents. In this area, Korea has been extremely successful, but at the same time they have experienced difficulties commercialising the results of the R&D investments and the patents filed. One of the key challenges for Korea is the limited role of long-term basic research, which may serve as a barrier to developing Korea's innovation capacity in the long run.[416] Therefore, in 2000 the Korean Government introduced the Technology Transfer Promotion Act. The idea behind this was to change focus *from quantity to quality of R&D and patents*, the advantage being that focus on high quality should increase market interest. Several support measures were launched in order to secure commercialization of R&D.

Below we will present three different organisations aiming to support this transformation.

Korean Technology Transfer Centre

The Korean Technology Transfer Centre (KTTC) was established in 2000 to realise the mission of the Technology Transfer Promotion Act by promoting transactions of technology transfer and commercialization. Part of the KTTC strategy is according to the interview with Mr. Jung from KIAT, based on the US SBIR program and connected activities, such as the MatchMaker Program (see US profile).

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414 Invest KOREA (Dec. 2009): The Investment Environments of Major Asian Countries.

[415] Invest KOREA (Dec. 2009): The Investment Environments of Major Asian Countries.

416 WIPO (2007): Technology transfer, intellectual property and effective university-industry partnerships. The experience of China, India, Philippines, the republic of Korea, Singapore and Thailand.

KTTC provide assistance for companies to find customers and industrial partners. They review the technology to sell, estimates the commercial viability the market and industry trends and identify potential licensees or partners. They also offer support related to problems generated by differences in legal system as well as the negotiation stage and deal closing.

KTTC also provide a valuation service where feasibility studies are undertaken on early-stage technologies through market, technical and economic analysis and performs business and technology valuation.

Finally, they promote mergers and acquisitions involving technology based companies and lab ventures and provides comprehensive services from finding a right partner to the signing a contract.

Korea Invention Patent Association (KIPA[417])

The Korean Invention Patent Association plays an important role in transferring patents into products. KIPA has three main goals, which are:

- Providing a one-stop service that offers assistance from the early stages of inventions to commercialization.
- Promoting intellectual property and expanding patent management support.
- Training human resources to handle intellectual property issues in the age of globalization.

One of the major steps to change from quantity to quality of patents is valuation of patents. KIPA valuate the patented technologies and promote the patents with commercial potential. They do this through several instruments, many of which are financial, backed up with management support.

KIPA provide several financial instruments to support commercialisation of patented technologies. They provide assistance to international application fees in order to encourage individual inventors and SMEs to venture out internationally. They also financially support for the production of prototypes to help companies commercialize inventions by providing government financing for manufacturing pilot products. Up to 70% of the total costs are provided. They also encourage companies possessing patents to develop major capital goods and products requiring sophisticated technology, as well as disseminate innovative technologies by offering long-term low-interest loans that can be used to cover production costs from *R&D to the manufacturing of pilot products*.

KIPA try to match the patented technologies (from local universities, research institutes and other companies) with industrial partners/customers by lending financial support and helping commercialize such patented technologies. This also includes recommendations to public agencies regarding which superior inventions are to be prioritized or purchased. Finally, KIPA also help explore the market, increase the volume of trade, enhance the

[417] http://www.kipa.org/english/index.jsp

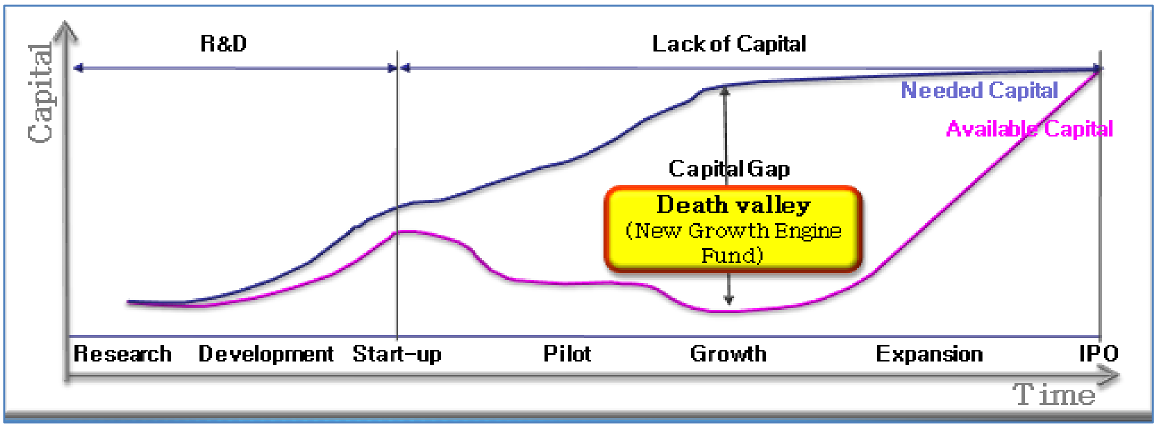
morale of SMEs and individual inventors, collect the funds for the development of patented technologies and secure profits.

Korea Institute of Advancement Technology

The Korea Institute for Advancement of Technology was established in 2009 as a public institute under the Ministry of Knowledge Economy. KIAT is set to play an important role to promote Korea's industrial development and industrial technology innovation. This role includes suggesting R&D strategies for industrial technology through systemic technology planning and policy research. It is promoting various activities including transferring and commercializing industrial technology. The Commercialisation Division in KIAT provides funds for technology commercialization in the future growth driver fields, and encourages the growth of global technology-based corporations by linking them with technology funds. One of the funds managed by KIAT is the major New Growth Engine Fund.

The New Growth Engine Fund[418]

Access to capital for the growth stage is one of the issues identified in the main report and in the European case studies, especially for companies with more than 250 employees, but without large internal R&D departments. In 2009 the New Growth Engine Fund was supported with €62 million and private funding (large companies and capital funds) is expected to reach €420 million. The fund is addressing the 'Valley of Death' issue in regards to access to capital. The figure below show that the R&D stage, including the start-up phase, is well supported in Korea. However, lack of capital start to occur towards the pilot stage and the gap is even larger at the growth stage.

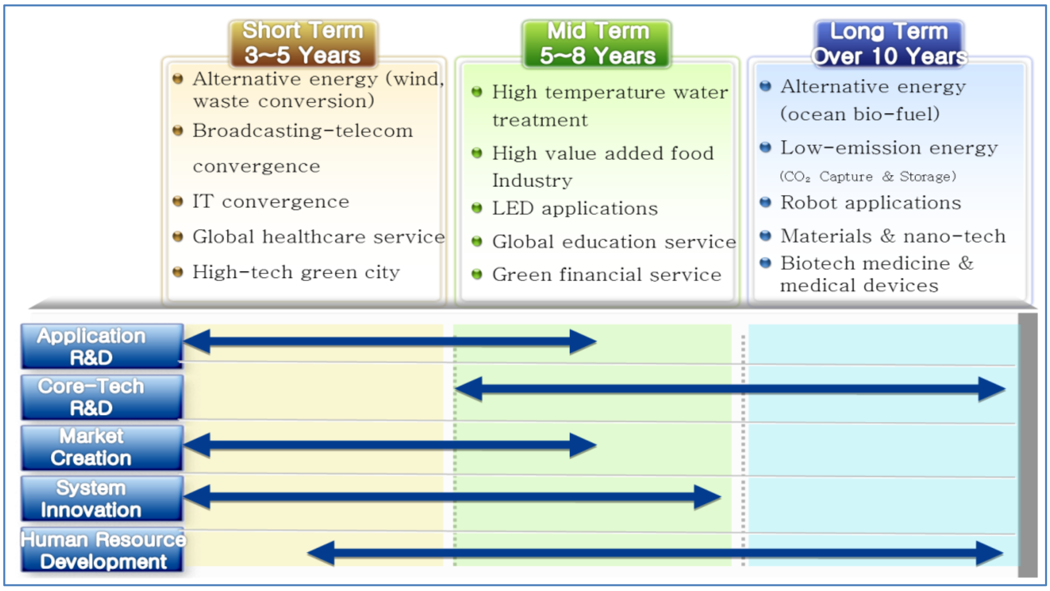


The objective is to expedite innovation and commercialization of technology and grow globally competitive medium-sized companies by inducing investment from the private sector domestically and globally to promote a substantial increase in high-quality jobs. Foreign involvement is encouraged.

The Korean Government has identified 3 industrial sectors (Green growth, High-tech convergence and Knowledge based service) and 17 new growth engines that are expected to drive economic growth in Korea.

[418] The information of the New Engine Growth Fund is provided by an interview with Mr. Jay H Jung from KIAT running the fund and a power point presentation sent from KIAT.

The 17 growth engines are highlighted in the figure below.



It is only companies operating within these growth engines that are eligible for funding. One requirement is that a minimum of 80% of the total fund must be invested in Korean companies (this includes foreign companies registered in Korea, joint venture with foreign companies, and overseas based Korean companies). This requirement can be lowered to 60%, if at least 30% of the total fund amount is derived from foreign investors.

KET initiatives

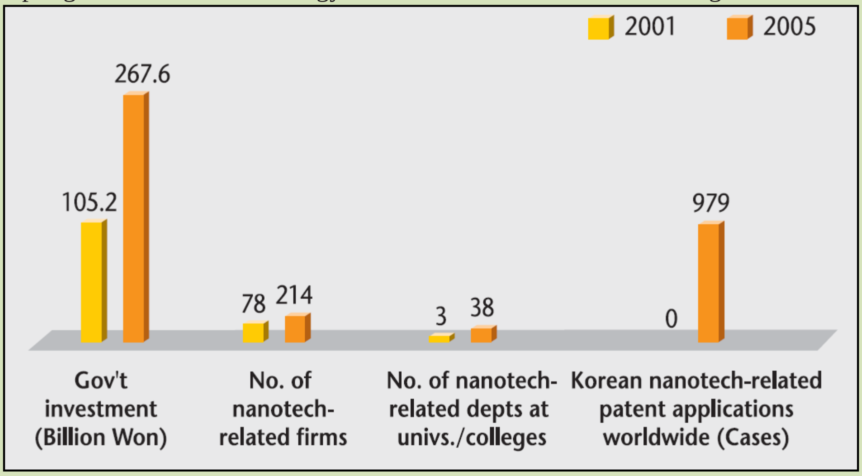
The Korean Government has launched several initiatives to support the development of specific KETs as well as high tech innovation and deployment in general. Below are two examples Korea Nanotechnology Initiative and KOSBIR, which is inspired by the US SBIR program (see US innovation profile).

KOSBIR - Korea Small Business Innovation Research
In order to strengthen innovation capabilities of SMEs and Ventures, the Korean Government specifically targets the technology innovations of SMEs and start-up companies. Prospective SMEs equipped with capabilities of technology development and innovation are designated as ‘Inno-Biz" and are provided with comprehensive support measures such as technology assurance and preferential treatment on credit loan. Additionally, government ministries and government-financed institutions are required to allocate a certain percentage (5%) of the R&D budget to support SME’s technology development under the KOSBIR system.

Source: http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=331&parentID=12&countryCode=KR

Korea Nanotechnology Initiative (2001-2010)

In Korea, the public sector is playing a leading role in the promotion of emerging technologies, especially in such areas as infrastructure construction to support nanotechnology as well as education and training programmes. The Korea Nanotechnology Initiative has been supported with approximately €100 million a year over a 10-year period, with 66% funding from the Government and the rest from private investors[419]. Already after 5 years Korea experienced a rapid growth in nanotechnology in several areas as shown in the figure below:



These growth rates may be a result of a strategic focus on application of R&D and close collaboration between domestic companies and nanotechnology research labs, such as LG and Samsung.

One important element of the Korean nanotechnology strategy is the NanoFab Centres. These Centres establish nanotechnology research facilities, provide one-stop service from idea generation to manufacturing, develop process equipment with manufacturers, train nanotechnology specialists with hands-on experience and contribute to the commercialization and advancement of nanotechnology.

Since the first-phase initiative (2001-2005) the following has been created:

- Nano support facilities (two integrated nanofab centres , three nanoclusters)
- Related support facilities (Nano Practical Application Center, Nanotechnology Industrialization Support Center, etc.).

In terms of commercialization the initiatives assist the early commercialization of technologies held by venture firms and SMEs, provide IPs secured at infrastructure facilities and specialized technologies to promising enterprises or support business start-ups.

Source: Nanotechnology Korea, http://www.microsystem.re.kr/data/tech/Nanotechnology%20Korea%5B1%5D.pdf

[419] http://www.nanoworld.jp/apnw/articles/library2/pdf/2-37.pdf

Taiwan

Introduction

Taiwan has a dynamic economy with gradually decreasing government guidance of investment and foreign trade. Exports, led by electronics and machinery, generate about 70% of Taiwan's GDP growth, and have provided the primary impetus for economic development[420]. Taiwan's rapid economic growth has been supported by growth in labour-intensive industries, whereas in recent years the government has recognized the importance of innovations and R&D to establishing national advantages in specific industries.

According to the most recent data for Main Science and Technology Indicator (MSTI) database of the OECD and Indicators of Science and Technology (S&T) Taiwan is ranked 12th in terms of GERD. The GERD growth rate (10.7% in 2007), shows that Taiwan has continued to invest in R&D in a relative higher rate than other leading economies (e.g., USA, Japan, and Germany). The primary sources of funding for GERD are the business sector (69%), followed by the government at roughly 30%. These two sectors accounted for more than 95% of Taiwan's GERD for innovations[421].

Taiwan is placed 6th for innovation among 133 countries in the Global Competitiveness Report 2009-2010 by the World Economic Forum and 5th for technological infrastructure out of 58 economies in the 2010 World Competitiveness Yearbook by the International Institute for Management Development. Taiwan also ranked 5th worldwide for the number of U.S. patents granted in 2009. These successes are attributed to a strong emphasis on R&D as well as close collaborations amongst government, industry, academia and the research sector[422].

Financial incentives to attract FDI and encourage indigenous R&D

In a report by published by Invest in Korea in 2009[423], Taiwan is described as similar to Korea in terms of the incentives for attracting FDI and encourages R&D in indigenous companies. Both countries are moving away from the 'catch-up' paradigm to innovation by providing incentives for entrepreneurs to engage in ventures with a high-risk profile[424].

[420] https://www.cia.gov/library/publications/the-world-factbook/geos/tw.html
[421] 2009 White paper on Taiwan Industrial Technology (http://doit.moea.gov.tw/itech/data/2009_1_1_EN.pdf)
[422] Science and Technology, 2009 (http://www.gio.gov.tw/taiwan-website/5-gp/yearbook/09Science&Technology.pdf)
[423] Invest KOREA (Dec. 2009): The Investment Environments of Major Asian Countries.
[424] *Source: Mina, Andrea, David Connell, and Allan Hughes (2010): Models of technology development in intermediate research organisations*

However, where financial incentives in Korea are mainly aimed at FDI, in Taiwan they are aimed equally at both FDI and indigenous companies and the FDI is encouraged to collaborate with local companies[425].

The tax incentives of the intuitive "*Statute for Upgrading Industries*", which was initiated in 1991, was replaced by "*Statute for Industrial Innovation*" in May 2010 in order to facilitate new industrial advantages in Taiwan. The first Statute has been successful in industrial upgrading and industrial clusters through the provision of tax incentives and the development of industrial zones, such as industrial parks and Enterprise Processing Zones (EPZ) by offering tax incentives and trade benefits[426]. The success is also shown in the World Economic Forum Global Competitiveness Report 2009-2010 where Taiwan ranked 6th out of 133 economies around the world in terms of the *state of cluster development*.[427]

The new *Statute for Industrial Innovation* is different than the predecessor as there will be a change in the business income tax, which will be lowered from 25% to 17% (China 25%, Korea 22%, and Singapore 17%), but at the same time the business income tax *credits* are reduced from 35% to 15% for the R&D expenditures. The idea is to support all industries and size of businesses in order to diversify industrial development. Another aspect is to encourage SMEs to transform while giving due consideration to economic growth and job creation, so in 2011 SMEs will be offered subsidies for the hiring of additional personnel with innovation abilities. The subsidies, which will be NT$10,000 (approximately €250) per employee per month for a period of up to one year, aimed at lowering operating costs for SMEs and strengthen their manpower.

The financial incentives have been, and still is, an important factor for the different policies and initiatives highlighted below, especially the science parks.

Key policies and initiatives

Three major initiatives are mentioned to have played a major role in successfully creating a high-tech industry and several innovative clusters in Taiwan. These are the *Technology Development Programs (TDPs), the Industrial Technology Research Institute (ITRI)* and the *Hsinchu Science Park (HSP)* [428].

Technology Development Programs (TDPs)

In Taiwan the Department of Industrial Technology (DoIT) is the main body for facilitating technological R&D innovation. The main mission of the DoIT is to leverage the Technology Development Programs (TDPs) to integrate the R&D resources and knowledge of research institutes, academia, and industry, with a view to jointly developing advanced key cross-domain technologies to enhance the R&D capability of the industry and consolidate Taiwan's strength in applied technologies[429].

[425] Invest KOREA (Dec. 2009): The Investment Environments of Major Asian Countries.
[426] http://www.cepd.gov.tw/encontent/m1.aspx?sNo=0014260
[427] http://www.moeaidb.gov.tw/external/ctlr?lang=1&PRO=publication.PublicationView&id=1372
[428] http://asia.stanford.edu/events/fall07/slides/wang.pdf
[429] http://doit.moea.gov.tw/doiteng/

The strategies of DoIT focus on:

- Smart technologies/service innovation
- Green energy
- Health and well-being
- Upgrade of traditional industries
- Establishment of Industrial Innovation Clusters
- Cultivation of Fundamental Industrial Technologies.

The KETs are included across the different focus areas. One interesting example for this study is the *Cultivation of Fundamental Industrial Technologies*. The industrial added value in Taiwan is still relatively low and as production is often moved to overseas locations in light of competitiveness, accumulation and innovation of mature technologies are relatively hard in Taiwan. In order to enhance the industrial core and fundamental technologies, the government has prioritised ten *key autonomous technologies*[430]. With the planned promotion of "Fundamental Industrial Technology Cultivation Project," the DoIT will work on establishing a comprehensive fundamental R&D system in industrial technology, aiming to transform Taiwan into a major industrial power in the next 5 to 10 years[431].

DoIT has launched three types of TPDs, *industrial*, *academic* and *organisational*. The organisational TDPs account for a share of 75.3%, Industrial TDPs for 20.6%, and the academic TDPs account for 4.1% of an overall budget of approximately €480 million in 2010. The budget has slowly increased since the start of the TDPs in 2005[432].

DoIT TDP Budget, 2005 to 2010	
Year	**Unit: NT$ 100milion**
2005	157.47
2006	187.00
2007	180.97
2008	185.00
2009	194.54
2010	198.82

The industrial TPD has through four programs increased the companies' willingness to engage in forward-looking technology high-risk R&D and to make early long-term R&D deployment. The industrial TDPs also encourages companies to increase and accumulate the value of intellectual properties (IP), attract R&D personnel, start up new business units or new companies, and engage in innovative product development and services.

[430] including high-efficiency separation and purification technology, high-performance textile product technology, high-efficiency display and lighting optoelectronic materials technology, all-electric urban transportation system technology, advanced manufacturing system technology, semiconductor process equipment technology, communications technology, high-end measurement instrument technology, 3D graphics and high-end video processor chip system technology, and high-end medical equipment technology.

[431] http://doit.moea.gov.tw/doiteng/contents/a_ad/default.aspx?sn=15

[432] http://doit.moea.gov.tw/doiteng/contents/b_acv/default.aspx?type=1&sn=9

The four programmes under the Industrial TDP are:

- Industrial Technology Development Program
- Small Business Innovation Research Program (SBIR)
- Innovative Technology Applications and Services Program
- Multinational Innovative R&D Centers in Taiwan Program.

The following will briefly describe the SBIR Program with focus on indigenous companies and the Multinational Innovative R&D Centers in Taiwan Program, with focus on attracting foreign investment and linking these with local companies and research institutions.

SBIR Taiwan[433]

Taiwan has, as many other of the Asian countries, copied the US SBIR program. The Taiwan SBIR programme cover up to 50% of the R&D costs and it is split up into three phases.

In the *SBIR Phase I* applicants must describe the key problems addressed, the creative concept they intend to use, anticipated benefits to industries, as well as relative R&D track records and implementation plans. This phase will run for 6 months and there the funding available for this stage is NT $1,000,000 (approximately €25,000).

The *SBIR Phase II* runs for two years with a maximum subsidy of €250,000. This phase covers the R&D of a product, production method or service mechanism based on a concept expected to benefit industries. The R&D of a production method can extend to the trial production or ramp-up stage. Again, applicants must describe the key problems addressed, the concept they intend to use, anticipated benefits to industries, as well as relative R&D track records and implementation plans.

Finally, the *SBIR Phase II+* with funding of up to €125,000 will run for one year. This phase is aimed at implementing the R&D results to meet market and customer demand. The focus of R&D extends from the emphasis on the design of technical innovations to the production of the technical application. This could include engineering techniques, moulding development techniques, product design, trial production and ramp-up techniques, or primary market surveys. Applicants must describe the application of the developed technique, feasible implementation, commercialization target and expected benefits.

The SBIR Programme has resulted in a total of 609 granted projects amounting to over NTD 640 million (approximately €15 million) in government sponsorship. According to the DoIT, this has resulted in industry re-investment in R&D amounting to approximately NTD 1.13 billion (approximately €27 million) and the direct involvement of over 3,000 people in R&D projects[434].

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[433] http://www.sbir.org.tw/SBIR/Web/Exist_eng.aspx
[434] http://doit.moea.gov.tw/doiteng/contents/c_gs/default.aspx?sn=9

The Multinational Innovative R&D centers in Taiwan Program[435]

With an aim to establish Taiwan as a global center for industrial innovation and R&D, the *Multinational Innovative R&D Centers in Taiwan Program* was initiated by the Ministry of Economic Affairs (MOEA) to encourage multinationals to set up their regional R&D centers in Taiwan. The ultimate goal is to get multinational corporations collaborating with local Taiwanese firms so that Taiwan can establish itself as a regional R&D center within the Asia Pacific region.

The implementation of the plan began in 2002 and since then more than 125 domestic companies and 48 multinational R&D centers has been established by companies including Intel, HP, Dell, Sony, Microsoft, IBM and Ericsson. Among these companies, many found that the industry environment and infrastructure in Taiwan are much better than what they had expected, and some even expanded the scale of their R&D centers.

This show that Taiwan is an attractive location for multinational corporations to establish their R&D bases for innovative R&D activities[436]. Financial incentives, such as tax credits and low business income tax, have been important for this success, but also the research infrastructure, exemplified by the clusters and science parks.

HP investing $112.5 million in Taiwan R&D centre[437]

HP has decided to invest $112.5 million in a new R&D centre in Taiwan. The money will be spread out over a three year investment for what will be known as the "Computing Hub" which will focus on R&D for computers and mobile devices. Interestingly, the new R&D facility doesn't appear to be only doing product R&D as it will also be heavily innovation focused, an area that doesn't always yield new products. It will also focus on high-end products and work with the local academia in Taiwan to develop new products and ideas. HP will be developing infrastructure for and share know-how with its Taiwanese partners through the R&D facility.

IBM Research Collaborates with Leading Taiwanese Institutions to Deliver Wellness-Centric Healthcare Via Cloud Computing[438]

In December 2009 IBM announced a new Research collaboratory, located in Taipei, Taiwan. The collaboratory will focus on using technologies - including cloud computing, analytics and mobile devices -- to advance wellness-centric healthcare that manages diseases more efficiently and effectively to keep people healthier. Taiwan has a highly-regarded healthcare system with established hospitals and provider networks. By collaborating with IBM Research, Taiwan hope to leverage this system to create new services and technologies that can be exported worldwide. "The goal is to create a research environment that leverages advancements in services science, analytics and cloud computing to create innovation that matters for Taiwan, IBM and the world," said Robert Morris, vice president, IBM Research.

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[435] http://innovation5.tdp.org.tw/content/application/mncf/generalb/guest-cnt-browse.php?vars=86820a145a9ec7d0d6be87de5f3dd39e

[436] Source: http://investtaiwan.nat.gov.tw/matter/show_eng.jsp?ID=433

[437] http://semiaccurate.com/2010/09/21/hp-investing-1125-million-taiwan-rd-centre/

[438] http://www-03.ibm.com/press/us/en/pressrelease/29086.wss

Industrial Technology Research Institute (ITRI)

The Industrial Technology Research Institute (ITRI) is a national research organization that serves to strengthen the technological competitiveness of Taiwan. Since the start, ITRI has three mission statements: first, to expedite the development of new industrial technology; two, to aid in the process of upgrading industrial technology techniques; and three, to establish future industrial technology. However, in order to face a new economic era and serving as a the premiere technology research institute, ITRI role is to transform Taiwan's research capability from a “follower” to a “pioneer” in order to provide major advantage and opportunities for domestic industries[439]. This has been very successful as exemplified in the text box below.

Building a semiconductor industry in Taiwan
In less than 20 years, Taiwan has managed to become a major world producer of semiconductors. A dedicated industry policy has driven the transformation and thereby managed to create an innovative and attractive environment for global semiconductor companies. Global companies and know how has been attracted by the strategic focus and commitment from the Taiwanese government to the semiconductor industry in the form of funding and fast administrative support leading to the establishment of a national industry. ITRI, the Industrial Technology Research Institute in Taiwan, has played a fundamental role in the development of the national industry by facilitating technology transfer, investing in training of the national work force, and supporting spin-offs. External collaboration is a key element of ITRI’s approach to research and innovation – the Institute collaborates with national industry champion TSMC when large scale facilities are needed for large pilots, and is also engaged in international collaboration with research institutes, including MIT (US) and AIST (Japan). ITRI is now ‘moving away from a catch-up paradigm’ and focusing on innovation by providing incentives for entrepreneurs to engage in ventures with a high-risk profile.

Source: Mina, Andrea, David Connell, and Allan Hughes (2010): Models of technology development in intermediate research organisations.

Hsinchu Science Park (HSP)

Taiwan currently has more than 70 industrial clusters in operation. The most important ones are the science parks, which have the goals of attracting high-tech industries and professionals, encouraging technological innovation, promoting industrial upgrading and balancing regional development[440].

There are three core parks: *Hsinchu Science Park*, *Central Taiwan Science Park* and *Southern Taiwan Science Park*, each having its own satellite industrial clusters. The oldest of these, the Hsinchu Science Park, is presented below.

The Hsinchu Science Park has since it was established in 1980 been a major player in the commercialization of research in Taiwan. This government-planned cluster was based on the Silicon Valley model, with easy entry for small and medium size manufacturing companies; easy access to venture capital; public funds and resources for public-private joint research and automation of production; and the focus on higher education for the workforce were all part of a strategy of letting firms specialize and be quick to go from design to production.

[439] http://www.itri.org.tw/eng/about/article.asp?RootNodeId=010&NodeId=0101
[440] http://www.taiwan.gov.tw/ct.asp?xItem=27510&ctNode=1906&mp=1001

The new firm ideas of original design manufacturing (ODM) and later design cell strategies led to Taiwan having the most flexible manufacturing system in the technology world.[441]

Today the science park is among the world leaders in technology research, development and production within the areas of integrated circuits, computers and peripherals, telecommunications, optoelectronics, precision machinery, and biotechnology[442]. The science park is especially important in *semiconductor manufacturing*, as the home of the two largest companies, Taiwan Semiconductor Manufacturing Company and United Microelectronics Company and several foreign multinationals, such as for example Philips.

The HSP currently has five satellite parks[443] and at the end of 2009, the HSP was home to 440 companies, of which more than 50 are foreign, with a combined workforce of 132,161 persons generating revenue of NT$883.5 billion (approximately €225 billion) for the year[444]. According to a study carried out in 2007 the HSP for approximately 10% of the Taiwanese economy.

Snapshots of investments in KETs

Below are three snapshots of investments and performance in three of the KETs.

Biotechnology

In 2009, the government launched the Biotechnology Take-off Package designating the field as one of the nation's six emerging industries. From 2009-2013, the government will invest US$1.2 billion into the program. One objective is to strengthen the commercialization process and bolster the industrial value-chain. The program will also create a US$1.8-billion Biotechnology Venture Capital Fund to invest in projects with high potential returns and double the industry's annual production from its current level to US$7.9 billion by 2013[445].

Nanotechnology

The government launched the National Science and Technology Program for Nanoscience and Nanotechnology in 2003. The program's main purposes are to encourage originality in nanotechnology research, commercialize its applications, establish core laboratories, and promote nanotech education at all levels of schooling. Through private-sector participation, technology transfers and government-sponsored technology development, the program is expected to directly help local industries generate US$4 billion in production value by 2012, and as much as US$10 billion by 2015[446].

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441 http://www.polecon.no/papers/papers/hsinchu_report.pdf

442 http://www.sipa.gov.tw/english/file/20100601133153.pdf

443 Jhunan, Tongluo, Longtan and Yilan, and the Hsinchu Biomedical Science Park

444 http://www.sipa.gov.tw/english/home.jsp?serno=201003210014&mserno=201003210003&menudata=EnglishMenu&contlink=content/introduction_1.jsp&level2=Y

445 Science and Technology, 2009 (http://www.gio.gov.tw/taiwan-website/5-gp/yearbook/09Science&Technology.pdf)

446 Science and Technology, 2009 (http://www.gio.gov.tw/taiwan-website/5-gp/yearbook/09Science&Technology.pdf)

Advanced Materials

Advanced materials are critical for today's complex micro and nano-scale devices in semiconductor, PV, LED and other applications. Taiwan is not only the world's 2nd largest semiconductor materials consuming market but also contributed 17% and over 37% of PV cell and LED shipment respectively[447].

[447] http://semicontaiwan.org/HowtoExhibit/ApplytoExhibit/CTR_042635

UK

Introduction

In the UK, the Department for Business, Innovation & Skills (BIS) is leading work across the government to create a balanced and sustainable model for growth. The Department for Business, Innovation and Skills was created in June 2009 from the merger of the Department for Business, Enterprise and Regulatory Reform and the Department for Innovation, Universities and Skills[448]. Several initiatives and platforms have been created to realize growth through promoting business and innovation. One of these initiatives is the Technology Strategy Board, which has been established as the prime channel through which the government incentivizes business-led technology innovation[449].

The Technology Strategy Board (TSB) is an executive non-departmental public body, established by the Government in 2007 and sponsored by the Department for Business, Innovation and Skills (BIS)[450]. Their job is to ensure that the UK is in the forefront of innovation enabled by technology[451]. Therefore, they launched a strategic plan “Connect and Catalyse” to explain the journey they will take. They focus on three themes namely challenge-led innovation, technology-inspired innovation and the innovation climate[452]. The Technology Strategy Board has a budget for 2008-2011 of £711 million plus aligned funding from the Regional Development Agencies of £180 million and at least £120 million from the Research Councils[453].

TSB has defined a number of technology areas with a huge potential for the UK. The areas include[454]:

- High value manufacturing
- Advanced materials
- Nanotechnology
- Bioscience
- Electronics, photonics and electrical systems
- Information and communication technology.

The Technology Strategy Board has also devoted attention towards the links between the different areas. An example of this overlap can be found in the table below[455].

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[448] http://www.bis.gov.uk/about
[449] BIS, Annual innovation report 2010
[450] http://www.innovateuk.org/aboutus.ashx
[451] http://www.innovateuk.org/_assets/pdf/Corporate-Publications/Advanced%20Materials%20Strategy.pdf
[452] Biosciences, Technology Strategy 2009-2012
[453] http://www.innovateuk.org/ourstrategy.ashx
[454] http://www.innovateuk.org/ourstrategy/technology-areas.ashx

Figure 16: Strong links of nanoscale technologies to other Technology Strategy Board activity

Technology areas	Examples of areas of cross-over
High Value Manufacturing	Modelling, design, scale-up, on-line and in-line monitoring, EHS, life cycle assessment and design of new processing techniques
Bioscience	Controlled release, protective coatings, toxicology, environmental analysis, food packaging, sensors, bio-processing and life science technologies
Electronics, Photonics and Electrical Systems	Quantum dots, nanotubes, graphene, molecular memory, plastic electronics, interconnect materials, shrinkage of feature size, new analysis techniques, data storage, integration and design into microsystems, displays, heat management and sensors
Advanced Materials	Structural, functional, multifunctional, biomaterials, multi-phase modelling, microscopy, metrology and characterisation, reusability and life cycle assessment

Application areas	Examples of areas of cross-over
Medicines and Healthcare	Drug delivery mechanisms, antimicrobial coatings, smart materials, handheld diagnostic equipment, imaging, implants, tissue engineering, coatings, bio-processing, cell therapies, gene therapies and regenerative medicines
Energy Generation and Supply	Coatings and materials, such as solar cell coatings, particle additives to improve energy efficiency, thermoelectric materials, integration into fuel cell and battery technology, supercapacitors, flow cells and thermal barrier coatings, next-generation photovoltaics
Environmental Sustainability	Nanoparticles for land remediation, waste stream applications, detection and monitoring, air filtration and water treatment
Creative Industries	Sporting goods, smart textiles and clothing, flexible displays, user interaction, and multifunctionality through design
Transport	Thermal barrier materials, coatings for anti-bio fouling, protective coatings, structural enhancement, and friction control through coatings and surface texturing
Emerging Technologies	Molecular computing, next-generation measurement techniques, metamaterials and nanophotonics, nanotechnology-enabled quantum information processing and synthetic biology, solar energy harvesting, diagnostics and drug delivery, next-generation carbon abatement technologies

Innovation platforms	Examples of areas of cross-over
Intelligent Transport Systems	Displays and sensors
Low Carbon Vehicles	Structural materials, coatings, sensors, fuel cells and battery technology and supercapacitors
Low Impact Buildings	Multifunctional materials, insulation coatings for protection and maintenance, sensors for condition monitoring and renewable energy micro systems taking account of design and flexibility
Assisted Living	Sensors and handheld devices for diagnosis
Network Security	Security tagging and molecular computing
Detection of infectious agents	Sensing, controlled release, diagnostics

National policies aimed at industrial deployment of KETs

The Technology Strategy Board has formulated several strategies in each of the selected areas. Each strategy highlights the opportunities and key exploitation challenges and contains a general background, provides an overview of the technology and the industry, and formulates a technology strategy. In several strategy documents, the Technology Strategy Board also formulates an action plan.

[455] Nanoscale Technologies Strategy 2009-12, Technology Strategy Board

Some examples are mentioned in the boxes below[456][457]. The different strategy documents can be found on the website of TSB[458].

Advanced Materials Strategy

To achieve the desired outcomes from the Advanced Materials strategy in the period 2008-2011, the Technology Strategy Board will:

- invest in materials technologies which address the key challenges of energy and the environment;
- invest in materials technologies focused on the 'reduce, reuse and recycle' sustainability agenda;
- continue to invest in materials for high value markets, including healthcare, the creative industries and defence and security;
- work with other government and industry stakeholders to identify opportunities for joint or aligned activities; including generic underpinning R&D and proof-of-concept studies;
- work with other stakeholders in respect of metrology and standards development;
- support an innovation culture via, for example, the use of Knowledge Transfer Partnerships (KTP) and Knowledge Transfer Networks (KTN); and
- seek, with other stakeholders, to identify European and other international strategic alignment and financial gearing opportunities in support of improved UK competitiveness and inward investment.

Table 4: Examples of actions of the Nanoscale Technologies Strategy

Knowledge transfer	Transfer of knowledge from academia to business	Work with the knowledge transfer networks and knowledge transfer partnership programme to develop ideas and pilot schemes for new ways of working (such as ‘reverse’ and ‘short’ programmes) together with others working in this area.
Clarity in roadmapping	A review of roadmaps in nanoscale technology	Review the current nanoscale technology roadmaps to produce a ‘super’ roadmap for nanoscale technology that is valued by the business community.
Promote UK excellence in nanoscale science and technology internationally	Access worldwide academic and industrial community to encourage trade, inward investment and collaboration	Showcase UK excellence in nanoscale science and technology to establish global standing and encourage research and innovation collaborations. Establish commercial partnerships to accelerate product development, process trading, and to widen market access.

[456] Advanced Materials, Key Technology Area 2008-2011, Technology Strategy Board
[457] Nanoscale Technologies Strategy 2009-12, Technology Strategy Board
[458] http://www.innovateuk.org/publications/strategy-documents.ashx

Policy measures towards industrial deployment and their impact

The Department for Business, Innovation and Skills (BIS) is also the main responsible actor to formulate policy measures in the area of industrial deployment of Key Enabling Technologies. The Technology Strategy Board has developed a number of interesting mechanisms to drive business innovation such as Knowledge Transfer Partnerships, Knowledge Transfer Networks, Technology and Innovation Centres, and Small Businesses Research Initiative[459]. These mechanisms are installed to stimulate innovation but they are not policy measures.

Knowledge Transfer Partnerships (KTP) is an initiative to provide businesses with partnerships with higher education institutions or other research centres to help identify innovative solutions that can help businesses increase growth[460]. It is a UK-wide programme helping businesses to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base[461]. A KTP involves the formation of a Partnership between a business, an academic institution (or knowledge base) and a recently qualified person, known as the Associate, to facilitate the transfer of knowledge and embedding of new capability within the business organization[462]. An Associate works on average 10 to 150 weeks on a KTP, 2 years is most common. A KTP typically receives 50% funding from the TSB and the company needs to fund the additional 50% themselves. For a project to get selected, it has to stand different selection criteria such as an assessment of the capabilities, the potential impact that can be realised, the size of the global market and the additionally.

The results of the KTP include:[463]
The portfolio comprises 1254 partnerships, over 15,870 business staff was trained, 1,443 new jobs were created (aside from the recruitment of KTP Associates) and an overall increase in annual profit before tax was realized of over £150 million. Due to its mission, the KTP wants to be flexible in its approach. Therefore they have create shorter KTP projects (10 to 40 weeks) to tackle more tactical issues, next to classical KTP projects (1-3 years) that are designed to tackle strategic issues. This implies that the projects are suitable for a spectrum of micro, small, medium and large businesses.

The Knowledge Transfer Networks (KTN) are created to stimulate a transfer of knowledge between people from business, universities, research, finance and technology organizations. They have been set up to drive the flow of knowledge within, in and out of specific communities by providing activities and initiatives that promote the exchange of knowledge and stimulate innovation[464]. They are hosted on connect, which is a platform that provides an effective and powerful way to collaborate, network and share knowledge[465]. The KTN does not provide funding for a project, but has the aim to improve the innovation climate by making people less risk adverse. During a review of

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[459] http://www.innovateuk.org/deliveringinnovation.ashx
[460] BIS Annual Innovation Report 2010
[461] http://www.ktponline.org.uk/strategy
[462] Knowledge Transfer Partnerships Annual Report 2009/10
[463] Knowledge Transfer Partnerships Annual Report 2009/10
[464] http://www.innovateuk.org/deliveringinnovation/knowledgetransfernetworks.ashx
[465] https://ktn.innovateuk.org/web/guest

the networks, 75% of business respondents rated KTN services as effective while over 50% had developed, or were developing, new R&D or commercial relationships with people met through a KTN[466].

The Technology Strategy Board will establish a network of elite **Technology and Innovation Centres**, the first of which will be in the area of High Value Manufacturing[467]. These centres of excellence will allow businesses to access equipment and expertise that would otherwise be out of reach, as well as conducting their own in-house R&D. They will also help businesses access new funding streams and point them towards the potential of emerging technologies[468]. The aim is to support the commercialization of research results by focusing on a specific technology where there is a potentially large global market and a significant UK capability. £200m is reserved to invest in these Technology and Innovation Centres.

The **Small Businesses Research Initiative (SBRI)** is a programme that brings innovative solutions to specific public sector needs, by engaging a broad range of companies in competitions for ideas that result in short-term development contracts[469]. The new SBRI programme aims to use government procurement to drive innovation[470]. Since the re-launch of the SBRI in April 2009 to end-December 2010 there have been 46 competitions resulting in 519 contracts awarded to the value of £35.6 million. The competitions have helped small and micro businesses to engage with government departments and the validation effect of having a government contract has helped a number to raise venture capital or other additional financing[471].

[466] http://www.innovateuk.org/deliveringinnovation/knowledgetransfernetworks.ashx
[467] BIS Annual Innovation Report 2010
[468] http://www.innovateuk.org/deliveringinnovation/technology-and-innovation-centres.ashx
[469] http://www.heacademy.ac.uk/sbricompetitions/about
[470] http://www.innovateuk.org/deliveringinnovation/smallbusinessresearchinitiative.ashx
[471] BIS Annual Innovation Report 2010

List of key innovation mechanisms

Innovation Mechanism	Funding	KET	Contact details/Link
Knowledge Transfer Partnerships	£42 million in 2009/10	Nanotechnology Photonics Advanced materials High value manufacturing Bioscience	KTP Programme Office Ktp-help@ktponline.org.uk
Knowledge Transfer Networks		Nanotechnology Photonics Advanced materials High value manufacturing Bioscience	_connect https://ktn.innovateuk.org/web/guest/home
Technology and Innovation Centres	£200m in 2011-2015	Nanotechnology Photonics Advanced materials High value manufacturing Bioscience	centres@tsb.gov.uk
Small Businesses Research Initiative	£35.6 million April 2009-December 2010	Nanotechnology Photonics Advanced materials High value manufacturing Bioscience	SBRI@tsb.gov.uk

Conclusion

The Department for Business, Innovation and Skills (BIS) has an important role at the heart of government as the 'department for growth'. Their policy areas range from skills and higher education to innovation and science to business and trade[472]. The Technology Strategy Board as a government agency focuses on formulating and installing innovation mechanisms. The Technology Strategy Board allows the UK government to focus its technology transfer and commercialization efforts. Thanks to the installation of the Technology Strategy Board, new mechanisms and programs can be quickly installed and adjusted to the market needs. Moreover, as the TSB oversees several initiatives, universities, small and large companies need to make a conscious choice of where to get the project funded. The TSB also encourage academics and policy makers to think about the potential impact of research. This might lead to a change in behaviour towards the commercialization of research results. The clear and direct approach of the Department for Business, Innovation and Skills (BIS) has the potential to contribute to rebalance the UK's economy towards sustainable growth.

[472] http://www.bis.gov.uk/about/what-we-do

USA

Introduction[473]

The US Government has just launched a new innovation strategy – *A Strategy for American Innovation*.[474] In the strategy there is especially focus on supporting R&D and promote market based innovation. In terms of technologies, the strategy has pointed out the following national priorities:

- Unleash a clean energy revolution
- Accelerate biotechnology, nanotechnology and advanced manufacturing
- Develop breakthroughs in space applications
- Drive breakthroughs on health care technology
- Create a quantum leap in educational technologies.

The US Government will increase R&D with $18.3 billion through the Recovery Act[475]. This is earmarked for additional support for science and basic research through double funding for three basic research agencies – the National Science Foundation (NSF), the Department of Energy's Office for Science, and the National Institute of Standards and Technology laboratories.

There is also a focus on promoting market-based innovation through a series of initiatives. In order to encourage private sector investments the Government has proposed to expand and simplify the Research and Experimentation tax credit. The Government propose to expand the tax credit with 20%, so the credit will amount to $100 billion over the next decade. At the same time they will simply the tax filing, in order to reduce the administrative burdens and increase interest. Also, the US Government will speed up the process for patent applications and dig into the 700,000 patent application backlogs. Finally, legal initiatives will support IPR enforcement and support American businesses rights overseas.

Related to challenges with access to finance an Innovation Fund has been set-up to support private sector financing with $1 billion over the next five years. This is especially earmarked for high-growth businesses that create the 'industries of tomorrow', as it is these companies with high-risk investment who have encountered the largest challenges.

[473] For this profile we have interviewed James Rudd (Director for SBIR at NSF), Murali Nair (Director of Innovation Accelerator at NSF), Srini Mirmira (Program Director, ARPA-E, US Department of Energy), and Leshika Samarasinghe (Commercialisation advisor, ARPA-E, US Department of Energy)
[474] http://www.whitehouse.gov/sites/default/files/uploads/InnovationStrategy.pdf
[475] http://www.recovery.gov/About/Pages/The_Act.aspx

Finally the technologies above will be supported through increased investments in existing initiatives, such as the National Nanotechnology Initiative (NNI), and also through new initiatives. The innovation strategy also highlights specific areas of national importance within each of the technology areas, which provide a focus for investments for both industry and academia.

Assessment of KETs situation

The strength of the US innovation system is the market focus of the research carried out, especially compared to Europe. This is also shown in the individual KET descriptions in section (section 2). One example is nanotechnology where the US has been leading the way for a while, but is now starting to experience increased competition from especially Japan, Russia and Korea.

All six KETs are not surprisingly subject to policy attention in the US. Some of these have got their own specific initiative, such as the NNI, while others are incorporated across different national programmes and in the agency research programmes, such as the SBIR/STTR at NSF or Advanced Research Projects Agency – Energy at the US Department of Energy. A mapping of these policies and initiatives, even at national level would require a substantial exercise.

This innovation policy profile will provide a snapshot of programs and related initiatives at the National Science Foundation (NSF) and the US Department of Energy (DoE) aiming at promoting industrial deployment of the research results in high tech sectors.

The SBIR/STTR program

The SBIR programme is active in 11 federal departments[476], with a total budget for all the SBIR programs of $2.6 billion/year, awarding 4000 contracts to small high-tech businesses. The US legislation underpinning the SBIR/STTR program requires that agencies involved in the programs distribute 2.5% of external R&D budgets through this means. SBIR/STTR awards are designed to provide 100% of the funding needed for a project, plus a small profit element for the business undertaking it[477].

Each department or agency publishes a list of topics under which small businesses can apply for SBIR/STTR grants. Following submission of proposals, the departments or agencies make decide on whom to grant awards based on small business qualification, degree of innovation, technical merit, and future market potential. Each agency or department has a list of third-party experts that can be called upon to assess incoming proposals on the publicised topics of interest. These experts give written recommendations to the agencies on which proposals the agency should support with an SBIR grant.

There is a slight difference between the SBIR and the STTR programmes. First, under SBIR Program, the Principal Investigator must have his/her primary employment with the

[476] http://www.sbir.gov/federal_links.htm
[477] ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/pcp/pcp-final-ramboll-report-js2_en.pdf

small business concern at the time of award and for the duration of the project period. In the STTR Program, primary employment is not stipulated. Second, the STTR Program requires research partners at universities and other non-profit research institutions to have a formal collaborative relationship with the small business concern. At least 40% of the STTR research project is to be conducted by the small business concern and at least 30% of the work is to be conducted by the single, "partnering" research institution.

The different departments and agencies also have different focus and approaches. We have chosen to focus on the National Science Foundation (NSF) as they have a broad technological focus and have launched some interesting activities for commercialisation of the research results. At the end the profile we will also provide an example of a support programme for the SBIR at the Department of Energy (DoE).

SBIR/STTR at the National Science Foundation (NSF)

The NSF manages over 2500 research grants annually to small businesses with an annual R&D investment of over $125 million each year. Approximately 1/8 of the applications are successful. An important difference to for example to European Framework Programmes (FPs) is the large focus on commercial application and high-risk technologies. These SBIR/STTR grants are competitively selected for their high-risk technological challenges and high potential for commercial applications[478]. Also, the IPR always stay with the companies.

The NSF SBIR and STTR programs mission is to '*increase the incentive and opportunity for small firms to undertake cutting edge, high risk, high quality scientific, engineering, or science and engineering education research that would have potential of high economic payoff if the projects are successful'*.

The SBIR/STTR programmes at NSF are interesting to look at for several reasons. One is the focus on Key Enabling Technologies, secondly, the programme itself has focus on the market, and third, there are several initiatives launched in order to encourage industrial deployment of the results from the programme.

<u>Focus on Key enabling technologies</u>

The technologies supported by the SBIR/STTR programme at NSF are very similar to the KETs pointed out by the European Commission. The SBIR/STTR programme supports the four technology categories:

- Biotech and Chemical Technologies
- Education Applications
- Information and Communication Technologies
- Nanotechnology, Advanced Materials, and Manufacturing.

Universities, industry and national organisations were asked to supply a proposal suggesting key technology areas with commercial potential. The different actors from

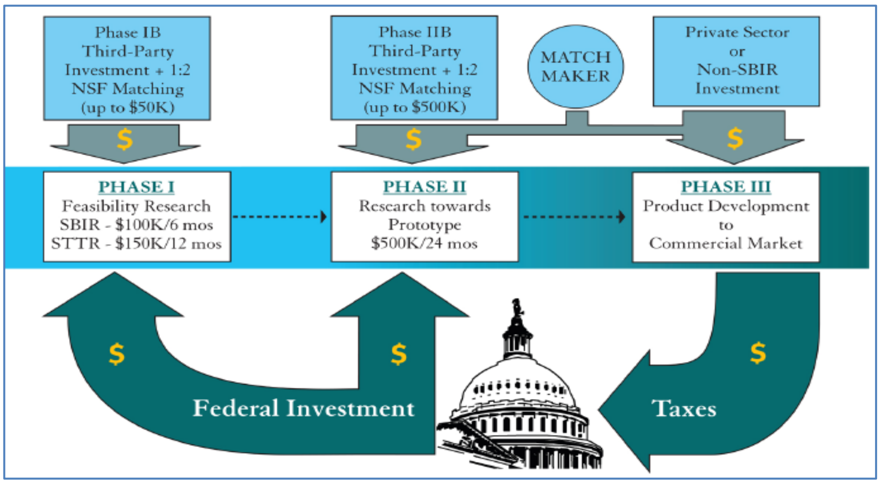
[478] http://www.nsf.gov/eng/iip/sbir/matchmaker/prospectus_full.pdf

research, industry and NSF meet for annual discussions on this topic to ensure up-to-date information on developments within these technologies.

The SBIR/STTR innovation model

The generic SBIR/STTR innovation model consists of three overall phases, where approximately 50% of the contracts are awarded phase II funding (only companies who have been awarded a Phase 1 grant can apply for a Phase II grant). The figure below provides an overview of the phases and how they are funded.

Figure 3: SBIR/STTR Innovation Model



As mentioned above, there is significant focus on market opportunities when selecting which proposals to grant funding for. One the NSF webpage is 'all proposals submitted must describe a compelling business opportunity to be enabled by the proposed innovation. The proposal must show scope and nature of the business opportunity. All proposals shall provide evidence of a market opportunity'[479]. The NSF has set up more than 40 panels each with eight external experts on the subject in order to review the proposals. For Phase 1 25% are from industry/capital funds and 75% are technology experts. The proposals must include a section on commercial *potential*, but the main focus is on feasibility research. For Phase 2 there is an increased focus on commercialisation. 50% of the expert panel come from industry/capital funds and the company need to submit 15 pages on the technology and a 15 page commercialisation *plan*.

Phase I: Feasibility Research

The primary objective of Phase I is to determine whether the innovation has sufficient technical and commercial merit for proceeding to a Phase II project. The support normally may not exceed the following:

- SBIR Phase I: $150,000 total costs for 6 months
- STTR Phase I: $100,000 total costs for 12 months[480]

[479] http://www.nsf.gov/eng/iip/sbir/program.jsp#PhaseI

[480] Costs are based on total costs which include direct costs, F&A costs, and negotiated fee

From the start of phase 1 NSF encourage the companies to seek further funding through what is called Phase IB. Here a third-party investor, for example another company, a venture capital firm, an individual "angel" investor, federal (non-SBIR), state or local government, or any combinations of the above, can invest in the project. The third party investor must commit a minimum of $30,000 and the NSF will contribute up to 50% of the outside investment, with a maximum NSF contribution of 20% of the Phase I award amount. The additional NSF funding can be used only for additional research and development tasks related to elements of the project. However, the third party investment can also be used for other business related efforts in order to accelerate the innovation toward commercialization of the project. Market research, advertising, patent applications, and refining of the business plan are good examples of uses of the third party investment.

After Phase I, approximately 50% of the projects will not receive Phase II funding.

Phase II: Research towards prototype

The objective of Phase II is to continue the R/R&D efforts initiated in Phase I and the funding is based on the results achieved in Phase I and the scientific and technical merit and commercial potential of the project proposed in Phase II. Support normally may not exceed:

- SBIR Phase II: $1,000,000 total costs for 2 years
- STTR Phase II: $750,000 total costs for 2 years.

Just like in Phase I there is a possibility to obtain further funding through a third-party investor, the Phase IIB option where the objective is to extend the R&D efforts beyond a current grant to meet the product/process/software requirements of a third party investor to accelerate the project to the commercialization stage and/or enhance the overall strength of the commercial potential of the Phase I project. A Phase IIB supplement up to $250,000 extends the Phase II grant for one year while a Phase IIB supplement in excess of $250,000 extends the Phase II grant for two years.

At the end of Phase II approximately 30% have secured private investments (Phase IIB) often through collaboration with large industrial partners or capital funds. At this stage the companies will typically have a prototype ready and have secured funding to test this, for example with larger industrial partners or potential customers

Phase III: Product development to commercial market

The objective of Phase III, where appropriate, is for companies to pursue with non-SBIR/STTR funds the commercialization objectives resulting from the Phase I/II activities. The companies must find funding in the private sector or other non-SBIR federal agency funding.

The companies struggling to find investors for their product the NSF have launched several initiatives. We will here briefly describe three of them.

The MatchMaker Program

The objective of the MatchMaker Program is to match SBIR/STTR Grantees with Venture capitalists, Angel Investors and Industry Partners to provide the on-going support necessary for achieving successful commercialization.

The NSF have managed a long list of projects and have good insight in what type of investors or strategic partners could be interested in the technologies developed through the SBIR/STTR program. The technologies are presented in the MatchMaker Program Technology Prospectus Catalogues with more than 500 technologies listed in different categories. The NSF staff asks especially large industrial partners what they are interested in and then present the different options. So, instead of contacting potential investors and present one technology, they are able to present 500 technologies. This makes the program more interesting for the large companies. The companies they approach are not only US companies, but also companies from Europe and Asia amongst others. When the large companies show interest the NSF facilitate the process. However, even though the MacthMaker program is seen some success it is still far from all companies who get investors through this program. This is also due to the fact, that the work is based on one person, Mr. James Rudd, and his extensive experience and personal relations.

One important network is the *industrial research institute*[481], which is a unique network platform with the aim to enhance the effectiveness of technological innovation by networking the leading practitioners and thought leaders to seek, share, learn and create. Currently there are more than 200 companies and leading national R&D labs in the network. This network has been an important platform for the MatchMaker program, but in order to fully reap the benefits the program will need more people and funding.

Approximately 30-35 companies have been successful in finding investors or companies through this program, but this is over a 5-year period.

Innovation Accelerator Initiative

After Phase II, 40-50 companies, not able to find an investor themselves, are pointed out by the individual SBIR/STTR Program Directors to join the Innovation Accelerator Initiative. These companies have to show great potential.

The Innovation Accelerator Initiative is sponsored by the NSF with a budget of $6.5 million over a five-year period. NSF has used the budget to contract a private company, which role basically is to commercialise the technologies developed in SBIR/STTR through helping the companies finding potential investors and customers, evaluate the potential of the technology, make an IP strategy and finally help the companies negotiate with potential customers or investors. Each company gets a mentor with many years business experience and a large network (connections).

The initiative is addressing a major challenge for small companies, which is that many small companies have limited management skills/resources to commercialise the

[481] http://www.iriweb.org/

technology. The key, according to Mr. Nair, who is Director for the Innovation Accelerator Initiative, is that extensive network and personal relations of the people working in the private company who won the contract.

The initiative has been a huge success and brought in more than $80 million in the two years it has existed for the 40-50 companies selected.

Specialised funds

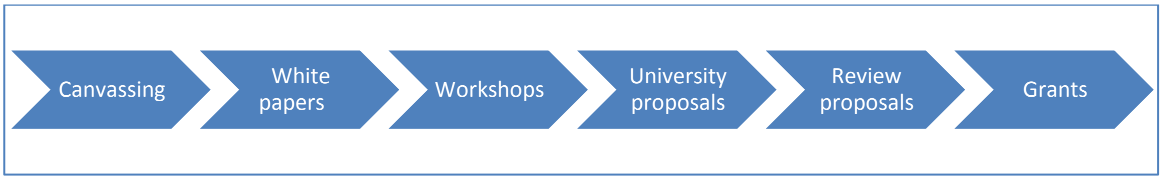
As is the case in Europe, companies in the US working with high risk technologies, such as advanced materials, where the return of investment is both risky and long, are having great difficulties to find private investors and especially banks and VCs are reluctant to finance these companies. Therefore, the NSF has set up a $10 million equity fund for these companies.

The funds can be used as Phase IIB funding with the aim of finding a customer or industrial partner who can bring the technology closer to commercialisation. According to Mr. Nair, in the US especially major Korean companies have invested heavily in these types of companies, which also mean that they will keep the intellectual property rights. The specialised fund compete with these investments, but encourage US based companies to invest by bringing funding into the R&D stage and also by showing the potential of the technologies developed.

Industry inspired fundamental research program

The industry inspired fundamental research program is not directly linked to the SBIR/STTR program. The idea behind the program is create better synergy between the R&D programs and what the industry (large) needs and thereby ensure that the R&D will create greater value for the leading companies in the US.

The NSF has awarded IRI[482] a $1.2 million grant to pilot the Industry-Defined Fundamental Research program. The program intends to allow participating companies to influence a scientific research agenda, in a pre-competitive space, by defining key questions and then partnering with universities and companies to explore them. For the NSF and also the SBIR/STTR programs, the program will help to define fundamental research requirements that could be addressed by the NSF. The Emeriti Activity Group (EAG)[483], which is a group of senior technology executives, also has an active role in the program. The program consisted of five stages over a time-period of one year:



[482] http://www.iriweb.org/Main/About_IRI/Public_Site/Navigation/About_IRI/About.aspx?hkey=3abf9016-ebde-4e80-96b2-782044e3528c

[483] http://www.iriweb.org/Main/Collaboration_Center/Public_Site/Navigation/Collaboration_Center/emeriti_activity_group.aspx

Six White Papers were developed by IRI member companies on the following subjects:

- Renewable Energy
- Nanotechnology
- Adhesives and Coatings
- Material Challenges
- Renewable Feedstocks
- Renewable Biopolymers.

The six White papers were reviewed with NSF Program Staff to see commonality with existing NSF research programs, quality of research ideas and identification of university experts in the field. Following this three topic areas were selected (Sustainable Feedstocks, Materials Interfaces and Nanotechnology Applications) and workshops were arranged to discuss the topics further. The results of the workshops were precise research questions within all three areas.

Universities submitted proposals, which were reviewed by industry and university experts. Following this the IRI has made the first instalments on awards of $500.000 (50% delivered and the remaining will be delivered upon completion of the research).

The concept presented for nanotechnology was not considered to be a frontier research topic by the IRI, but rather a request for formation of a collaborative between industry and universities in New York State to advance commercialization of nanotechnology.

Whereas the NSF run the most commercialised focused SBIR/STTR program, the other agencies/departments have larger budgets and also have other very large research programmes. One of these agencies is the Department of Energy (DoE).

Department of Energy (DoE)

The Department of Energy (DoE) have three overarching goals:

- Catalyse the timely, material, and efficient transformation of the nation’s energy system and secure U.S. leadership in clean energy technologies
- Maintain a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity, with clear leadership in strategic areas
- Enhance nuclear security through defence, non-proliferation, and environmental efforts.

The annual budget of the DoE in 2010 was $32.7 billion. Approximately $10 billion is used for R&D, including $2.4 billion for loan guarantees for renewable energy and electric power transmission projects, €1.6 billion for basic scientific research, €400 million for ARPA-E and $114 million for SBIR/STTR[484].

[484] http://www.cfo.doe.gov/budget/12budget/Content/FY2012Highlights.pdf

The interviews carried out in this study showed that several of the large European companies, especially companies involved in industrial biotechnology, have been involved in DoE projects, mainly in projects in the Advanced Research Projects Agency – Energy (ARPA-E).

The following will provide two examples of how the DoE focus on commercialisation of the research results through ARPA-E and the SBIR/STTR Program.

Advanced Research Projects Agency – Energy (ARPA-E)[485]

The Advanced Research Projects Agency – Energy (ARPA-E) was launched in 2009 and was allocated a budget of $400 million, which is set to rise to $550 million in 2012. The agency sponsors specific high-risk and high-payoff transformational R&D projects that overcome the long-term technological barriers in the development of energy technologies to meet the US energy challenges, but that industry will not support at such an early stage. ARPA-E is dedicated to the market adoption of those new technologies with the aim to fuel the economy, create new jobs, reduce energy imports, improve energy efficiency, reduce energy-related emissions, and ensure that the US maintains a technological lead in developing and deploying advanced energy technologies[486].

One of the objectives ARPA-E was charged with was to *create a new tool to bridge the gap between basic energy research and development/industrial innovation*[487].

Commercial Division

The Commercialisation Division was established in order to commercialise the results of the research. According to the interview with the commercialisation team the major barrier to finding follow-on funding is related to management issues in especially the smaller companies.

At every launch for new projects the commercialisation team is present and will already then start working with the companies in need of support. The initial role of the support is to identify the commercial potential of the technology being developed, but the role of the commercialisation team span from preparing IP strategies, cost modelling, to finding potential investors. The main funding sources are found through Venture Capital funds, industrial partners, potential customers, and also through other departments, especially the Department of Defence (batteries and fuels). The commercialisation team also facilitate the negotiations, especially for the smaller companies.

One important element is the ARPA-E Innovation Summit, which convene the key players in the US energy innovation community, in order to spur the networks for future research in clean energy technologies.

Participants include venture capital investors, technology entrepreneurs, large and small companies with an interest in clean energy technologies, policy makers and government officials. In 2011 there were 2,100 attendees from the US and more than 20 countries.

[485] http://arpa-e.energy.gov/
[486] http://www.cfo.doe.gov/budget/12budget/Content/FY2012Highlights.pdf
[487] http://arpa-e.energy.gov/About/About.aspx

According to the interview with the commercialisation team at ARPA-E, this event is extremely important in order to showcase the R&D results and thereby find potential investors.

In 2010 the commercialisation team managed to help the companies to find $254 million in follow-on funding.

SBIR XLerator awards

The DoE has awarded $57 million to follow-on funding for the DoE SBIR Program through the newly established *Phase III XLerator awards*. Normally when Phase II projects come to an end, there is no federal funding available, only private funding, which can be hard to locate for high risk projects. The *Phase III XLerator awards* gives small companies funding needed to bring their clean energy technology projects to commercialization. 33 small companies will lead projects that received SBIR or STTR funding, teaming up with universities, national labs and industry to bring their work to the commercial marketplace. The aim is that by drawing upon the resources of universities, labs and industry, innovative small companies will be able to develop the manufacturing processes needed to scale up production of their new and proven technologies[488].
Below are two examples of a Phase III Xlerator projects[489]:

Dynalene, Inc. (Whitehall, Pa.) — Large Scale Testing, Demonstration and Commercialization of the Nanoparticle based Fuel Cell Coolant. Dynalene will demonstrate a patented fuel cell coolant that showed significant potential in Phase I and Phase II research for improving fuel cell durability and reducing system size, weight, and operating cost. The coolant, which contains ion exchange nanoparticles and non-ionic corrosion inhibitors, will undergo long term (5000 hour) testing under freeze thaw conditions. Testing will be conducted in house as well as in subcontractor facilities. The Phase III research will test the coolant under severe fuel cell operating conditions such as temperature cycling and high electric fields to validate the previous encouraging results using the coolant. **DOE Funding: $1,000,000**

Altex Technologies Corporation (Sunnyvale, Calif.) Low Cost Microchannel Heat Exchanger. Altex has discovered an innovative manufacturing process for compact heat exchangers that uses low cost materials and fabrication techniques that can form the high performance channels at much reduced cost. Under the Phase III project the WASHEX manufacturing process will be refined and introduced into a high volume field application. Analysis of results from earlier phase projects indicated that WASHEX could be manufactured at up to 75 per cent lower cost than existing high performance heat exchangers. **DOE Funding: $1,470,000**

[488] http://blog.energy.gov/blog/2010/09/15/boost-small-business
[489] http://www.energy.gov/news/documents/SBIR_Phase_III.pdf