THE FOURTH INDUSTRIAL REVOLUTION WILL REQUIRE GREATER SUPPORT AT ALL LEVELS FOR INNOVATIVE MATERIALS RESEARCH

The fourth industrial revolution

The actual materials used to manufacture industrial products can account for up to 10-15% of the total cost of the product. In Germany, the Federal Ministry of Education and Research (BMBF), considers that about five million people are currently employed in materials-based industries. To maintain this position, a large funding programme of €100m has been launched to support industries in the country.

There is currently no common agreement on the definition of 'innovation'. It is either related to an economical image (for example, the Organisation for Economic Co-operation and Development's definition includes a flux of investment money) which cannot be applied to universities as they principally work on inventions; or, on a more political level, innovation is interpreted as the creation of new jobs in a competitive world.

The total hybridisation of the university and industry sectors throughout Europe is required in order to generate a new natural transfer of research findings from academia to start-ups and industry

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It is generally accepted that Europe's fundamental research is world class, but our ability to transform new knowledge into innovative goods is grossly inefficient – the so-called 'Valley of Death'. The consequence of this inability to exploit research outcomes is that European industry accounts for only around 15% of the new high-technology products coming to the market. As such, the question regarding reasons why Europe lags behind other countries still remains.

Year after year, the promoters of successive European Framework Programmes have promised a significant improvement. However, the lack of success can be simply illustrated by a US newspaper comment about Europe: 'Billions spent and nothing to show'. For some time now, the E-MRS has been aware of this situation and has worked to gain a proper understanding of the reasons behind it by making comparative investigations of overseas competitors.

Overseas innovation mechanisms

In the mid-1980s, the E-MRS – along with its sister materials research societies in the USA, China, Japan and Taiwan – established the International Union of Materials Research Societies (IUMRS), which enabled the organisation of worldwide networking, collaboration and exchanges. Today, IUMRS covers the entire world. Through this friendly collaboration, we have investigated how innovation works overseas, particularly in two major countries: in the USA in the field of photovoltaic; and in China, where we had already been invited to make suggestions for the industries China needs to develop. If CO_2 emission is used as a reference point, when the economy's rapid growth started (around 2005), the specific topics were rare earth elements, magnets for medicine, electronics and aircraft.

Perfect hybridisation

Later, a second delegation was invited by the Chinese authorities to analyse innovation in two

very different situations: start-ups in a number of universities, and large industries employing over 1,000 staff in various cities. In short, it was found that there is a perfect hybridisation between university type research and innovation by companies.

It was found that, in large companies, all the directors were technically very competent, often holding scientific doctorates awarded in Europe, and they also acted as professors in the universities. In addition, students can study for a doctorate degree within these institutes/companies. Other university professors act as industrial consultants. New companies can be created and the technical staff at the university can be shareholders with the potential for additional income.

The universities are able to select their students from all over the country, and 70% of the young people there are attracted by science and technology.

Education and motivation

Essentially, two models were identified:

A) Industry financing a new laboratory in a university campus and the 'clean room' being shared by the industry and the university; and

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B) Start-ups can be created and localised within the University, not only by the professors but with participation by the technical staff as shareholders. These start-ups have access to the facilities and equipment under the same conditions as the university staff and students.

A representative from the Ministry of Research indicated that start-ups get no public support, but that individuals have to take the risks and the consequences.

What can we learn?

It should first be indicated that Europe does not have a unique model for the development of new high-technology-based products. In general, each country has its own model and its own financial structures for technological developments. The following points should be considered:

1) **Education for a better social acceptance of innovation**

   The importance of science and technology in education is well recognised and it is essential to engage the next generation. However, today the vast majority of young people in Europe are not really attracted to science. In the USA, to interest young people in the field of materials, an exhibition with games has been developed which travels all over the country. In Europe, the lack of interest is even more serious in the older generation, who tend to largely reject any innovation (EUROSTAT). The mass media should be motivated to arouse interest including the potential gain or loss of employment opportunities for the population.

2) **'Precautionary principle'**

   Because of the reluctance to accept the concept of innovation, the political elite, especially in the European Parliament, may be seen to apply over-restrictive conditions or inappropriate regulations that

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seriously restrict new developments. There are numerous examples of this with the Registration, Evaluation, Authorization & Restriction of Chemicals (REACH) perhaps being the most widely known. Furthermore, MEPs voted for the sequestration of CO_2 in the ground (CCS), while overseas countries developed new industries for the chemical recycling of CO_2, thereby creating new jobs which cannot be delocalised. This could be due to the fact that very few MEPs have any international scientific knowledge.

Instead of investing in CCS, perhaps a better solution would be to develop an ambitious programme to recycle CO_2 into a chemical fuel or polymers

3) **Technical/scientific knowledge of industry leaders**
Increasingly, the leaders of European industry come from the financial sector and fewer have any practical knowledge of science and technology. Consequently, the correct decisions regarding the development of advanced fields are not taken. The same trend is also developing in the USA.

4) **Fragmentation**
In China, as well as the USA, there is one single RDT space, whereas in Europe each country follows its own development policy. The consequence is that many countries replicate the same research. For example, Germany has launched its own €200m programme on the capture and recycling of CO_2 to produce polymers.

Towards a new European innovation policy

The model developed by China is extremely successful, and we should take into account most of its characteristics. Europe must adapt to the 'new' competition being developed in a globalised world. This will mean that important new decisions are taken by the European authorities as well as by the national policy makers. Furthermore, the following should also be noted:

- Definition of a medium and long term strategy for the fourth generation industry: it would be best to have a model defining what the European Commission and each country should develop. The European Framework Programme, as currently defined, is largely the result of lobbying and is no longer adapted to the real needs of Europe;

- Definition of an energy policy for the longer term: today, it has become very difficult for Europe to compete with shale gas and oil from the USA. Consequently, companies with high energy demands mainly invest in the US – around $75bn (~€66.4bn *cf. Bloomberg*). Europe has ambitious and very expensive programmes for the extensive use of renewable energy sources, even if Europe is a rather low emitter of CO_2 compared to China and USA. Two problems are yet to be solved: electricity storage and cost per kW/h – the Wp as indicated by the photovoltaics industry is totally irrelevant. In practice, the supply of renewable energy

Norwegian innovation

In Norway, the 'Nanotechnology and Advanced Materials (NANO2021)' programme is the Research Council of Norway's large scale initiative for research on nanotechnology, microtechnology and advanced materials, and will run from 2012 to 2021. According to the Council, it is a key instrument for following up the Norwegian Government's national R&D strategy for nanotechnology covering that same period. This identifies three priority areas for publicly-funded R&D activities: basic knowledge development, innovation and commercialisation, and responsible technological development.

The NANO2021 programme follows in the footsteps of the Programme on Nanotechnology and New Materials (NANOMAT), which was concluded in 2011, and is designed to bring the national knowledge base in nanotechnology and advanced materials to an even higher international level. New, sustainable technological solutions are needed to meet critical societal challenges and provide a basis for industrial innovation.

The NANO2021 programme promotes concentrated, integrated research activities to help to achieve a long term, sustained research effort in the technology area while further enhancing the expertise, quality and capacity obtained in recent years. New knowledge and solutions that would otherwise be difficult to realise will be developed by bringing together long term basic research, applied research and innovation across R&D actors, interest groups, disciplines and subject areas.

The Research Council's website states that the programme uses a wide array of its application types and strategic measures to promote:

- The development of basic knowledge relating to priority areas such as energy, the environment, climate impacts, health and medical technology, and use of natural resources. Activities under this pillar of the programme will create a national competency base for solving current and future societal challenges and lay the foundation for tomorrow's knowledge-based industry;

- The development and use of technology through innovation and industry-oriented research activities relating to these priority areas. Activities here are targeted towards tackling current societal challenges and creating new industrial activity in new and existing industries; and

- Socially responsible technology development: both the development of basic knowledge and the development and use of technology entail ensuring that knowledge and insight are utilised to the benefit of society and the community at large. In all projects, importance will be attached to generating a better understanding of the different impacts of nanomaterials on human health and the ecosystem, and to addressing broad-based ethical and social issues relating to the development, production and application of the technologies, when this is relevant. Activities under this pillar of the programme will provide the knowledge platform needed for responsible, sustainable technology development as well as input for legislation in and regulation of the technology area.

has far to go to before it is economically competitive in Europe;

- Total hybridisation of the university and industry sectors throughout Europe: this is required in order to generate a new natural transfer of research findings from academia to start-ups and industry; and

- Do not enforce frequent changes in rules and regulations: this is crucial as such changes are expensive for industry to implement, and make it very difficult for small companies and start-ups to follow as an external expert frequently charges €5,000-€10,000 per day.

The framework programmes

The question of whether the priorities for a 'new industry' are adequate and clearly defined is an important one. For example, the European Parliament has decided to invest €10bn in CO_2 sequestration. However, both the scientific community and the general population do not see it as the best solution.

Why not develop an ambitious programme to recycle this pollutant into a chemical fuel or as polymers? Several industrial installations are already under construction in Asia which will generate employment that cannot be delocalised. In Europe only Germany, as stated above, has an adequate research, development and technology programme of €200m in this area. This example also highlights the disconnection between national and European policies.

It should also be asked whether the recently launched 'Vanguard' programme is adequate. Such programmes should have as a priority the development of competence centres open to all SMEs at a reasonable cost, such as common clean rooms able to develop specific electronic chips, which are available to university students in some countries.

Regarding the SME calls found in the framework programmes (FP), we feel that innovation will occur first through start-ups and SMEs. In general, the 15% target for SMEs within the FPs has not been attained, and the recent calls have generated much criticism. It would appear to us that the choice of the so-called 'experts' here is inappropriate.

Finally, with regard to the following up of projects, in our opinion, the financial follow-up works very well, but the same follow-up does not exist for the technical domain. Because the European Commission pushes for the immediate application of new strategies by industry, the contractors promise roadmaps which cannot be followed in practice.

Europe thus has enormous potential to play a significant role in the 'fourth industrial revolution', but the current mechanisms are not optimal and a new vision needs to be accompanied by huge changes by European policy and decision makers for this to be realised.

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