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SCIENCE AND SOCIETY
Time for a new deal

Edited by the Team of the Chief Scientific Adviser

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FOREWORD

"We also need a fundamental review of the way European institutions access and use scientific advice. In the next Commission, I want to set up a Chief Scientific Adviser who has the power to deliver proactive, scientific advice throughout all stages of policy development and delivery. This will reflect the central importance I attach to research and innovation." José Manuel Barroso, 15 September 2009

This is the *leitmotiv* for the creation of the Chief Scientific Adviser post at the European Commission: President Barroso's wish to make research and innovation a central part of his policy during his second mandate aiming to ensure more evidence-based European Union policy-making, to promote the understanding of science and technology in society and last, but not least, to boost European competitiveness through a better transformation of knowledge into innovative solutions.

As an independent, respected and trusted voice I not only deliver expert advice, analysis and opinions to President Barroso, but I also provide guidance to him and the Commission services on how to interpret scientific evidence in the presence of uncertainty. In so doing, I collaborate with the scientific community at large as well as with other science advisory structures in the EU and beyond. Most notably, the link between national science academies and the Commission has been reinforced to harness their expertise and a network of government science advisers in Europe is being set up. I also interact closely with the Joint Research Centre (JRC), the Commission's in-house science service, and with the different EU Agencies that provide scientific advice to the Commission and the member states.

Another aspect of my post is the early warning on novel science and technology issues that might be an opportunity or threat for the EU. To this end, a foresight working group involving those services of the Commission that are engaged in foresight activities has been established and is being coordinated by my office. I believe that foresight is a key element for the design of better policies as it enables us to identify developments that might require support and regulation in the future.

Finally, a core task of the Chief Scientific Adviser is to promote a European culture of science and technology and, in particular, to foster public dialogue with the aim of enhancing the confidence of European citizens in science and technology. I am convinced that only by creating such a positive attitude it will be possible to inspire young people to pursue a career in science, technology, engineering and mathematics. It will also help to make Europe less risk-averse and fully capable of exploiting its innovation potential.

Complementing the Chief Scientific Adviser role, a Science and Technology Advisory Council reporting to the President – and chaired by me – was created at the beginning of 2013. A description of the Council's mandate and structure as well as its first Opinion Paper can be found in this edition. The President and I are immensely grateful to the Council for the work achieved so far.

In line with the title of the first Opinion Paper of the Science and Technology Advisory Council – "Science for an informed, sustainable and inclusive knowledge society" – this edition of the *Berlaymont Paper*, apart from introducing the work of the Council, looks at the broader science and society relationship. I wish you an interesting read and hope that you will find the contributions stimulating.

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Table of contents

INTRODUCTION

In his recent State of the Union address on 11 September 2013, President Barroso referred to the need for Europe to transform itself and show global leadership by, amongst other things, reinforcing Europe's science and technology. In particular, he stated:

"We must encourage this innovative dynamism at a European scale. That is why we must also invest more in innovation, in technology and the role of science. I have great faith in science, in the capacity of the human mind and a creative society to solve its problems. The world is changing dramatically and I believe many of the solutions are going to come, in Europe and outside Europe, from new science studies, from new technologies. And I would like Europe to be leading that effort globally. This is why we – Parliament and Commission – have made such a priority of Horizon 2020 in the discussions on the EU budget" (José Manuel Barroso, State of the Union speech, September 2013).

The purpose of this Berlaymont Paper is to discuss how Europe can deliver on these expectations. Most notably, the following questions need to be addressed:

- What do we need and want from science?
- What actions need to be taken to unleash innovation based on science?
- How can we enhance the relationship between science and society with the aim of fostering a wider acceptance of new technologies?

In the first article, "Aligning science, innovation and society: An integral part of European Research and Innovation policy" the role science plays in changing, improving and driving the world is considered. Robert-Jan Smits, Director-General for Research and Innovation, gives an overview of the main policies proposed by the Commission and discusses how Europe will lead this change and, through science, contribute to reinforcing growth and competitiveness.

The citizens of Europe are the target audience. In order to invent and shape the future, in spite of the crisis, we need to make a real effort to "invest in skills, education and vocational training, dynamising and supporting talent" (José Manuel Barroso, State of the Union speech, September 2013).

Once again, the same questions arise: what skills and what education? How do we foresee our citizens' needs to address the world as it is and as we suppose it will be in the near future (tomorrow almost)? The article "Citizens for the 21st century" addresses this issue, flagging the needs, the changes foreseen and what the Commission is proposing to member states.

In a nutshell, through science and education we are preparing future generations to lead a Europe to make it stronger, more united and more open.

We are only able to improve Europe if we are able to ensure the engagement of all Europeans, all our citizens. Europe, to be successful, needs the support of citizens and "citizens will not be convinced with rhetoric and promises only, but only with a concrete set of common achievements" (José Manuel Barroso, State of the Union speech, September 2013).

Scientific evidence has shown that to engage our citizens we need to learn how to improve our communication. There is still a lack of (or "difficult") communication amongst politicians, policy-makers, citizens, scientists and media. No true dialogue can ever be achieved without a common understanding of the issues at stake.

The President's Science and Technology Advisory Council

With the aim of strengthening the voice of science and of fostering the dialogue between science and society, President Barroso appointed a Science and Technology Advisory Council (STAC) in January 2013, which reports to him. This follows the creation of the first ever post of Chief Scientific Adviser in the European Commission, filled by Professor Anne Glover since January 2012. Professor Glover also chairs the STAC, an independent and informal group of science and technology experts from academia, business and civil society, covering a broad range of disciplines and uniting expertise from across the European Research Area. Its members have been selected by the President himself in consultation with the Chief Scientific Adviser based on their scientific reputation, experience at the science-policy interface and communication skills. A list of the STAC members, their background and expertise can be found at the end of this issue.

The main aim of the STAC is to provide advice directly to the President. In particular, the STAC will advise on the opportunities and risks stemming from scientific and technological progress. It will also advise on how to communicate these in order to foster an informed societal debate and ensure that Europe does not "miss the boat", and remains a global leader in cutting-edge technologies.

The Science and Technology Advisory Council differs from other advisory bodies in the Commission in that it does not have a specific subject remit. Rather, it tackles issues that are of cross-cutting nature, with a clear societal dimension. It operates in a proactive way, identifying topics of value and of interest to support future growth and development in Europe. The President seeks the Council's advice on science and technology related topics that are of key importance to the Commission's growth agenda. With the creation of this Advisory Council (and other key proposals to support the development of research and innovation, such as the Innovation Union, the European Research Area and Horizon 2020), President Barroso has added another building block to pursue the goal of delivering smart, sustainable and inclusive growth for Europe.

President Barroso expects to receive inputs from this Council on how to create the correct environment for innovation by shaping a European society that embraces science, technology and engineering. However, being aware of the necessity of a good communication strategy, he asked the STAC to address first the science communication issue: how should science interact more with citizens? How can science engage citizens from all ages? How can we make sure everyone is talking the same "language" to achieve a true innovative society that will contribute to unleashing Europe's innovation and contribute decisively to the growth and jobs agenda. We have to ensure that our young generation will embrace a scientific career and be trained accordingly, considering that the share of highly qualified jobs will increase from 29 percent in 2010 to about 35 percent in 2020.[1]

The first question the Council dealt with was the public acceptance and perception of science. The debate, which also included a discussion with President Barroso, led to the delivery of the Council's first opinion paper, entitled "Science for an informed, sustainable and inclusive knowledge society", which is reproduced in this Berlaymont Paper. With the support of the STAC Secretariat, the production of the document was coordinated by Professor Alexandre Quintanilha and Professor Ortwin Renn who served as rapporteurs.

You will find in this issue an interview with Professor Renn on the difficulties surrounding the societal acceptance of new technologies as well as the concepts to be taken into account to ensure that Europe's decisions, at all levels, are supported by scientific evidence.

Photo from the second meeting of STAC at the Berlaymont, 10th April 2013.

[1] European Centre for the Development of Vocational Training (CEDEFOP) (2010): *Report "Skills Supply and Demand in Europe - Medium-term forecast up to 2020"*, Publications Office of the European Union: Luxembourg.

Aligning science, innovation and society: An integral part of European Research and Innovation policy

*By Robert-Jan Smits**

'Europe 2020' outlines the EU's strategy for delivering smart, inclusive and sustainable economic growth. Smart, through more effective investments in education, research and innovation; sustainable, by making our economy greener and more competitive; and inclusive, by focusing on job creation, poverty reduction and social cohesion.

Research and innovation have thus moved to the heart of EU policy, as the key path to deliver 'smart' growth. But to ensure that smart growth is at the same time sustainable and inclusive, it is of paramount importance that science, research and innovation are well geared towards addressing societal challenges, and robustly engage with society to jointly create an inclusive future. As such, optimising the interaction between science, innovation and society is key to a successful EU science and innovation policy that can deliver the Europe 2020 objectives.

EC recognition of the importance of addressing the science and society relationship at a very early stage

The European Commission has long recognised the strategic importance of fostering a good relationship between science, innovation and society; in fact well before the current Europe 2020 strategy came into being. Indeed, since the second Framework Programme for Research (FP2, 1987-1991), the Commission has explicitly aimed to address Ethical, Legal and Social Aspects (ELSA) of research, in particular in relation to the life sciences.[1,2] During these early years, the focus of activities was at the level of individual projects or action lines within research programmes and, by and large, confined to the life sciences (FP4, 1994-1998: Biotechnology, Biomedicine and Health, FAIR; FP5, 1998-2002: Quality of Life and Management of Living Resources). However, as a result of controversies related to risks and ethical issues associated with new technologies (GMO foods, human embryonic stem cell research, etc.) and, equally importantly, with the way scientific expertise was used in the context of public policy and risk governance (BSE crisis, GMOs, etc.), the awareness grew that the relationship needed to be pursued more systematically.

In response, the Commission has developed principles and guidelines that could help address these challenges more effectively. It adopted a White Paper on European Governance in July 2001,[3] listing five key principles of good governance: openness, participation, accountability, effectiveness, and coherence. In December 2002, the Commission adopted a Communication on the collection and use of expertise,[4] re-emphasising the core principles of quality, openness and effectiveness.

In between the adoption of these two documents, the Commission also adopted the "Science and Society Action Plan" in December 2001,[5] comprising a set of 38 actions to improve the relationship between science and society. This action plan was implemented via the "Science and Society" (S&S) programme, as part of FP6 (2002-2006) and with a budget of 88 million euro. The S&S programme was also the main instrument for the implementation of the principles and guidelines identified in the White Paper on governance and the Communication on the use of expertise. The actions of the S&S programme were further developed in FP7 (2007-20013) under the "Science in Society" (SiS) programme, with a budget of 330 million euro.

Lesson learned

The Science-Society activities undertaken as part of the S&S and SiS programmes have had significant impacts on research and innovation policy and practice in Europe. For example, with regard to fostering high ethics standards for research, the Commission has established a very robust procedure for ethics review for EU-funded research projects,[6] and has contributed significantly to the establishment of both 'ELSA' research capacity in Europe, and an

*Robert Jan Smits is the Director-General of DG Research and Innovation.

[1] Elizalde, J. (1998): General Introduction: ELSA in F.P. 4, European Commission, E(thical), L(egal) and S(ocial) A(spects) of the Life Sciences and Technologies Programmes of Framework Programme IV. Catalogue of Contracts. EUR 18309, Brussels. ftp.cordis.europa.eu/pub/elsa-fp4/docs/catalogue-of-contracts.pdf

[2] Aguilar, A., Magnien; E. and Thomas, D (2012): Thirty years of European biotechnology programmes: from biomolecular engineering to the bioeconomy, *New Biotechnology*, Volume 0, December, http://cdn.elsevier.com/promis_misc/05042NBT.pdf

[3] European Commission (2001): *European Governance - A White Paper*, COM(2001) 428 final, of 25 July 2001.

[4] European Commission (2002): *Communication from the Commission on the collection and use of expertise by the Commission: Principles and guidelines*, COM(2002) 713 final of 11 December 2002.

[5] European Commission (2001): *Science and Society Action Plan*, COM(2001) 714 final of 4 December 2001.

[6] http://ec.europa.eu/research/science-society/index.cfm?fuseaction=public.topic&id=1289

ethics review infrastructure via initiating networks of both local research ethics committees (EURECNET)[7] and national ethics committees.[8]

Moreover, the programmes and projects carried out under the Framework Programmes have also significantly contributed to a better understanding of the dynamics between science and society. To take stock of the outcomes of the programmes, a number of evaluations and studies have been carried out. In particular, the Technopolis Group carried out an interim evaluation in 2012 of Science in Society activities under FP7, with support from Fraunhofer ISI and Science-Metrix.[9] Key insights coming from those evaluations are that:

- Betting on 'technology acceptance' by way of good marketing is no longer a valid option for ensuring a good relationship between Science and Society;
- Diversity of actors in R&I is a must for achieving greater creativity and better results;
- Early and continuous iterative engagement of society in R&I is key to innovation appropriateness and acceptability.

The outcomes of the evaluations carried out point towards the same 'lessons learned', and also to similar recommendations, such as those identified in the recent policy paper "Science for an informed, sustainable and inclusive knowledge society", by President Barroso's Science and Technology Advisory Council (STAC).[10] In line with these evaluations and studies, the STAC paper also points to key factors that influence societal opinion on science and innovation: public engagement, trust and education.

Public engagement and trust

A key finding from SiS research is that there is no rejection of the impetus towards innovation as such; the general attitude of Europeans towards science and technology is positive.[11] Europeans are concerned, however, that unchecked research and innovation (R&I) advances may lead European societies down irreversible paths that threaten their values, interests and security; and they wish to be involved in decisions about new technologies when social values are at stake.[12, 13]

Public involvement in science and innovation is crucial for several reasons. Evidently, science and innovation need to be well-aligned with societal values if they are to play an effective role in helping address societal challenges. Such alignment can only be achieved if there is a robust exchange of ideas and aspirations between science, innovation and society. Furthermore, as the STAC policy paper also highlights, engagement is an important means to foster societal 'ownership' for R&I, and build societal trust in R&I governance. The STAC paper also observes that building trust is crucial for creating the appropriate conditions for a positive general attitude towards technological change and innovation. The lessons learned from the SiS activities also make clear that public engagement will only contribute to building trust if it has a genuine impact on the R&I agenda and outcomes; and that it is conducted in a truly inclusive way, involving a wide range of stakeholders and citizens.

Science education and scientific careers

Whereas robust societal dialogue on science, research and innovation underpins the building of trust, informed societal dialogue itself is underpinned by (informal) science education and 'science literacy'. In this respect, it is important to note that the 2013 Eurobarometer "Responsible Research and Innovation" shows that while 53 percent of Europeans say that they are interested in developments in science and technology, only 40 percent feel informed about them.[14] However, public engagement and science education have important impacts beyond sustaining dialogue: they are also crucial to mobilising the creative and innovative capacity of society (including youth, female talent, and diverse user groups), and to stimulate people's interests in pursuing scientific careers. Europe needs to improve its performance on this aspect as well, as it needs an estimated one million more researchers by 2020 to realise smart growth. Research has indicated that other economies in Asia and the US are doing rather better than Europe in terms of investment in

[7] http://www.eurecnet.org/index.html

[8] Forum of National Ethics Councils: http://ec.europa.eu/research/science-society/index.cfm?fuseaction=public.topic&id=1305

[9] Technopolis / Fraunhofer (2012): "Interim Evaluation & Assessment of Future Options for Science in Society Actions"- http://ec.europa.eu/research/science-society/document_library/pdf_06/executive-summary-122012_en.pdf

[10] http://ec.europa.eu/commission_2010-2014/president/advisory-council/documents/stac_policy_paper_no_1_290813.pdf

[11] European Commission (2010): *Eurobarometer 'Europeans, Science and Technology'*: http://ec.europa.eu/public_opinion/archives/ebs/ebs_340_en.pdf

[12] European Commission (2010): *Eurobarometer 'Life Sciences and Biotechnology'*, http://ec.europa.eu/public_opinion/archives/ebs/ebs_341_en.pdf ; Gaskell *et al.* (2011): The 2010 Eurobarometer on the life sciences. *Nature Biotechnology*, 29, 2, pp. 113-114.

[13] European Commission (2010): *Eurobarometer 'Europeans, Science and Technology'*: http://ec.europa.eu/public_opinion/archives/ebs/ebs_340_en.pdf

[14] European Commission (2013): *Eurobarometer 'Responsible Research and Innovation'*, in press.

Science, Technology, Engineering, and Mathematics (STEM) education and in addressing skills shortages.

Taking together, these findings reinforce the message that Europe needs to foster a broader and deeper participation of society in knowledge creation both by analogue and digital means. This implies promoting (formal and informal) science education, public engagement, Open Access, citizen science, science 2.0, digital science, inter- and trans-disciplinary research and social innovation.

These lessons learned about the interplay between governance, public engagement, science education and trust (and their connections to science and innovation policy) have been taken into account by the European Commission. This has resulted in the development of a more holistic approach by the Commission towards fostering a fruitful relationship between science, innovation and society. Key to this approach is that all societal actors (researchers, citizens, policy makers, business, third sector organisations etc.) must work together during the whole R&I process. This co-creation, aligning the R&I outcomes to the values, needs and expectations of European society is termed Responsible Research and Innovation (RRI). In practice, the Commission has started to implement RRI as a package that promotes societal engagement in science, research and innovation, further supported by activities that enable easier access to scientific results, better uptake of the gender equality and ethics dimension, and formal and informal science education.

The "Science in Society" lessons learned are reflected in Horizon 2020

The lesson learned from the S&S and SiS programmes have informed the architecture of the next research and innovation framework programme that will start in 2014: Horizon 2020 (2014-2020).[15] First of all, Horizon 2020 has a strong orientation towards addressing the societal challenges faced by Europe and the world: challenges such as climate change, energy security, food security, health and an ageing population, and of course the economic crisis. Science, research and innovation are key to finding the solutions and answers to these challenges.

Second, Horizon 2020 has the specific objective 'Science with and for Society' alongside its main three priorities (scientific excellence, industrial leadership and societal challenges), with a dedicated budget of 462 million euro. This objective will be cross-cutting and aims to build effective cooperation between science and society, for example via the uptake of RRI, and to recruit new talent for science and innovation.

Third, as another cross-cutting action, RRI will be implemented throughout Horizon 2020. This means in practice that Work Programmes in Horizon 2020 will include actions relating to public engagement, gender equality, science education, ethics and Open Access. To this end, 0.5 percent of the Societal Challenges and Industrial Leadership priorities budget of Horizon 2020 is earmarked for Science with and for Society actions.

Fourth, the Socio-economic Sciences and Humanities (SSH) will be mainstreamed and embedded in research themes, which will provide additional momentum to inter- and trans-disciplinary approaches and societal innovation.

What should also be mentioned here is that the European Commission has committed to devoting a minimum of 60 percent of spending under Horizon 2020 to support sustainability objectives comprising, for the most part, mutually reinforcing actions for achieving climate change and resource efficiency objectives. Across the whole programme, this will include measures for energy efficiency and low carbon energy, sustainable mobility and food security, and turning waste into a resource.

Horizon 2020 *de facto* implements key recommendations of the STAC policy paper

With all the foreseen actions mentioned above, Horizon 2020 is, in fact, well on track to implement the key recommendations of the STAC paper. Its first recommendation calls for a thematic action on Science and Society in Horizon 2020, which is now fully realised via the Science with and for Society objective. As its second recommendation, it calls for more investment in more inclusive pan-European citizen participation. Besides the reinforced level of ambition in Horizon 2020 to broaden and wider participation, the Commission has also initiated actions to bolster pan-European participation via a number of new initiatives. For example, the VOICES[16] project is an innovative Europe-wide public consultation process in the area of urban waste launched by FP7-"Science in Society" in 2013, in coordination with DG Communication and DG Environment. It is testing a pilot methodology to involve European citizens in the definition of research priorities in this field. Some 99 focus groups, involving a total of 990 citizens in all European countries, have met and provided ideas, values, needs and expectations concerning 'Urban waste and innovation'. The results of the consultation have been fed into the development

[15] http://ec.europa.eu/research/horizon2020/index_en.cfm

[16] http://www.voicesforinnovation.eu/

of the Work Programme for the Societal Challenge 'Climate Action, Environment, Resource Efficiency and Raw Materials' of Horizon 2020.

Other ambitious engagement activities have been developed under FP7, notably the so called 'Mobilisation and Mutual Learning (MML) Action Plans'. MML Action Plans are innovative projects that support sustainable collaborations between researchers, policy makers, citizens, civil society organisation and industry to tackle societal challenges based on shared values, a common vision and joint approaches. In the course of Horizon 2020, under the Science with and for Society line, other ambitious activities can be funded.

The third recommendation proposes establishing a European Radar System for early detection of risks, opportunities and societal concerns with regard to science and innovation. Such a system is currently the focus of a new joint activity between DG Research and Innovation and the Chief Scientific Advisor to President Barroso. This activity will develop a pan-European survey that allows for prospective assessment of research and innovation with the involvement of stakeholders and citizens. This activity will identify the expectations of citizens as regards science, technology and innovation, which will help us to shape policies and set priorities for our research and innovation programmes that generate socially robust outcomes.

The fourth and final recommendation of the STAC paper – to devote a part of the total national research budget to Science and Society issues – is addressed directly to the member states rather than to the Commission. Nevertheless, Horizon 2020 does devote a significant budget to Science and Society issues, and as such it can be concluded that all recommendations of the STAC paper are well reflected in Horizon 2020, – which suggests that it is also robustly underpinned with regard to this important societal dimension!

The way forward: more action still needed

Even though one can feel bolstered by the fact that there is agreement between the recommendations of the STAC paper and the actions foreseen under Horizon 2020, the challenge that still remains is to deliver an effective implementation of Horizon 2020. Also, emerging trends in science and innovation change the way knowledge is produced (Science 2.0, Open Access, citizen science, digital science, and social innovation among others) and these trends also affect the way citizens engage with science and innovation. It is of paramount importance that the EC 'Science, Innovation and Society' strategy also seizes the opportunities that these developments offer. Furthermore, for it to be effective, the strategy needs to be coherently applied and communicated throughout EU science and innovations policies. At this point, close to the start of Horizon 2020, it is urgently needed to communicate the foreseen actions on the theme of Science, Innovation and Society to stakeholders. This will optimise the impact of our initiatives, encouraging participation and foster understanding by stakeholders about the rationale and expectations of the EU.

For the longer term, it is essential to realise societally robust framework conditions for science, research and innovation in the context of ERA and Innovation Union. This has also been recognised by the EU member states. In a 2008 Council Conclusions, it was stressed that the European Research Area (ERA) "is firmly rooted in society and responsive to its needs and ambitions in pursuit of sustainable development".[17] Council conclusions of April 2010 furthermore stated that "the social dimension of the ERA should […] support research and debate on the principles of responsible research through partnerships between researchers, policy-makers and society at large".[18] The European Economic and Social Committee has also recently stated that socially-generated innovation should be at the core of the Innovation Union.[19]

The results of the 2013 Eurobarometer on RRI indicate that there is also support from the citizens of Europe for further initiatives. For example, three quarters (76 percent) agree that the EU should take measures to address the ethical risk of new technologies, with at least six out of ten in each country in agreement. Eight out of ten respondents also agreed that the EU should actively promote worldwide respect for European ethical principles in the conducting of scientific research.

Clearly, the approach that smart growth through research and innovation at the same time has to be sustainable and inclusive is broadly supported. As it is also key to achieving the objectives of Europe 2020, it remains of paramount importance to continue fostering the systematic integration of the societal dimension throughout EU research and innovation policy.

[17] http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/intm/104434.pdf

[18] http://register.consilium.europa.eu/pdf/en/10/st09/st09450.en10.pdf

[19] European Commission (2010): *Opinion of the Section for the Single Market, Production and Consumption on the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: State of the Innovation Union 2012 - Accelerating change*, COM(2013) 149 final, INT/695, 18 September 2013.

Science for an informed, sustainable and inclusive knowledge society

*Policy paper by President Barroso's Science and Technology Advisory Council, 29 August 2013**

Introduction

The welfare of modern society depends to a large extent on the continuous advancement of scientific knowledge, the development of technical and practical knowhow and the fostering of entrepreneurial spirit. Extraordinary advances have taken place in science and new technologies in the last decades.[1] For example our understanding of genetics, synthetic biology, neurosciences, material sciences, computer sciences, space science and advances in nanotechnologies have provided both a deeper understanding of the grammar of nature and new opportunities for industrial and economic development. Innovative engineering tools and new forms of manufacturing have also shown how to foster better communication, to improve access to information and how to use many resources more efficiently and with reduced environmental impact. These developments offer new opportunities to tackle major societal challenges; enhance economic prosperity and a fair distribution of wealth for all members of society; address climate change, energy and resource scarcity; stimulating advances in healthcare and reducing the impact of ageing societies, and many other potential benefits.

During this period, the global and European context in which these advances are taking place has also changed significantly. Complex issues of sustainability, global competitiveness and equity have loomed ever more critically in the conscious minds of many EU citizens.[2] And yet, if knowledge from scientific research is to become the driver of a knowledge-based economy, how do we ensure that its evolution and development reflect not only a step forward into sustainable development but also meet societal expectations and concerns?

In 2012 the *Innovation Union flagship initiative*[3], the proposals for *Horizon 2020*[4] and the *Communication on A Reinforced European Research Area Partnership for Excellence and Growth*[5], just to quote some recent policy papers on research and innovation, highlight the idea that European future prospects depend on our ability to deliver growth that is *smart*, *sustainable*, and *inclusive*.[5] The term "inclusive" illustrates the need to gain public support for the necessary changes in technologies, production processes and societal transformations.[6] The EU encourages citizens to become active actors in the innovation and research policy designs of the EU. The Science and Society link has therefore been considered an important strategy pillar of European science and innovation policy.[7]

Public concerns about science and technology

In spite of the fact that Europe's fate depends on a prudent utilisation of knowledge, most European societies face a growing distance between knowledge producers, users and citizens. Many innovative applications of science and technology lack significant public support, regardless of what the balance of scientific evidence suggests about the level of risk associated with any specific application.[8] In the abstract, the European

* This document can also be found on the website of President Barroso: http://ec.europa.eu/commission_2010-2014/president/advisory-council/documents/stac_policy_paper_no_1_290813.pdf

[1] Compare: Uzagalieva, A., Kočenda, E., and Menezes, A. (2012): Technological innovation in New European union markets. *Emerging Markets Finance and Trade*, 48 (5), 51-69. And: Parrilli, M. D., and Elola, A. (2012): The strength of science and technology drivers for SME innovation. *Small Business Economics*, 39 (4), pp. 897-907.

[2] Compare: Barr, S. (2012): *Environment and Society: Sustainability Policy and the Citizen*. Ashgate Publishing: London. With respect to energy systems, compare: Huijts, N. M. A., Molin, E. J. E. and Steg, L. (2012): Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable and Sustainable Energy Reviews*, 16 (1), pp. 525-531. With respect to risks, compare: World Economic Forum (2013): *Global Risks 2013*. 8th Edition. WEC: Genf, p.63f. http://www3.weforum.org/docs/WEF_GlobalRisks_Report_2013.pdf, accessed on July 26, 2013.

[3] http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/flagship-initiatives/index_en.htm

[4] http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=h2020-documents

[5] http://ec.europa.eu/euraxess/pdf/research_policies/era-communication_en.pdf

[6] Renn, O. and Schweizer, P. J. (2009): Inclusive risk governance: concepts and application to environmental policy making. *Environmental Policy and Governance*, 19 (3), pp. 174-185.

[7] From a policy viewpoint, additionally to the EU research programmes some examples of relevant EU policies include the *Science and Society Action Plan* (COM(2001)714), the *Action Plan Life Sciences and Technology* (COM(2007) 175), the *Nanotechnology Action Plan* (COM(2007) 505 final), the *Digital Agenda for Europe* etc.

[8] Compare public attitudes towards technologies: Pardo, R. and Calvo, F. (2002): Attitudes toward science among the European public: A methodological analysis. *Public Understanding of Science*, 11 (2), pp. 155-195. The discrepancy between risk perceptions of new technologies and statistical risk analysis is described in: Garner, D. (2009): *Risk. The science and politics of fear*. Virgin Books: London, pp. 290f.

population is still strongly in favour of science and its application (e.g., plant biotechnology). Eurobarometer 2011 data[9] show that 75 percent of EU citizens are positive about science and 66 percent feel that science is making our lives healthier, easier and more comfortable[10]. However, since 2005 the share of Europeans experiencing trust in science has declined from 78 percent to 66 percent. In all countries, except Norway, Hungary and Luxembourg, some citizens have lost part of their trust in science[11]. The largest decline in trust has taken place in Germany, Italy and Poland.

Many people seem to be fixated on the risks and the uncertainties of new developments while commonly underestimating their potential for positive change and economic opportunities. Recent examples of public concerns on innovative products include, *inter alia*, the internet of things and smart cities (privacy); shale gas (risk assessment); GM food (socio-cultural concerns); dual use and biotechnology (biological threats); synthetic meat and animal cloning for food (safety and cultural concerns); personalised medicine, gene testing and DNA banking (benefits for society and socio-economic inequalities).[12] Other concerns include carbon capture and storage (citizens raise safety concerns over storage facilities in their neighbourhood despite the fact that this technology is regarded as potentially beneficial in fighting climate change); smart energy meters (privacy issues); electronic health records (privacy and autonomy concerns) etc.[13]

At the same time, social change associated with the advancement of knowledge has lost some of its attractiveness for at least two reasons.[14] Many European citizens enjoy increasing levels of economic prosperity and see less need for change. For the less privileged groups in society, sophisticated knowledge (for example in the financial sector) often seems to run counter to the common good and benefit only the rich.

This perception of a gap between those who produce and apply new knowledge and those who will be affected by the positive and negative consequences of these applications is exacerbated by new developments in knowledge generation and in the institutional settings where knowledge generation takes place. Due to the complexity, uncertainty and ambiguity of contemporary knowledge construction, knowledge claims are often contested and leave ample room for different interpretations.[15] Knowledge often increases the experience of uncertainty rather than reducing it. This has led to the problematic belief, allegedly supported by post-modern thinking, that all truth claims are more or less arbitrary and driven by personal or institutional interests rather than factual insights.[16]

Challenges for improving public understanding of new developments in knowledge and technology

A principal challenge in science and technology information and education is therefore to convey a modern understanding of knowledge as a temporary, contested and multi-faceted body of truth claims and, at the same time, provide the assurance that it is the "fuzziness" of contemporary

[9] http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/chapters/new_perspectives_smarter_policy_design_chapter_3.pdf

[10] In five countries, three quarters or more of respondents agree with the statement : Malta at 78 percent, Iceland at 77 percent, the United Kingdom at 76 percent and Luxembourg and Norway at 75 percent. http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011

[11] It is clear that specific uses of science differently affect public acceptance in EU member states and the EU as a whole. Levels of optimism about computers and information technology and solar energy have been high and stable over the period. By contrast, optimism in biotechnology, which declined steadily over the period 1991-1999, rose considerably between 1999 and 2002 but from 2005 onwards, is in decline.

[12] Compare for technological trends in general: Allum, N., Sturgis, P., Tabourazi, D. and Brunton-Smith, I. (2008): Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science*, 17 (1), 35-54. Compare for biotechnology: Frewer, L.J.; van der Lans, I.A., Fischer, A.R.H.; Reinders, M.J.; Menozzi, D.; Zhang, X.; van den Berg, I. and Zimmermann, K.L. (2013): Public perceptions of agri-food applications of genetic modification – A systematic review and meta-analysis. *Trends in Food and Science*, 30 (2), pp. 142-152.

[13] Compare for carbon sequestration: von Borgstede, C., Andersson, M. and Johnsson, F. (2013): Public attitudes to climate change and carbon mitigation—Implications for energy-associated behaviours. *Energy Policy*, 57 (June), pp. 182–193; compare for health records: Luchenski, S., Balasanthiran, A., Marston, C., Sasaki, K., Majeed, A., Bell, D. and Reed, J. E. (2012). Survey of patient and public perceptions of electronic health records for healthcare, policy and research: Study protocol. *BMC Medical Informatics and Decision Making*, 12 (1), 40. doi:10.1186/1472-6947-12-40.

[14] Compare the classic essay by: Mongardini, C. (2002): The decadence of modernity: the delusions of progress and the search for historical consciousness. In: J.C. Alexander and P. Sztomka (eds.): *Rethinking Progress*. Unwin Hyman: Winchester, MA, pp. 53-66.

[15] Compare the analysis in: Forsyth, T. (2013): *Critical political ecology: The politics of environmental sceince*. Routledge: London, pp. 77ff.

[16] Leonardi, P. M. and Barley, S. R. (2010): What's under construction here? Social action, materiality, and power in constructivist studies of technology and organizing. *The Academy of Management Annals*, 4 (1), pp. 1-51.

knowledge that leads to a successful and responsible application of knowledge in different societal domains. Uncertain knowledge is by no means arbitrary. It portrays reality much better than traditional deterministic models of the world. Complex models of reality have proven to be more successful than simple and unambiguous images of reality.[17] Even with all the uncertainty and ambiguity associated with new knowledge, the implications of this knowledge have the power to make human interventions more robust, efficient and even sustainable. Taking risks and exploring uncertain areas is thereby connected to creating new opportunities and to providing economic and social benefits to all.

To convey this message about the nature of contemporary knowledge to all parts of the European population is first and foremost an educational task. In particular, the science curricula of schools need to be revised to reflect this new understanding of knowledge and provide guidance on how to handle complex questions in an appropriate – but still knowledge-based – manner.[18] These attempts at revising school curricula need to be accompanied by additional efforts to launch programmes on public engagement with science, knowledge and society. To focus on scientific literacy only is not enough. The participants of these programmes need to become familiar with the concept that knowledge, technology, organisational structure and patterns of behaviour are closely interwoven and constitute the main fabric of our modern, knowledge-based culture.[19]

Secondly, we need new and effective programmes to help people understand the rationale for comparing risks and benefits and for making prudent trade-offs between the different values we care about. The empirical analysis of people's attitudes towards changes in their environment, in particular new technological infrastructure, has shown that four factors are crucial for a positive position towards proposed changes[20]:

- *Why do we need change?* This cognitive aspect includes the insight that the proposed change is going to provide the service that is associated with this change and that the concomitant risks can be managed by the societal institutions mandated to deal with these risks.
- *What is in it for me?* People need to be convinced that the proposed changes will have a benefit either for themselves or for others for whom they care. If the common good is invoked it needs to be articulated in the form of concrete advantages to those who will need the services. Abstract promises such as "it will improve the competitiveness of a country" are insufficient to serve this objective.
- *Does this limit my options?* People tend to reject innovations or changes if they believe that their personal range of options or their personal freedom is negatively affected. Loss of sovereignty or the perception of being dominated by others are powerful threats to self-efficacy and autonomy. Innovations such as smart grids or self-learning computers may be good examples where this feeling of being governed by others may easily evolve.
- *Do I feel personally engaged?* Changes always mean interventions into one's way of life. If these changes are seen as something alien in people's neighbourhoods they are likely to be rejected. A good example is the ownership of municipal wind parks. If they are owned by a distant company, people often feel that they do not fit into the landscape in which they live. However, if people in the community own the wind parks themselves, they may feel that these generators seem to match the community's heritage.

Meeting these four conditions for a positive attitude towards planned changes and innovations are moderated by trust.[21] None of the four conditions can be met if there is insufficient trust in the decision-making process and in the institutions or organisations that are involved in

[17] Duit, A., Galaz, V., Eckerberg, K. and Ebbesson, J. (2010): Governance, complexity, and resilience. *Global Environmental Change*, 20 (3), pp. 363-368.

[18] De Haan, R. L. (2011): Teaching creative science thinking. *Science*, 334 (6062), pp. 1499-1500.

[19] Tàbara, J. D. and Chabay, I. (2012): Coupling human information and knowledge systems with social-ecological systems change: Reframing research, education, and policy for sustainability. *Environmental Science & Policy*, 28 (April), pp. 71-81.

[20] The list is originally from: Renn, O. (2013): Citizen participation in public projects – State of research and conclusions for practice (in German). *UVP-Report*, 27 (1/2), pp. 38-44, here 40. A similar list of influential factors can be found in; Fiske, S. F. 2010: *Social beings. Core motives in social psychology*. 2. edition. New York: John Wiley, pp. 89 ff. Susan Fiske explores three aspects: Understanding, Controlling and Self-Enhancing . Personal utility is not on her list. This aspect is highlighted in: van Zomeren, M.; Postmes, T. and Spears, R. (2008): Toward an integrative social identity model of collective action: A quantitative research synthesis of three socio-psychological perspectives. In: *Psychological Bulletin* 134 (4), pp. 504-535.

[21] Earle, T.C. und Cvetkovich, G.T. (1999): Social trust and culture in risk management. In. G.T. Cvetkovich and R. Löfstedt (eds): *Social trust and the management of risk*. Earthscan: London, pp. 9-21.

this process. If people do not trust the authorities, even the best education or communication programme will fail because the truth claims therein will not appear as credible. Since these claims are, as stated above, uncertain and ambiguous, it is easy to dismiss them as being interest-driven positions disguised as facts. In essence, building trust and confidence in knowledge-producing institutions is therefore crucial for creating the appropriate conditions for a positive general attitude towards knowledge implementation and planned changes.[22]

Key factor: Trust

How can trust and confidence in our knowledge-producing and implementing institutions be enhanced? As we have said before, polls all over Europe show that most public authorities have experienced an erosion of trust in the last decades. The record is even worse for institutions belonging to the private sector.[23] More trust is assigned to civil society actors. Even non-governmental organisations (NGOs), as they get closer to real power, for example institutional decision making, seem to suffer in terms of trustworthiness.[24] Many observers of the situation are convinced that the loss of trust can be compensated for by better communication. The empirical evidence for this claim is not very convincing.[25] Good communication is certainly a necessary condition for improving trustworthiness, but it is not sufficient. First of all, trust is linked to transparency of decision-making and an effective interplay of checks and balances. Second, involving the affected stakeholders and citizens in the decision-making process can generate and enhance trust.[26] The change of perspective from being a "victim" to being a 'co-generator' of political decision-making has a major impact on the perception of the governance process and contributes to the growth of trustworthiness assigned to the other actors in this process. The few pan-European participation processes that have taken place over the last decade clearly demonstrate that participants gained more confidence in knowledge-producing institutions.[27] Effective and fair participation has therefore been proved to promote trust and confidence among the actors involved. But there is a note of caution: participation is only one, albeit a significant prerequisite for making people more willing to consider proposed changes from the benefit as well as from the risk side. Once people feel they have the right and possibility to co-generate change and to own part of the change process they are much more inclined to assign trade-offs between risks and benefits and to value changes that promise the advancement of European ideals and goals.[28] But there is no guarantee for more acceptance.[29]

More appropriate education programmes, effective investment into initiatives for improving public understanding of the interplay between science, technology, institutional settings and patterns of behaviour, effective and targeted communication programmes that are tailored towards different target groups in Europe. Also, last but not least a major drive for public participation are the main ingredients that can help Europe to live up to its claim of a knowledge-based continent with a broad future.

Conclusions: A new science and society contract

Europe's well-being and future depend largely on the generation and implementation of knowledge with respect to technical innovation, economic

[22] Siegrist, M. and Cvetkovich, G. (2000): Perception of hazards: The role of social trust and knowledge. *Risk Analysis*, 20, pp. 713-719.

[23] http://ec.europa.eu/public_opinion/archives/ebs/ebs_340_en.pdf, p.19.

[24] Fehrler, S. and Kosfeld, M. (2013): *Can you trust the good guys?: Trust within and between groups with different missions*. Discussion Paper No 7411 (May). Institute for the Study of Labor (IZA): Bonn. Compare for climate change policies: Terwel, B. W., Harinck, F., Ellemers, N. and Daamen, D. D. (2009): How organizational motives and communications affect public trust in organizations: The case of carbon dioxide capture and storage. *Journal of Environmental Psychology*, 29(2), pp. 290-299.

[25] Roberts, M. R., Reid, G., Schroeder, M. and Norris, S. P. (2013). Causal or spurious? The relationship of knowledge and attitudes to trust in science and technology. *Public Understanding of Science*, 22 (5), pp. 624-641.

[26] Arvai, J.(2003): Using risk communication to disclose the outcome of a participatory decision-making process: Effects on the perceived acceptability of risk-policy decisions. *Risk Analysis*, 23 (2), pp. 281-289; Compare also: Dovey, K. (2009): The role of trust in innovation. *The Learning Organization*, 16 (4), pp. 311-325.

[27] Compare: Hüller, T. (2010): Playground or democratisation? New participatory procedures at the European Commission. *Swiss Political Science Review*, 16 (1), pp. 77-107. And: http://www.macaulay.ac.uk/socioeconomics/research/path/PATHpercent20Policypercent20Brief.pdf

[28] Compare the empirical results in; US-National Research Council (2008): *Public participation in environmental assessment and decision making*. National Academies Press, pp. 77ff. Compare specifically for participation in impact assessments: O'Faircheallaigh, C. (2010): Public participation and environmental impact assessment: Purposes, implications, and lessons for public policy making. *Environmental Impact Assessment Review*, 30 (1), pp. 19-27.

[29] Mercier, H. and Landemore, H. (2012): Reasoning is for arguing: Understanding the successes and failures of deliberation. *Political Psychology*, 33 (2), 243-258. Compare also: Bora, A. and Hausendorf, H. (2006): Participatory science governance revisited: Normative expectations versus empirical evidence. *Science and Public Policy*, 33 (7), pp. 478-488.

competitiveness, social cohesion and environmental resilience. Globalisation creates the conditions for success in which Europe has to find its place by means of a vibrant, scientifically-grounded knowledge-based economy. Europe's reliance on knowledge is not limited to the subsystem of science but includes other types of expertise, i.e. practical, experiential, tacit and indigenous knowledge.[30] One of the main challenges in generating and applying knowledge is the task of providing adequate incentives for innovative ideas to prosper, creating the conditions for an intelligent selection and diffusion of knowledge and improving the general level of education and skills so that all actors are capable of handling knowledge professionally and responsibly. The main goal is to enhance the capacity of knowledge production and application, including the development of adequate human resources in order to bring the advancement of knowledge in line with economic, social, political, and environmental goals that all European countries share.

For Europe to become a sustainable, prosperous, democratic and secure society, it is important that legitimate societal concerns concerning science and technology development are taken on board, entailing an enhanced democratic debate with a more engaged and informed public and better conditions for collective choices on scientific issues. **A new science and society contract should be proposed**. Social learning and co-production of knowledge where appropriate together with the involvement of civil society in science and technology are all examples of relevant factors to address. This may be the European solution to a responsible and socially inclusive role of innovation as specified in the EU *Communication on A Reinforced European Research Area Partnership for Excellence and Growth*.

The Advisory Council feels that under the present conditions of financial constraints, increased pressures from a globalised economy and pressing societal and environmental issues that need improved knowledge for their resolution, the EU should launch an initiative called "Public Contract for a Smart, Sustainable and Inclusive Knowledge Society". The main goal is to launch a European and national communication, education and deliberation programme that pursues the following objectives:

- to listen to the aspirations of the citizens for new knowledge;
- to demonstrate the usefulness of and need for new knowledge generation and application in Europe;
- to highlight the economic, societal and cultural value of scientific knowledge and its application in various sectors of society;
- to be sensitive, inclusive and responsive to public concerns and worries;
- to place more emphasis on improved communication and dialogue programmes that help to integrate public aspirations and concerns into a future oriented and sustainable pathway towards a responsive knowledge society.

Science and technology are not only means for productivity and competitiveness, but are integral components of European history, its cultural heritage and its vision. It is therefore essential to link all communication activities to a broader understanding of knowledge as part of the collective identity of Europe since the Age of Enlightenment. This broader understanding of knowledge may be the European solution to a responsible and socially inclusive science and technology policy design bearing in mind that solutions in different regions of the world may differ from this model.

Recommendations

1. The Commission should introduce, and properly finance, a **thematic action on Science and Society in the Horizon 2020 programme**[31]. The Commission should also open a dedicated thematic programme on science communication in the Marie Curie programme (or other educational and vocational programmes in Horizon 2020) with the clear purpose of broadening public engagement with science and technology and to involve experts in the dissemination and dialogue process.

[30] Simmie, J. (2003): Innovation and urban regions as national and international nodes for the transfer and sharing of knowledge. *Regional Studies*, 37 (6-7), pp. 607-620.

[31] In addition, Horizon 2020 rules should require Horizon 2020 projects to have a Work Package (WP) on communication of the scientific sector covered by the project (with *ad hoc* deliverables, such as citizens conference, communication tools and dissemination strategies – e.g. audio-visual – for lay people and information leaflets for lay people) and, if applicable, a WP on the societal, socio-cultural and ethical aspects of the topic being addressed. These work packages should be coordinated by professionals from the social sciences or communication research.

2. The Commission should invest in more and more inclusive **pan-European citizen participation** and involvement programmes aimed at advising the Commission (and or the European Parliament) on science and technology issues. A major topic should be the inclusion of evidence-based and precautionary decision making as important elements of dealing with opportunities and risks of new developments. Furthermore, the Commission should encourage meetings, conferences and symposia directed to bringing experts, civil society and policy-makers together. The Commission should establish a taskforce that collects all available education in science, technology and humanities material (publications, multi-media presentations, videos) that have proved to be successful and disseminate them among all EU member states in their native language. The Commission or the European Parliament should initiate a European wide competition for the best event "Science and Technology meet Society" with attractive prizes to win. The Commission should establish a teacher award for promoting excellent education in science, technology and humanities (PUSH). School teachers, at all levels, should be encouraged to submit short proposals (1 page max) for micro-grants (up to 5,000 Euros) to improve the way in which knowledge is acquired in their classes.
3. The Commission should establish a **European Radar System** for the early detection of risks and opportunities of new knowledge applications including a warning system for emerging social controversies and concerns of stakeholders and the general public (concern assessment). This should serve as an instrument for preparing policy makers and society to deal with potential side effects of new developments in science and technology, and to become aware of risk perceptions early in the process. The Commission should also facilitate the establishment of a **pan-European platform and forum on public concerns about science and technology**. This platform should operate like a broker. It should help people to find reliable and robust information and to arrive at a balanced and well-reflected judgment of their own (pro and con information that meets predefined quality criteria). The European Radar could be instrumental in providing this balanced information. One option to implement this platform would be to use EU structural funds to establish a public-private partnership or publicly-financed information communication system (EU science TV channel and EU science communication web portal).
4. The Commission should encourage all knowledge-producing actors to **devote a part (for example, 3 percent) of the total national research budget to Science and Society issues** when they pursue projects in research and innovation. This dedicated amount should be earmarked in particular for dialogue and communication programmes with stakeholders and the affected public. The Commission should encourage national and regional parliaments across Europe to conduct several open houses every year with sessions (e.g. Science-Cafés) where stories about successful and unsuccessful innovation processes are offered to the public in various presentation formats.

"To be responsive to public needs, we should be sensitive to gut feelings, but should not subordinate our policies to them"

Ortwin Renn*, Professor of Environmental Sociology and Technology Assessment at the University of Stuttgart and Member of the Science & Technology Advisory Council of the European Commission President (STAC) talks to Dr Jan Marco Müller, Assistant to the Chief Scientific Adviser to President Barroso, about the challenges and ways of enticing society into accepting new discoveries and technology.

How has the digital age changed the way society perceives innovation?

The digital age represents first and most prominently an accelerator of public opinion forming and worldwide dissemination, and, secondly, an engine that produces increased variety and heterogeneity. This leads to subjective impressions of disorientation and arbitrariness that go along with plurality and the inability of most people to prove truth claims by personal experience. As with many technological changes, the digital age has its merits and problems. Inadvertently, technology has a Janus face with a positive and a negative side.

What role does the young generation play when it comes to shaping societal behaviour?

The young generation is often a trendsetter for all of society. However, today we can observe both the effect of young trendsetters in most European nations, but also how the 1968 rebellious youth movement has kept its continuous influence on society over the last five decades. Therefore, this relationship is changing as the former students rebels reach the age of 65 or older and are now considered 'old' by the young generation.

Do you think that Europeans are more risk-averse than, say, Americans or Chinese?

In all countries that reach a high level of affluence, we observe that the lure of technological modernisation loses its magic power and attractiveness. This is true within Europe (partly a north-south divide) but even more pronounced worldwide. In addition, European societies face hardly any life-threatening natural disasters and enjoy a high level of personal security. Thus, technological risks have a much higher relative weight for being perceived as a threat than in many other countries in the world, including the USA and Japan.

There are significant differences between EU member states when it comes to the acceptance of certain technologies, e.g. the stance on nuclear energy in France and Germany. How can these differences be explained?

Interestingly enough, the risk perceptions between the Germans and the French are not that far apart when it comes to nuclear power or genetically modified organisms. The differences in policy responses and public outrage are partly due to a higher level of trust of French citizens in the technical elite (most citizens believe that the technical elite knows how to deal with the risks) and partly to the French political system, which is more centralised than in Germany and which therefore makes it harder for social protest groups to become national movements. If such national mobilisation develops (e.g., the French resistance against 'American' GMOs) it can become a very powerful political force.

Which role do cultural values and ethical/religious beliefs play?

From a global perspective, religious beliefs play a major role in shaping people's attitudes and values. Yet, in our more secularised societies (apart from the new immigrants) religious convictions are less powerful agents in shaping people's views on technology. Indirectly, they play a larger role as many secular values of today have religious origins. Often, social scientists refer to ethical or religious beliefs if they cannot find any other obvious reason. I would be careful when pursuing this line of interpretation. Even in public surveys, people like to cite ethical beliefs when they are asked about their motivation for resisting specific technologies. However, they are often unable to specify what these ethical beliefs are. I am rather convinced that many people have sceptical feelings and emotions about many technologies which they cannot put into words. Then they refer to ethics as a good placeholder for their feeling of discomfort.

Public acceptance (e.g. of new wind turbines or high voltage lines) seems to be a major obstacle of the German "Energiewende". Why is this the case?

Many people are not convinced that these new energy infrastructures are necessary to replace

* Ortwin Renn's biography is available in Annex I, p. 28.

nuclear energy. They do not see any personal benefits. They feel that their own agency is negatively affected and they cannot identify with 'cold' technologies such as big wind turbines and large power lines. So all four conditions for positive acceptance may be violated. One successful way to meet these acceptance problems is to offer joint ownership to residents. If the wind park is owned by the neighbours, personal agency is enhanced and incentives for identifying with this technology are given. Many co-owned wind parks in Germany have not experienced any major citizen protest.

Why is it that people run for the newest smartphone, but are worried when a gsm antenna is set up in their neighbourhood?

The acceptance of technology differs according to the kind of technology we are dealing with. We distinguish three types of technology: consumer technology; technology at work; and technology in the environment. Most consumer technologies are well liked by consumers (otherwise they would not be sold). We have no resistance movement against vacuum cleaners or iPads. Technology at work denotes the devices we use when performing our work such as production machines or computers in the office. In history, we had many protests movements against automation reforms in manufacturing (for example, weaving machines in the 19th century).

In the course of globalisation most Europeans are convinced that the most modern technology in the workplace is the best guarantee for economic prosperity and employment. There is hardly any major protests against modernisation at work nowadays. Rather we witness major protests against technology in such environments as traffic infrastructure (airports), energy facilities (e.g., nuclear power plants, chemical factories, etc.) The common characteristic of these technologies is the asymmetry between those who can benefit (often everyone) and those who have to bear the risks (the neighbours). This is often perceived as unjust and motivates part of the protest. Coming back to the question: mobile phones belong to the category of consumer technologies. Antennas, however, belong to the category of "technology in the environment". This explains most of the different responses of public groups and individuals.

How can we ensure that the public debate on new technologies is based more on scientific facts and evidence rather than gut feelings?

To be responsive to public needs we should be sensitive to gut feelings but should not subordinate our policies to them. Gut feelings are, as cognitive psychologist Gert Gigerenzer was able to show in his research, good indicators for a subjective impression that something is not quite right with what is going on. They could serve as early indicators of unease with a development. However, once such an issue is identified, it is the task of analysis and practitioners to find out what the risks are and how we can manage them properly. This can be done in cooperation with stakeholder groups and representatives of the affected public so that a mutual learning process can take place. In the end, we need a scientifically robust and socially compatible solution to deal with these problems.

What do you expect from scientists in this context? And what from politicians?

Scientists need to be involved as knowledge providers. They can, better than anyone else, determine which truth claim is nonsense, possible, likely or certain. They may err but they are better prepared than anybody else to be independent and impartial judges on what is factually true and what is not. What is important, however, is the clear mandate to spell out the remaining uncertainties and ambiguities that go along with almost all risk assessments. However, factual grounding is not enough to make a prudent decision. We also need to know what is desirable. Which option and subsequent impacts do we prefer? This selection is truly value-laden and political. No scientist can answer this question with any claim of legitimacy. This is the domain of political process in which elected officials, executive agencies and affected stakeholders, as well as the public(s) have the mandate to chose the option that is in line with what society as a whole desires to pursue as a future vision. Coming to consensus here is not easy in a pluralist society, but we are constantly reforming our governance system to cope with this challenge.

What about the media: are they part of the problem or part of the solution?

The answer is both. The media rarely invent new topics or shape the political agenda. They often act as agenda setters (what the media report is what the public discourse will reflect) and they amplify and select topics produced by societal agents. In addition, the selection rules influence the way that reality is conveyed to the audiences. Conflicts are normally emphasised, blame is often assigned to real or alleged villains, sensations are preferred as news stories, while success stories are rarely reported – to name a few. This, of course, shapes our view of the reality and may lead to a misperception of the risks and benefits of technologies.

What can the EU do to create an innovation-friendly societal environment in Europe? What role can the European Commission's Chief Scientific Adviser play?

The most obvious answer is good performance. If people have the feeling that industry is trying to play a responsible part in managing risks and public authorities are able to demonstrate prudent oversight and regulatory power, the public will have trust in the process. At this point, many surveys show that people associate industry with greed (in particular after the financial crisis) and they believe that public authority, although it has good will, is incompetent to be ahead of the regulatory game.

To overcome this impression we need to bring science, the private sector, the public sector and civil society together and construct an inclusive governance process in which each of the four actors bring to the table what they are best at: science can provide factual evidence about the effectiveness of policies; the private sector can contribute efficiency; the public sector common good orientation, in particular resilience; and civil society the plurality of values, in particular fairness. If these actors join forces, I could see that the public image of technological and social change may become better over time. As long as policy-making is rather fragmented and adversarial I see that trust is permanently destroyed. It is important to maintain a watchdog function over public policies but for complex and uncertain problems, we need the input of all actors in order to be successful and, at the same time, convincing in the eyes of the public.

The Chief Scientific Adviser can be a catalyst in this endeavour. She or he can ensure that the best scientific expertise is inserted in the policy process and that the other actors are also given their due input into the process.

Many people have 'fallen out of love' with the EU today. What would be your recommendations to build trust in – and enthusiasm for – the EU again?

What I said about acceptance of technological changes is also true for political institutions. We need convincing arguments, clear benefits, proof that people gain agency and do not lose it, and have opportunities for personal identification. Evidence of good performance is just as important as a critical review of subsidiarity and encouragement of cultural variety. One of my personal surprises arose when our team evaluated the few pan-European citizen participation projects. In addition to the outcomes of the process and the recommendations, more than 70 percent of the citizens involved stated that they felt transformed into truly European citizens through this process of participation. This was not the purpose of the exercise but rather a side effect. Yet, this side effect demonstrates the need for direct citizen input into the European policy arena. If the distance is too large, people are likely to feel alienated.

Europe was home to the Renaissance, the Enlightenment and the Industrial Revolution. What next?

We should be careful in our quest to move Europe forward. We would not be well-advised if we try to demonstrate Europe's superiority in the world. Modesty is a much better companion to success than self-indulgence. Given the financial problems and the still unsustainable practices, Europe is not the ideal role model for the rest of the world. Yet, we have some experiences that we can proclaim as key to success and prosperity: to appreciate the richness of cultural diversity as an asset rather than as a barrier; to focus on a broad education in science and humanities; to be sensitive to inequities and unjust living conditions; and to emphasise the importance of respect for social, racial, cultural, gender and sexual diversity. Most importantly, I would advocate the ideal of inclusive democratic and pluralistic governance as the main value that we can export to the rest of the world.

Citizens for the 21st century

*By Ana Costa Freitas**

Delivering our aspirations for the 21st century fundamentally depends on having a strong, imaginative and fit-for-purpose educational system. It is what is most important to provide for every citizen and it is key to supporting democracy, competitiveness and social well-being.

Education and democracy are highly correlated: democracy can only be really effective if designed 'with' and 'for' an 'educated' population. As the level of education increases, so too will civic participation and this will eventually increase support for more democratic forms of government[1] and reduce the appeal of anti-democratic forces. Moreover, when education is extended, citizens become more engaged with societal changes: they become more demanding but much more constructive in their objectives and their aims or suggestions.

The ability of a country to compete as a nation, or of Europe to compete as a Union, demands the constant input of creative and innovative minds which are most often the product of a high quality education.

Our modern economies are mainly driven by innovation and knowledge, which results in intensive competition, and this approach is what will ensure that we are able to tackle the complex challenges ahead of us (technological, environmental, scientific, political and industrial/business or even in the financial/banking sector). Addressing these difficulties is what will make us achieve a smart sustainable and inclusive growth. But, growth and competitiveness need a truly engaged society, which means citizens have to be fully involved with the proposals and decisions being made.

We now live in a globalised world with few frontiers and it is unlikely this will change. This in itself makes new demands on our educational needs. For our citizens to engage and compete in this environment, our educational system also needs to accommodate cultural and language diversity.

Therefore, education is a fundamental platform for success in our modern world, and there is a clear obligation for countries to give to their children, and anyone who needs continuous learning, the competences and skills to be economically independent and able to have a self-fulfilled life. Such results can only be achieved if countries/governments believe that every citizen deserves access to a high quality education system. Only with educated citizens will we be able to achieve true European unity and success.

Educating for the 21st century

Cultural and economic diversity means that the challenge to deliver a 21st century education system is not the same across different cultures and countries. The changes from an industrial world to a digitally driven world in the so-called developed countries, are good examples that the skills needed (the right education) are changing dramatically. It is the role of governments to be aware of this and to be able not only to deliver education, but the most appropriate education and skills needed, even in a very fast changing world. The penalty for not addressing this as a priority is reducing the opportunities for young people and becoming uncompetitive as a nation.

Education budgets are usually limited, and might also, in some cases, be reduced in response to the economic crisis. This is surely a mistake as the ability to be resilient and recover from economic downturns depends on a flexible, imaginative and well-educated workforce.

The evidence[2,3] demonstrates that investing in education, even during a crisis, always gives a good return. In spite of the evidence, it does not seem an easy option for politicians and this may be because the return on this investment is only realised in the long term. It is clear that investment is always important but the question to ask is "where does it make sense to invest most in education"?

Generally speaking, investing in early education has the highest returns, though this is deeply influenced by the 'educational' system of a country.[4,5] It is safe to say that a key prerequisite is 'quality'. The difficulty

* Ana Costa Freitas is an Adviser in the Chief Scientific Adviser's team.

[1] Young, E. (2011): The impacts of educational attainment, professional interests, and residency on community involvement. *Colonial Academic Alliance Undergraduate Research Journal*, vol. 2, Article 4.

[2] World Bank (2008): Economic returns to investment in education. *The Mena Development Report: The Road not Traveled. Education Reform in the Middle East and North Africa*. Washington, DC.

[3] Bhatt, P., Bulloch, G., Winthrop, R. and Wood, A. (2013): *Investment in global education: A strategic imperative for business*. Center for Universal Education at the Brookings Institution: Washington, DC.

[4] Education, Audiovisual and Culture Executive Agency (2009): *Tackling social and cultural inequalities through early childhood education, Brussels.*

[5] Menne, S., Stein, A. (2012): *Effective investment in education*. Background paper, Global Economic Symposium 2012, Rio de Janeiro.

perhaps comes in defining what 'quality' is and also the appreciation that the nature of education is not fixed but should respond to the world and conditions around us. Good education has to deliver the right tools at the right moment and this means constant adaptation of the skills and competencies needed in this globalised world. This places great demands on our teachers as they must be constantly aware of the need to adapt teaching and learning to rapidly changing conditions. It also places a demand on citizens as education for the 21st century should be regarded as a lifelong journey. Lifelong learning (LLL) and vocational education and training (VET) programmes will help minimise unemployment and prepare our citizens for a more fulfilling and active life, including healthy ageing. They will also raise awareness of the fact that lifestyle and behaviour are responsible not only for numerous diseases, but also for most of our planet's 'diseases' (e.g. climate change). Better education can only improve this situation.

A high-quality education

We need to define what we mean by quality education and to accept that the quality and level of education are a prerequisite for contributing to society and living a self-fulfilled life with economic independence. Quality education has to be tailored to enable citizens to meet the challenges of an ever-changing world; these changes can be technological, economic and cultural.

In terms of technology, the world is changing quickly and the future is difficult to predict, so preparation to meet this unpredictable challenge is quite demanding. Economically speaking, the markets seem to be ruling our lives and the present crisis was not predicted. Given the other global constraints of finite resources, avoiding catastrophic climate change and sustaining an increasingly global population, the need for a new economic model is urgent. In terms of culture, borders are almost gone, and racial, ethnic, cultural, linguistic and religious diversity in nations are a fact that challenges the concept of citizenship. Before we can speak of a true European identity, one should embrace each and every cultural identity.

Updating curricula

The first step in delivering education for the 21st century is to address the curriculum so that it meets the demands of our ever-changing societies. Education institutions need wider involvement of various stakeholders in curricula design, of both pre- and post-university education. The knowledge gained by students must include cross-cutting skills which need to be constantly adapted to fulfil the demands of 21st century life.

We will continue to rely on innovation to react positively to addressing challenges. The provision of a basic platform of education in science, technology, engineering and mathematics (STEM) will become ever more necessary to prepare citizens to contribute for the positive changes we need, but also be able to benefit from them at all levels. Citizens who embrace innovation and are comfortable with the opportunities and risks that it presents will be more confident in thinking critically about the world and will feel more confident in being involved in the decision-making processes. Greater inclusion and transparency around the adoption of new technologies will contribute to raising competitiveness. Literacy in these fields is essential for understanding the world of today and of tomorrow and is required for the preparation of successful global citizens.

Curricula will need constant adaptation to accommodate changes and prepare citizens for life, not only to find a job but also to create jobs and truly engage in society. Who is best placed to deliver these challenging curricula?

Teachers' education

Our teachers are uniquely placed at the interface between our changing society and the demands of a fit-for-purpose education. Teachers' training must in turn include the tools to prepare them for the demands of a complex, diverse, and changing society.

Teachers have to respond both to the world their pupils are living in and to prepare them for the challenges that they will have as global citizens. These include:

- coping with diversity in schools as well as society;
- understanding that the access that students have to information is massive, that information travels very fast and that teaching methods must respond to this;
- awareness that an exchange of opinions is constant and global (social networks) and needs to be integrated into the teaching process;
- bearing in mind that science and technology produce new ideas constantly and whilst teaching basic principles will always be necessary, an appreciation of the relevance and impacts of this sea of knowledge must be addressed;
- considering that a 'job for life' is no longer an option; the job market (and demands for skills) is changing faster and faster;
- addressing the need for the development of critical thinking which is fundamental for the citizen's ability to influence future society and make the 'right' choices, as well as for the ability to find the right information in an even more 'information-flooded' society;

This is no small task. The teacher's role is to prepare his/her students to be able to 'survive' in a world that might tomorrow be totally different from today. It is about supplying fundamental knowledge as well as resilience to change and the ability to exercise critical thinking. All this must be done against the background of a highly connected world where the young are particularly adept at seeking and sharing knowledge independently. This should alert us to the fact that how young people satisfy their intellectual curiosity has changed fundamentally over the last decade. The teaching profession should adopt methods that are compatible with the information and computer technology (ICT) world we live in.

Therefore, the development of new ICT-based teaching materials, that is carefully peer-reviewed, needs to be considered, developed and spread. This is a considerable demand but it is also a great opportunity: investment in new ICT-based teaching methods can be shared, and thus avoid duplication and take into account the increasing potential diversity in resources.

School infrastructures

Besides the quality of education and teachers, schools need to be accountable for their students' achievement. High exclusion rates, increased dropout rates, and increased performance gaps are linked to a failure of accountability and investment.

School and educational achievements will very likely be affected by the starting conditions. If we compare a school in a privileged neighbourhood with a school that has a socio-economically disadvantaged and multi-ethnic student body, we might expect achievements to be different.[6] In addition, comparing schools in Europe is no longer only about books, teachers, buildings and 'common infrastructures', but it is also about easy and quick access to the internet and all the opportunities it can deliver.

Although the World Wide Web (www), developed by Berners-Lee between March 1989 and December 1990, initially aimed to ease the communication and data between CERN researchers, its adoption and implementation worldwide created a fundamental change in our world.

At the turn of the century, the dot.com boom occurred (1999-2001). Everything has been different since then: our citizens (and governments and businesses) demand updated information 'every second' and our capacity to collect information has also grown considerably. As the young generation is growing up knowing only this reality, we need to ensure that this is absorbed into our teaching methodology. It implies that:

- all young people have equal access to information with a 'click';
- teachers are prepared to teach in this way and to educate students to be discriminating;
- schools provide the proper equipment to support this challenge;

In the short term, this is the gap we need to close and these are the skills we need to develop for the next (and current) generation, and these are some of the infrastructures that we need to provide. For competitiveness, this is not an option, it is a necessity.

Jobs vs. education

As stated before, a high quality education is a prerequisite for a self-fulfilled life with economic independence, for the provision of the tools to contribute to tackling the challenges of being a global citizen, as well as underpinning the basic needs of a democratic society.

In all OECD countries, a higher educational qualification correlates with greater chance of finding a job, reduced risk of being unemployed, and higher wages[7]. A person with tertiary education earns over 50 percent more than someone with an upper secondary or postsecondary degree. Not having completed at least upper secondary education will result on average, in someone earning 23 percent less than those who have completed that level of education[8].

Across the OECD, 84 percent of the population with a tertiary degree is employed compared to only 57 percent of those without an upper secondary education.

Unemployment rates decrease as educational attainment increases. The evidence should cause politicians to stop and consider that investment in education will enhance competitiveness and societal satisfaction, as it means that: citizens have the potential to gain better jobs, more self-respect, become more engaged with society, and potentially benefit from reduced social costs due to healthier lifestyles as well as reduced criminality due to reduced social exclusion.

Tomorrow's job markets

At the present time, the European economic crisis is all-consuming and unemployment in Europe is becoming a nightmare especially for young people.

[6] Dyson, A., Gunter, H., Hall, D., Jones, L., Kalambouka, A. and Raffo, C. (2007): *Education and poverty. A critical review of theory, policy and practice*. Joseph Rowntree Foundation: York.

[7] Organisation for Economic Co-operation and Development (2011): *Education at a glance 2011: OECD indicators*, OECD Publishing.

[8] OECD (2011)*: op. cit.*

The natural response to a changing world is innovation, but this does not impact immediately on the labour market. In fact, some industries and career paths are disappearing, while new ones are being created.

It is, however, reasonable to assume that the economic crisis is responsible for part of the unemployment rate, but the 'under preparation' of our young generation to the new job market, in which new and different skills are required, is also part of the problem. This is evidenced by the observation in many European countries that although there is substantial unemployment, there are also many jobs available (and more projected in the future) which are not filled due to skills shortage.[9] There is both a challenge and an opportunity here for our governments and politicians. If no attention and investment is given to changing the education paradigm when the economic crisis is over, we will not have citizens prepared to drive innovation in our countries and develop our societies.

Education in Europe

There is a need to rethink education.[10] The European Commission is aware of the fact that ICT is changing our lives and training skills need to be adapted. Innovation must be a priority.

The European Council endorsed the Growth Strategy,[11] an agenda which aims to assist Europe to overcome the current crisis and come out of it stronger. The targets Europe has drawn are quite demanding and education is at the core of this agenda. From the education side, by 2020 Europe should reduce the rate of early school leaving to 10 percent and should support at least 40-50 percent of citizens by the age of 30-34 years old to complete tertiary education.[12]

The Commission backed this by proposing an ambitious strategy in which the education budget was enhanced, and by proposing a highly innovative programme: Erasmus+.

Commissioner Vassiliou has said: "Investing in education, training and research is the best investment we can make for Europe's future. Each year, the EU's Lifelong Learning Programme (Erasmus, Leonardo Da Vinci, Comenius, and Grundtvig) and the Marie Curie Actions enable more than 400,000 people to study, work, volunteer or do research abroad. This experience enhances their skills, personal development and job prospects – and it can also contribute to overcoming the crisis."[13]

The Commission has launched a new initiative which aims to open up education to the digital world, to prepare for the new era and the new digital jobs which will become available.[14] There is also an opportunity for education institutions to join forces to ensure that internationalisation[15] will be a priority. There is a need to assume educational networks at all educational levels, including VET and LLL. The expectation and demand for mobility[16] can no longer be an option, but a prerequisite, either for workers or for students.

This is clearly within the new framework programme Erasmus+ which will continue to contribute to enhancing intercultural dialogue by reinforcing the mobility of young people and workers. These mobility programmes have been, over the years, a valuable tool to make European citizens aware of the differences among member states and, due to this awareness, make citizens understand better the European Union motto "united in diversity" which is in fact what makes the European project unique.

Europe's richness lies in its citizens: people are the value of a country. Europe's citizens have made Europe a very special place to live in. In Europe we have by far the highest standards in terms of social rights, workers' rights, elder people's rights. Europeans have become used to being 'taken care of'. The European Union has an obligation to its citizens to continue to provide an increasingly enlightened environment in which to live by underpinning our economies with smart resilient people delivering innovation and opportunity.

[9] Kroes, N. (2013): *Europe urgently needs the right jobs and skills. My mission in Davos*, published on her blog on 23 January 2013.

[10] European Commission (2012): *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Rethinking education: investing in skills for better socio-economic outcomes.* COM(2012)669 final of 20 November 2012.

[11] European Commission (2010): *Communication from the Commission - EUROPE 2020 A strategy for smart, sustainable and inclusive growth*, COM(2010)2020 final of 3 March 2010.

[12] European Commission (2010): *op. cit.*

[13] Accessed on Commissioner Vassiliou's website on 25/10/2013 - http://ec.europa.eu/commission_2010-2014/vassiliou/

[14] European Commission (2012): *op. cit.*

[15] European Commission (2013): *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European higher education in the world*, COM(2013)499 final of 11 July 2013.

[16] Main policy initiatives and outputs in education and training ("ET 2020") - http://ec.europa.eu/education/lifelong-learning-policy/policy-framework_en.htm (accessed on 25/10/2013)

Innovation in Europe

Innovation[17], therefore, is key to maintaining Europe's competitiveness in the global market, for creating satisfying and rewarding jobs and improving our quality of life.

European policies aim at encouraging innovation by providing incentives to stimulate and improve this economic driver. The new Framework Programme Horizon 2020[18] is the Commission's proposal to enhance competitiveness and innovation. It aims to respond to the economic crisis investing in future jobs and growth, alongside education proposals, but it also addresses citizens' concerns about their livelihoods, safety and environment thus strengthening Europe's global position in research innovation and technology.

These are concrete means to achieve a "smart sustainable and inclusive growth" where growth can only be considered a value if sustainability and inclusiveness are considered. The acceptance of innovation, however, is not always straightforward: citizens tend to reject innovation when they do not understand it or they do not see immediate benefits for themselves.[19] This is why Horizon 2020 needs a strong focus on coupling research and innovation with the biggest societal challenges. Citizens will embrace innovation and accept it much more easily if care is taken to understand their needs and their concerns.

All this can only be achieved if our citizens are simultaneously being prepared for the changes and challenges of the 21st century and are in a position to understand the value of the opportunities delivered by science, engineering and technology. This is what can ensure that Europe continues to be at the forefront of innovation and development, education is central.

Creating Jobs

Europe is the sum of our citizens including our young people whose talents, energy and creativity are the future of Europe. Yet, they have been hit particularly hard by this crisis and currently 6 million young people (under the age of 25) are unemployed, while a total of 7.5 million are not in employment, education or training. Youth unemployment rates in Europe stood at 23.5 percent in the first quarter of 2013, more than twice the already very high rate for the population at large[20]. This situation is neither acceptable nor sustainable if Europe is to have a healthy future.

This Europe of high youth unemployment is not the Europe we dream of, nor the one our citizens deserve. Just rethinking education or boosting innovation will not solve this problem. Long-term structural reforms are required, but the situation also needs urgent and short-term solutions. To tackle this problem, the Commission has proposed some practical and achievable measures that will hopefully make an immediate impact on youth unemployment, namely the Youth Employment Package and the Youth Employment Initiative.[21] Europe must take care of its citizens preparing them to face whatever future lies ahead.

Citizens for tomorrow

It is important that citizens become aware of the beauty of creating and disseminating knowledge (and art) through research. To understand this beauty it is important that young people develop an enquiring mind-set, a 'need' to understand life, developments, technology, engineering and the value of living in an environment that is concerned with sustainability and inclusion.

Europe 2020 aims for a "smart sustainable and inclusive growth". It is important that citizens are aware that we have to grow and increase our competitiveness bearing in mind that:

- we must adjust to sustaining an increasing population on a finite planet;
- we must ensure that we live to protect our planet for the future generations;
- we have a responsibility as global citizens to work towards equal access to resources;
- Europe has a responsibility in global leadership;
- Europe is not a perfect society; it can improve, but no society can change without citizen involvement;

… and education is central to all of this.

[15] UNU-MERIT / European Commission (2013): *Innovation Union Scoreboard 2013*. European Union: Brussels.

[16] European Commission (2011): *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Horizon 2020 - The Framework Programme for Research and Innovation*, COM(2011)808 final of 30 November 2011.

[17] Science and Technology Advisory Council (2013): "Science for an informed, sustainable and inclusive knowledge society". Policy paper for President Barroso, 19 August 2013.

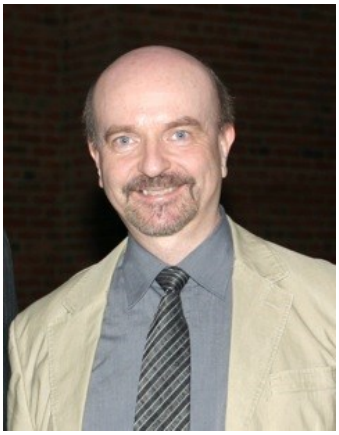
[18] *Unemployment rate by age group* - http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdec460 (accessed on 25/10/2013).

[19] European Commission (2013): *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Working together for Europe's young people*, COM(2013) 447 final of 19 June 2013.

ANNEX 1: Biographies of the members of the Science and Technology Advisory Council

Alan ATKISSON (SE)
Alan AtKisson is the President and CEO of "AtKisson Group". He has been working at the forefront of sustainability initiatives since 1988, advising large companies, governments, cities, foundations, NGOs, and the United Nations. AtKisson has specialised experience in the areas of sustainability indicators and reporting, climate change strategy, renewable energy finance, green economic transformation, and large process facilitation. AtKisson also coaches sustainability executives on how to sharpen their knowledge, capacity, and effectiveness at leading change. AtKisson draws on over twenty years of leadership experience in sustainable development, including chief executive roles in organisations such as Sustainable Seattle (which he co-founded and co-led, 1990-1995) and the International Network of Resource Information Centers (also known as the Balaton Group, in which he served as President, 2006-2012). He was Director of the National Indicators Programme (and later Interim Executive Director) at Redefining Progress, a US economic policy think-tank; and transitional Executive Director of Earth Charter International, the coordinating hub for the global Earth Charter Initiative. Alan is the author of two highly regarded books on sustainability theory and practice. *Believing Cassandra: An Optimist Looks at a Pessimist's World* (1999, updated and reissued in 2010) explains the origins of the modern sustainability movement. AtKisson's latest book is *The Sustainability Transformation* (Earthscan, 2010), an empowering and inspirational look at doing sustainability in practice today.
http://www.atkisson.com/wwa_bio.php

Ferdinando BECCALLI-FALCO (IT)
Ferdinando "Nani" Beccalli-Falco is President and Chief Executive Officer (CEO) of GE Europe and CEO GE Germany. He is a Senior Vice President of GE and a member of the Corporate Executive Council of the Company. In his current role, Beccalli-Falco is responsible for maximising growth opportunities and process optimisation to drive profitability across all business in Europe, Russia and the CIS. He works across GE's businesses to help identify and develop new market opportunities as well as to increase the existing customer base and build strategic relationships. Beccalli-Falco is also responsible for the leadership of GE in Germany where he heads the creation and operation of a "One GE" country business. Strengthening GE's operations in Germany is key to accelerating growth in Europe, which currently represents 40 percent of GE's international revenues. He is based in Frankfurt, Germany. He has enjoyed a long career at GE, starting in 1975 in the United States. Most recently, Beccalli-Falco served as President & CEO GE International where he successfully built GE's global team over nine years. Prior to that, he held leadership positions in GE Capital and GE Plastics in the United States, the Netherlands and Japan. In February 2012, he was appointed to the board of INTER RAO the Russian energy company. He is also a board member of the Emmanuel Center Stiftung, Germany, the GE Foundation, and the Junior Achievement Young Enterprise. He is a Member of the Trilateral Commission and is on the Board of Directors for the Centre for European Policy Studies (CEPS). He also serves as an International Advisor to Bocconi University in Milan. Previously, he was an International Advisor to Prime Minister Raffarin of France from 1994-1995, and was International Advisor to the Polish Minister of Finance in 1995. In 2007, the President of Italy, Giorgio Napolitano, appointed Beccalli-Falco "Cavaliere del Lavoro." In 2009, the President of France, Nicolas Sarkozy, awarded Beccalli-Falco La Légion d'Honneur. A native of Italy, Beccalli-Falco earned a Master's degree in chemical engineering from the Polytechnic of Torino in Italy.
http://www.ge.com/company/leadership/bios_exec/ferdinando_beccalli-falco.html

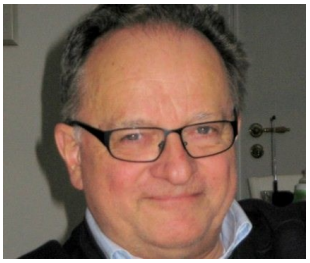


Victor DE LORENZO (ES)
Víctor de Lorenzo is a Spanish Chemist and Microbiologist. He works as Professor of Research at the National Centre of Biotechnology in Madrid, where he is employed since 1996 after running a large number of projects at the Pasteur Institut (Paris), the University of California (Berkeley), the University of Geneva, and the Federal Center of Biotechnology (Braunschweig). His research exploits advanced molecular biology and genetic engineering of microorganisms for the sake of biomonitoring, bioremediation – and wherever possible valorisation of chemical pollution in the environment. He is a Member of the European Molecular Biology Organisation (EMBO), the American Academy of Microbiology (AAM) and the European Academy of Microbiology (EAM). He has served in the OECD *ad hoc* Committee of Governmental Experts in Biotechnology for a Clean Environment and as a National Delegate and core group member of the Standing Committee for Life and Environmental Sciences of the European Science Foundation (ESF). During the period 2002-2004 he chaired *The European Group on Life Sciences* (EGLS). This group was established by the Research Commissioner Philippe Busquin to meet *inter alia* the need for an informed debate with the various stakeholders interested in the beneficial application and dissemination of modern research in biology. De Lorenzo's more recent activities at the interface between synthetic biology and environmental biotechnology have merited the 2008 GSK Award of the American Society of Microbiology (ASM) and the Grand Prix de L'Académie des Sciences de L'Institut Français du Pétrole (2008).
http://www.cnb.csic.es/~meml

Tamás F. FREUND (HG)
Tamás F. Freund is a Professor and Director of the Institute of Experimental Medicine, Hungarian Academy of Sciences, Budapest, and Chairman of the Neuroscience Department of the Péter Pázmány Catholic University in Budapest. He was President of the Federation of European Neuroscience Societies (FENS) from 2004 to 2006, and served as Member of the Executive Committee of IBRO between 1998-2003, and as Chairman of the IBRO Central and Eastern Europe Regional Committee (1999-2003). He is a Member of the Hungarian Academy of Sciences (1998), the Academia Europaea (London, 2000), the German Academy of Sciences Leopoldina (2001), the Academia Scientiarum et Artium Europaea (2001), and the recipient of numerous prizes and awards of which The Brain Prize (2011, Denmark) is considered the most prestigious. His main scientific interest is the synaptic and molecular organisation, functional architecture and physiology of neuronal circuits in the cerebral cortex and related structures, the network basis of behaviour-dependent neuronal activity patterns, the changes in neuronal connectivity/chemical architecture underlying epileptic and ischemic brain damage, the mechanisms of anxiety and endocannabinoid signaling in relation to addiction.
http://www.koki.hu/main.php?folderID=832&langchanged=1

Susan M. GASSER (CH)
Susan Gasser holds a PhD in biochemistry and was named Professor for Molecular Biology at the University of Geneva in 2001. In 2004, she moved to Basel as the Director of the Friedrich Miescher Institute for Biomedical Research, which is funded by the Novartis Research Foundation, and became Professor of Molecular Biology at the University of Basel. She is one of Switzerland's most outstanding scientists, and has received numerous awards for her achievements in genetics. She is a Member of various National Science Academies, including those of Germany and France, was Chairman of the EMBO Council, and was awarded the EMBO Women in Science award in 2012. She has been engaged in various European capacities, including membership on the advisory panel the European Commission on health research and as Chair of the panel for ERC Starting Grants.
http://www.fmi.ch/research/groupleader/biography/?group=42

Anne GLOVER (UK)
Professor Anne Glover joined the European Commission as Chief Scientific Adviser to the President in January 2012, and is the first person to hold this position. In this role she advises the President on any aspect of science and technology, liaises with other science advisory bodies of the Commission, the member states and beyond, coordinates science and technology foresight, and promotes the European culture of science to a wide audience, conveying the excitement and relevance of science to non-scientists. She also chairs the recently established Science & Technology Advisory Council of the President. Prior to her current appointment, she was Chief Scientific Adviser for Scotland from 2006-2011. Professor Glover currently holds a Personal Chair of Molecular and Cell Biology at the University of Aberdeen. Most of her academic career has been spent at the University of Aberdeen where she has a research group pursuing a variety of areas from microbial diversity to the development and application of whole cell biosensors (biological sensors) for environmental monitoring and investigating how organisms respond to stress at a cellular level. Professor Glover holds several honorary doctoral degrees and is an elected Fellow of the Royal Society of Edinburgh, the Society of Biology, the Royal Society of Arts and the American Academy of Microbiology. Professor Glover was recognised in March 2008 as a Woman of Outstanding Achievement in the UK and was awarded a CBE for services to environmental science in the Queen's New Years Honours list 2009.



Søren MOLIN (DK)
Søren Molin has more than 40 years of microbiology research experience with over 260 publications. He is a member of the Royal Danish Academy of Sciences as well as the Danish Academy of Natural Sciences. In the 1990s, he undertook pioneering research in biofilm activity and developed molecular tools and image analysis for studies of bacterial biofilm development. These activities are still the foundation for on-going science comprising also cell-cell interactions and evolutionary processes. He is a Professor of Biosustainability at the Danish Technical University Copenhagen and Director of the Novo Nordisk Centre for Biosustainability.
http://www.csm.bio.dtu.dk/Scientists/Spercentc3percentb8renpercent20Molin.aspx

Joanna PINIŃSKA (PL)
Joanna Pinińska is a geologist and a Full Professor at the Warsaw University. She graduated from the Academy of Mines and Metallurgy, in Cracow, with the MSc and Engineer diploma in applied and mining geology. She obtained a PhD and DSc degrees at the Warsaw University where, later on, she served two terms as a Dean of the Faculty of Geology. She specialises in engineering and economic geology focusing on rock properties under high pressure and temperature. As a Head of Department of Geomechanics, she has created a high-tech, unique Laboratory of Rock Mechanics dedicated to research of rock properties at great depths, aiming at solving theoretical and practice problems. She was a co-organiser and CEO of the Inter-Faculty Studies on environment protection. For two terms she was a Member of the State Committee for Scientific Research; remains a long-time Member of the Commission for Geological-Engineering Documentations at the Ministry of the Environment; and belongs to the expert group on the Strategic Programme "Improving Work Safety in Mines" at the National Center for Research and Development. She examines the impact of fracking on rock behavior, safety of extraction of shale hydrocarbons and, rock stability changes under modeled complex conditions. She has advised the European Commission for many years as a Member of the so-called 'Helsinki Expert Group' preparing country reports on Women in Science. Lately, she led a team of specialists, which made a comprehensive regional study on the geomechanical properties of rocks in Poland, which resulted in a twelve-volume monograph report with an integrated GIS data base. She also holds an honorary degree of the General Director of Mining.
http://www.geo.uw.edu.pl/IHIGI/ang/instytut/inst_staff_jp.html

Alexandre Tiedtke QUINTANILHA (PT)
Alexandre Tiedtke Quintanilha (1945, Maputo, Mozambique) read physics and mathematics at Witwatersrand University in Johannesburg, completing his PhD in Theoretical Physics in 1972. He spent the next two decades in California at UC Berkeley and the Lawrence Berkeley National Laboratory as Professor of cell physiology and Director of a Center for Environmental Studies. At Berkeley he was on the search committee for the selection of the first director of the Human Genome Centre and on the Life Sciences advisory team for the design of Advanced Light Source. He then moved to the University of Porto in Portugal to become Professor of biophysics at the Biomedical Faculty and, until 2010, Director of both the Institute of Molecular and Cell Biology and the Institute of Biomedical Engineering. He now chairs the committee responsible for implementing a newly formed consortium of the three major biomedical research institutions in Porto. He is a Member of the Academia Europæa, the World Academy of Arts and Science, and the European Academy of Sciences Arts and Literature, and is on the Council for Research and Exploration of the National Geographic Society (USA). Over the years he has chaired various committees at the European Science Foundation (ESF), the European Commission (Chair of Advisory Committee for Marie Curie Actions, Chair of ELSA and Member of EURAB), the Organisation for Economic Cooperation and Development (OECD) and other national and international research organisations. He currently chairs the Council of Associate Laboratories (CLA) of the Ministry of Science, is President of the Ethics Committee for Clinical Research in Portugal, and is a Member of the National Council for Science and Technology (chaired by the Prime Minister). He has published well over one hundred and twenty peer-reviewed scientific articles and six books and has always been involved in science policy. His current interests are in the areas of biological stress, risk perception and public understanding of science.
http://en.wikipedia.org/wiki/Alexandre_Quintanilha

Ortwin RENN (DE)
Ortwin Renn serves as Full Professor and Chair of Environmental Sociology and Technology Assessment at the University of Stuttgart (Germany). He directs the Stuttgart Research Center for Interdisciplinary Risk and Innovation Studies at the University of Stuttgart (ZIRIUS) and the non-profit company DIALOGIK, a research institute for the investigation of communication and participation processes in environmental policy making. Professor Renn also serves as Adjunct Professor for Integrated Risk Analysis at Stavanger University (Norway) and as Affiliate Professor for Risk Governance at Beijing Normal University. Renn holds a doctoral degree in social psychology from the University of Cologne. His career included teaching and research positions at the Juelich Nuclear Research Center, Clark University (Worcester, USA), the Swiss Institute of Technology (Zuerich) and the Center of Technology Assessment (Stuttgart). Among others, he is a Member of the Scientific and Technical Council of the International Risk Governance Council (IRGC) in Lausanne, the National Academy of Disaster Reduction and Emergency Management of the People's Republic of China, and the Risk Communication Advisory Committee of the European Food Safety Authority in Parma (Italy). In the past he served on the panel on Public Participation in Environmental Assessment and Decision-Making of the US National Academy of Sciences in Washington, DC (2005-2007) and on the German Federal Government's 'Commission on Energy Ethics' (2011). He is a Member of the Senate of the Berlin-Brandenburg Academy of Sciences (Berlin) and of the Board of Directors of the German National Academy of Technology and Engineering (Acatech). In 2012, he was elected President of the Society for Risk Analysis (SRA). His honours include an honorary doctorate from the Swiss Institute of Technology (ETH Zurich), an honorary affiliate professorship at the Technical University Munich, the 'Distinguished Achievement Award' of the Society for Risk Analysis (SRA) and several best publication awards. In 2012, the German Federal Government awarded him the National Cross of Merit Order in recognition of his outstanding academic performance. Renn is primarily interested in risk governance, political participation and technology assessment. His has published more than 30 books and 250 articles, most prominently the monograph *Risk Governance* (Earthscan: London 2008).
www.zirn-info.de/**zirius**.htm and ortwin-renn.de

Riitta SALMELIN (FL)
Riitta Salmelin is Academy Professor (Academy of Finland) and Professor of Imaging Neuroscience at the Aalto University. She received her PhD in physics in 1989. She is a Member of Academia Europæa (2002-). Professor Salmelin conducts research in the field of systemic and cognitive neuroscience. Her expertise is exceptionally far-ranging and internationally unique. She is an expert in the world famous MEG method, a non-invasive imaging technique that can be used to analyse the function of both healthy and diseased brains. The Finnish neuroscience research community has greatly contributed to the development of the MEG method and has some of the world's foremost expertise in its use. Professor Salmelin's interdisciplinary research on language processing, neuroimaging and computational methods represents the absolute cutting edge in the field of cognitive neuroscience. During her second term as Academy Professor, it is expected that Salmelin's research will generate critical new information that will have wide application in both language research and neuroimaging. A better understanding of brain function, and of how it can be measured, will open new avenues to the treatment of brain diseases and injuries.
http://ltl.tkk.fi/wiki/Riitta_Salmelin

Pat J. SANDRA (BE)
Emeritus Professor Pat J. Sandra received his Master's degree in Organic Chemistry in 1969, followed by a PhD degree in Analytical Chemistry in 1975 from Ghent University, Belgium. He joined the Faculty of Sciences of Ghent University in 1976 as Assistant Professor and was promoted to Full Professor of Separation Sciences in 1988. In 1986, he founded the Research Institute for Chromatography in Belgium, a center of excellence for research and education in chromatography, mass spectrometry and capillary electrophoresis. He was Extraordinary Professor at the Eindhoven University of Technology, The Netherlands (1991-2000), the University of Stellenbosch, South Africa (1998-2013) and the University of Evora, Portugal (2006-2012). He was Co-founder of the Pfizer Analytical Research Center (PARC) that he directed during 2003-2011. He has authored or co-authored over 500 scientific publications and presented over 250 invited lectures at scientific meetings. Professor Sandra's research interests were in all fields of separation sciences (GC, LC, SFC and CE) and major keywords of his research include: high-throughput, high-resolution, miniaturisation, hyphenation and automation.
Among his numerous awards are the ACS Chromatography Award (2005), Doctor Honoris Causa in Pharmaceutical Sciences (2004, Turin, Italy), Doctor Honoris Causa in Food Safety (2007, Messina, Italy), Honorary Professor at the Dalian Institute for Chemical Physics, Chinese Academy of Sciences (2007) and Doctor Honoris Causa in Chemistry (2012, Bucharest, Romania).
http://www.sep-sci.org.uk/2009/sandra.pdf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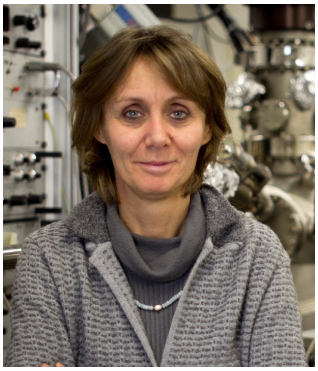
Hans Joachim SCHELLNHUBER (DE)
Hans Joachim "John" Schellnhuber is the founding and present Director of the Potsdam Institute for Climate Impact Research (PIK) and Chair of the German Advisory Council on Global Change (WBGU). He is Professor for Theoretical Physics at the University of Potsdam and External Professor at the Santa Fe Institute, USA. Being one of the leading climate scientists worldwide, he was Member of the President's Advisory Board on Climate Change and Energy during the Barroso I Commission and served as Climate Change Adviser to Chancellor Merkel during Germany's EU Council Presidency and G8 Presidency. He has qualifications in mathematics and physics – a Doctorate in Theoretical Physics from the University of Regensburg, which he completed in 1980, followed in 1985 by his Habilitation in Theoretical Physics at the University of Oldenburg. In 2001-2005, he served as Research Director of the Tyndall Centre in the UK and became a Visiting Professor at Oxford University. The National Academy of Sciences (US) appointed him as a Member in 2005. He has also been elected a Member by the German National Academy of Sciences (Leopoldina), the Academia Europæa, the Max Planck Society and several other academies. He was appointed a CBE (Commander of the British Empire) by Her Majesty Queen Elizabeth II in 2004. He was awarded the German Environment Prize in 2007 and the Volvo Environment Prize in 2011.

Schellnhuber has published more than 250 scientific papers and authored, co-authored or edited 50 books or book chapters. He has helped create numerous iconic concepts such as the now famous analysis of tipping elements in the climate system, the burning embers, and the budget approach for emissions. Maybe most notably, in 1995 already, Schellnhuber put forward the two degrees guardrail for global warming which has been adopted first by the German government and the European Union – and then, following the Copenhagen accord in 2009, as a global target by governments worldwide.
http://www.pik-potsdam.de/members/john



Roberta SESSOLI (IT)
Roberta Sessoli received her PhD in Chemistry from the University of Florence working on low dimensional molecular magnetic materials under the supervision of Dante Gatteschi. Since 2012 she is Full Professor of Chemistry at the University of Florence. Her research interests have focused on the magnetic properties of molecular materials. She has been a pioneer in the field of magnetic bistability at the molecular level and quantum effects in these mesoscopic materials, for which in 2002 she was awarded, among colleagues, with the Agilent Technology Europhysics Prize. With the help of her ERC funding, Professor Sessoli is advancing the knowledge on fundamental properties of molecular magnets and quantum spin, research which may lead to new molecular spin-based technologies. She is now tackling the challenging world of magnetism at the nano scale, making also extended use of large scale research facilities, in particular synchrotrons. She is currently engaged in European commitments as a panel member for the assignment of ERC Starting Grants.

http://www.unifi.it/LAMM/STAFF/roberta_sessoli.html

Cédric VILLANI (FR)
Cédric Villani (1973) is a French Mathematician working primarily on partial differential equations and mathematical physics. He received his doctorate at Paris Dauphine University in 1998 and became Professor at the École Normale Supérieure de Lyon in 2000. He is now Professor at Lyon University. He has been the Director of Institut Henri Poincaré in Paris since 2009. Villani has worked on the theory of partial differential equations involved in statistical mechanics, where, with Laurent Desvillettes, he was the first to prove how fast convergence occurred for uniformly smooth solutions of the Boltzmann equation not initially near equilibrium. With Clément Mouhot he established nonlinear collisionless damping of small inhomogeneities for the Vlasov-Poisson model of plasma dynamics. He received the Fields Medal for his work on Landau damping and the Boltzmann equation.
http://en.wikipedia.org/wiki/CpercentC3percentA9dric_Villani

Ada E. YONATH (IS)
Ada Yonath is an Israeli Crystallographer best known for her pioneering work on the structure of the ribosome. Following postdoctoral positions at the Carnegie Mellon University, she established in 1970 what was for nearly a decade the only protein crystallography laboratory in Israel. She is the current Director of the Helen and Milton A. Kimmelman Center for Biomolecular Structure and Assembly of the Weizmann Institute of Science. Yonath elucidated the modes of action of over twenty different antibiotics targeting the ribosome, illuminated mechanisms of drug resistance and synergism, deciphered the structural basis for antibiotic selectivity and showed how it plays a key role in clinical usefulness and therapeutic effectiveness, thus paving the way for structure-based drug design. For enabling ribosomal crystallography, Yonath introduced a novel technique, cryo bio-crystallography which became routine in structural biology and allowed intricate projects otherwise considered formidable. In 2000, she was awarded the first European Crystallography Prize. In 2009, she received the Nobel Prize in Chemistry along with Venkatraman Ramakrishnan and Thomas A. Steitz for her studies on the structure and function of the ribosome, becoming the first Israeli woman to win the Nobel Prize, the first woman from the Middle East to win a Nobel Prize in the sciences, and the first woman in 45 years to win the Nobel Prize for Chemistry.
http://en.wikipedia.org/wiki/Ada_Yonath