

## **TNO Working paper series**

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### **Is Climate Change and Energy a model for the societal challenges approach to innovation?**

**Keywords:** Horizon 2020, grand challenges, innovation policy, industrial policy, research policy, systems integration, European policy, global innovation networks, climate change, European energy reform, socio technical transitions

***Authors***

Carlos Montalvo (TNO Strategy and Policy, the Netherlands)

Jos Leijten (JIIP Joint Institute for Innovation Policy)

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TNO – Netherlands Organisation for Applied Scientific Research  
Schoemakerstraat 97  
2628 VK Delft  
The Netherlands

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**TITLE**

**Is Climate Change and Energy a model for the  
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**Authors**

**Carlos Montalvo and Jos Leijten**

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(\*) Corresponding author's email:

Carlos.Montalvo@tno.nl

josleyten@gmail.com

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## 1 Introduction

One of the major differences between Horizon 2020 and the preceding Framework Programs is a rather explicit “portfolio approach”. Horizon 2020 has three distinct and complementary funding boxes: research excellence, industrial leadership and societal challenges. The creation of an excellent European research base has always been one of the major Framework Programme goals. Apart from a considerable increase in funding under H2020, “Industrial Leadership” also brings another major new element, which could be summarised as “funding for the removal of closer to market barriers”. So far Framework Programmes mainly focused on the development of new technologies and applications in a collaboration of industry and public research. Horizon 2020 also explicitly addresses barriers in bringing these new technologies and applications to market: funding is available for setting up pilot production facilities (in particular in fields of high risk and high costs) and other barriers which are associated with the so-called “commercialisation valley of death”.<sup>1</sup> This approach to Industrial Leadership significantly expands the role of public funding within the traditional linear model – from fundamental science discoveries, via technology development to marketable products. But an even deeper change can be found in the third box of H2020: Societal Challenges. The central goal of this approach is to foster innovation to work on solutions to (grand) societal challenges and thus also to create drivers and opportunities for economic growth (new business activities). In other words, the starting point is not scientific discovery but important societal needs. According to the Horizon 2020 website these needs will guide a process of bringing together “resources and knowledge across different fields, technologies and disciplines, including social sciences and the humanities”, and it will not only include research activities but also “innovation related activities such as piloting, demonstration, test-beds, and support for public procurement and market uptake”. The focus is on the following challenges:

- Health, demographic change and wellbeing;
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bio-economy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world - inclusive, innovative and reflective societies;
- Secure societies - protecting freedom and security of Europe and its citizens.

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<sup>1</sup> This is extensively discussed in the final report of the High Level Expert Group on Key Enabling Technologies, European Commission, June 2011.

From these titles it can be gathered that implementation of the challenge oriented research and innovation programmes under Horizon 2020 (still) shows a wide diversity of not very well targeted and coordinated actions. The goals with regard to economic growth and job creation remain largely at the level of ambitions. But these ambitions might mark the starting point of the development of a completely new approach to innovation in which societal demand is taken as the prime driving force. In a way grand challenges or major societal problems have always been important as drivers for innovation, economic growth, and solving social and environmental problems.<sup>2</sup> In particular they have been drivers for public investments in science, technology and related infrastructures. *What is new is that thinking in terms of grand challenges as shared visions or goals which guide the actions of a broad (international) stakeholders' community is put forward as a means to bring Europe to the front of R&D and innovation.* This is a change of policy thinking after a period of more than 20 years in which science, technology and innovation policies were dominated by a preference for generic measures and a relative reluctance on the side of politics to identify and implement strong guiding principles and make strong thematic choices.

In this note we will explore the opportunities and potential impacts of the societal challenges approach. In particular we will look at the experiences in the field of climate change and energy – which can be seen as the oldest politically recognised challenge - as innovation driver and if these experiences provide a model for other challenges. But first we will provide more background on the challenges approach and how it has now become an essential part of Horizon 2020.

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<sup>2</sup> It should also be noted that demand driven innovation is not new. There is extensive literature on the topic and many governments, including the European Commission, have experimented with smaller programmes for demand driven research and innovation.

## 2 Horizon 2020: the introduction and conceptualisation of the grand challenges approach

After a decade of increasing productivity accompanied with decreasing employment rates, sluggish demand and economic growth Europe is now in the mid of a transition stage. This transition period might range from the end of the strategic period guided by the Lisbon Strategy in 2010 to well beyond the end of the Europe 2020 Strategy. The Lisbon Strategy had several flagship targets (notably growth, employment, productivity, innovation and research, education and training and social and environmental policies) that to were not met during its implementation period. For this failure the European Commission was strongly criticized (European Parliament, 2011). The midterm and final review of the Lisbon strategy period demanded a different rationale with a more ambitious and inclusive strategy that would allow pursuing previous targets but also a different emphasis. Such a new emphasis should provide some political slack and higher legitimacy for new policies. Exploratory and evaluation studies on the rationale of the societal challenges for innovation policy making date back to 2006 (e.g., Montalvo *et al.* 2006, Leijten *et al.*, 2012; McGrath *et al.*, 2014). After 2010 with the advent of the new European 2020 strategy the notion that Europe should focus its efforts on tackling grand challenges became mainstream in policy documents (Cagni *et al.*, 2012). What is new in the approach taken in Europe is the commitment (or need) to create a shared vision or goals to guide a broad international community as a mean to bring Europe to the front of R&D and innovation (Leijten *et al.*, 2012).

It is expected that the way politics, business and society handle societal challenges such as climate change or ageing populations will strongly affect economy and society in the coming decades, in Europe and worldwide. But the broad societal risks and problems which the challenges represent are at the same time also providing opportunities for new (business) activities, goods and services and for moving towards a smart, sustainable and inclusive economy.

In Europe the challenges approach was announced in “Europe 2020” (Communication from the Commission, 2010) which was building on earlier thinking about “grand challenges” such as the views expressed in the report of the ERA-rationales expert group.<sup>3</sup> This expert group addressed a problem which was identified in the 2007 ERA Green paper (p.6-7):

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<sup>3</sup> Challenging Europe’s Research: Rationales for the European Research Area 2008, p. 36: “To capture the imagination of the research community and its stakeholders we are proposing that the next stages of ERA are rolled out through a series of actions addressing the Grand Challenges facing Europe. These challenges are both economic and more broadly concerned with social and environmental goals. This approach can shift perceptions as well as focus from deficit to opportunity. (p.36)

“National and regional research funding (programmes, infrastructures, core funding of research institutions) remains largely uncoordinated. This leads to dispersion of resources, excessive duplication, unrealised benefits from potential spillovers, and failure to play the global role that Europe's R&D capability would otherwise allow, notably in addressing major global challenges.”

Grand challenges involve a combination of major public and private interests, are seen as key for realising future economic growth, and are concerned with important human, social and/or environmental problems. Grand challenges are not to be defined, assessed or solved by any single scientific or technological discipline or within one specific sectoral policy framework. Societies are facing complex, interlinked, global and local challenges. It is evident that we need new policies, new governance models, new innovation solutions and strategies, and new investment models for challenges like healthy aging and climate change. But the necessary holistic or generic approach also includes the need for highly specialised knowledge and highly specific technological and organizational solutions. Grand challenges involve many different stakeholders, are multidimensional, transdisciplinary, systemic and they require new ways of thinking which go beyond traditional frameworks and disciplines. And they lead to a need to re-think research and innovation policy.

The most common use of the concept of “grand challenge” is in the meaning of scientific or technological challenges. This type of challenge approach may also gain in popularity again in Europe, because there appears to be a growing interest in “prize mechanisms” to stimulate a demand driven search for solutions of societal problems<sup>4</sup>. This approach lends itself particularly well for soliciting technological solutions.

Although there are clear linkages with such engineering challenges, it is obvious that Europe is aiming for a broader approach to societal challenges. The 2009 Lund Declaration, building on the recommendations of the ERA rationales expert group, proposes the following characteristics as important<sup>5</sup>:

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<sup>4</sup> See also: Jos Leijten, Han Roseboom, Reinhold Hofer (2010): MORE FRONTIER RESEARCH FOR EUROPE, A Venture Approach for Funding High Risk – High Gain Research, Report to European Commission, JIIP, Brussels

<sup>5</sup> It is important to recall that the Lund Declaration also includes a set of broader framework conditions which need to be fulfilled for a successful grand challenges approach:

- Strengthening frontier research initiated by the research community itself.
- Taking a global lead in the development of enabling technologies such as biotechnology, information technology, materials and nano-technologies.
- Bringing together supply- and demand-side measures to support innovation, business development and public policy goals such as lead market initiatives, public procurement, problem- and issue-driven policies and priority setting.,
- Excellence and well-networked knowledge institutions. Modernisation of universities and cooperation between universities and research institutions is a key element for enhancing the competitiveness of European research.

- Move beyond rigid thematic approaches, focus on societal challenges;
- Approach to include global public and private stakeholders
- EU has process ownership, but it includes alignment of national initiatives.

Reviewing the different policy documents addressing the issue we can distil the following characteristics as important elements of a European approach to grand challenges:

- The longer term sustainability of a society or country is at stake
- Mission oriented, looking at solving societal problems and systemic solutions
- Multi-level, multi-stakeholder participation
- Focused on alignment and coordination of strategies
- Linking economic growth to societal benefits
- Combining research, technology & innovation in a multi-disciplinary way

In a more operational way, this new mission-led approach works along the following principles (Gassler et al. 2008, S. 214ff.):

- combining societal needs and technological inputs to generate solutions for these needs and challenges,
- decentralised process of identifying and selecting priorities,
- involvement of multiple actors,
- quick and broad diffusion of research results,
- acknowledgement of the importance of incremental innovations rather than of radical innovations.

It is clear from the above that the “European approach” to grand challenges starts from the recognition of the complexity of the problems at hand and the need to include broad stakeholder perspectives. An important element is the fact that the challenges are mostly defined as “global” and thus require a certain amount of international coordination. There are several attempts to tackle challenges globally, by governmental (UN, OECD<sup>6</sup>) and non-governmental bodies (foundations), by world regions based collaboration (East-Asia) and by bilateral collaboration (e.g. Australia-India). In the case of Europe there is ambiguity about the way intra-European coordination should take place: is this based on voluntary actions from the member states with support from the

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- The creation and maintenance of world class research infrastructures in Europe including installations for big science as well as those serving the needs of social sciences and humanities.
  - A risk-tolerant and trust-based approach in research funding entailing actions for necessary changes in the Communities’ Financial Regulation and Rules for participation and dissemination.

<sup>6</sup> Governance of international cooperation on science, technology and innovation to address global challenges, Discussion Paper Submitted to the Oslo Workshop on International Co-operation in Science, Technology and Innovation to Address Global Challenges, Oslo, Norwegian Ministry of Education and Research, May 18 - 20 2011



Commission (Joint Programming Initiatives) or is stronger coordination at the European level needed?

But there are major differences in how a challenge is addressed in research and even more so in innovation. The “climate change and energy” challenge falls in a tradition of many years of debating and policymaking for environmental issues, also in an international context. Other challenges are less explicitly recognised partly because they are of a more recent nature, less “internationalised” (healthy ageing) or less broadly recognised in society (security). Apparently it takes time before a challenge is really taken up as a broad societal challenge. The following paragraph very briefly discusses how this happened in the climate change/energy field

### 3 Climate change and energy as a challenge.

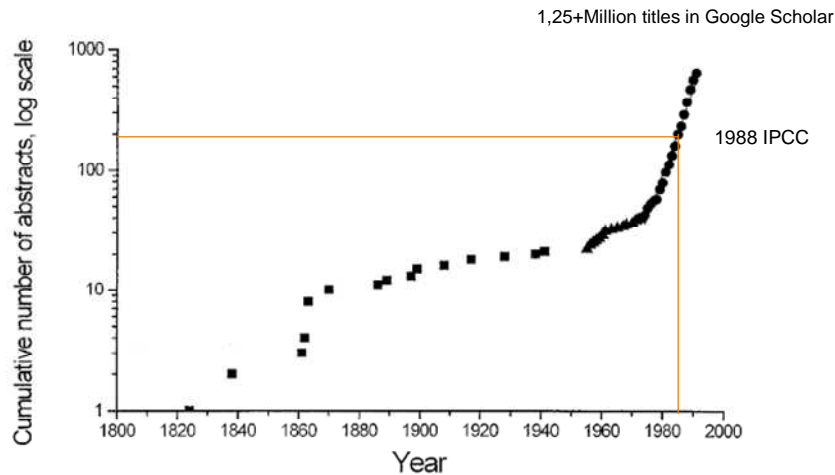
Where to look for a model of a societal challenge approach from which we can learn and which eventually might be applicable to other challenges? The issue of climate change in relation to energy provides us with a strong model to analyse the likely pattern of development of a societal challenge and how it relates to networks of innovation and global production. The analysis leads to a stylized description of how the structuration process of the challenge develops from identification and legitimization to the creation and expansion of a new market and how this is mediated by technical change and innovation. The following sequence of events is not necessarily linear and there are some recursive loops included:

- a) definition of the societal challenge (the issue);
- b) development and accumulation of a critical mass across different type of actors that recognize the issue as important and is willing to generate visions and contribute to the solution;
- c) appearance of lobbying groups (pro and against) and increased public debate;
- d) emergence of institutions advocating, hosting and proposing approaches to address the issue;
- e) development of technical and managerial approaches to address the issue;
- f) adoption of the issue in the policy agenda by government and multilateral organizations;
- g) investment flows to develop and test solutions while patenting and IPRs are settled; h) early adoption sprout niche markets supported by policy instruments (e.g., taxes and subsidies), regulation and standards start to consolidate markets;
- i) investments for production up-scaling often backed by sectoral policy and regulation and wider diffusion takes place;
- j) mass markets growth, competition and distribution of production locations become issues for industrial policy.

Climate change and innovation could well be one of the first visible and working models of a (global) societal challenge and how the innovations it drives are restructuring global production and consumption in energy markets. Some of the elements and events of such a model are outlined below. Figures 1, 2 and 3 present a summary of the process outlined above in a few indicators. Figure 1 shows the growth of the number of publications on climate change and Figure 2 depicts the parallel development of technical solutions and critical moments in which institutions advocated the taking of actions. In many publications most of the attention so far has been given to energy sources

and usage, but other publications are also linking energy sources and usage to developments in other sectors such as transport, lighting, construction, cement, and agriculture.

Figure 1. Number of publications on climate change



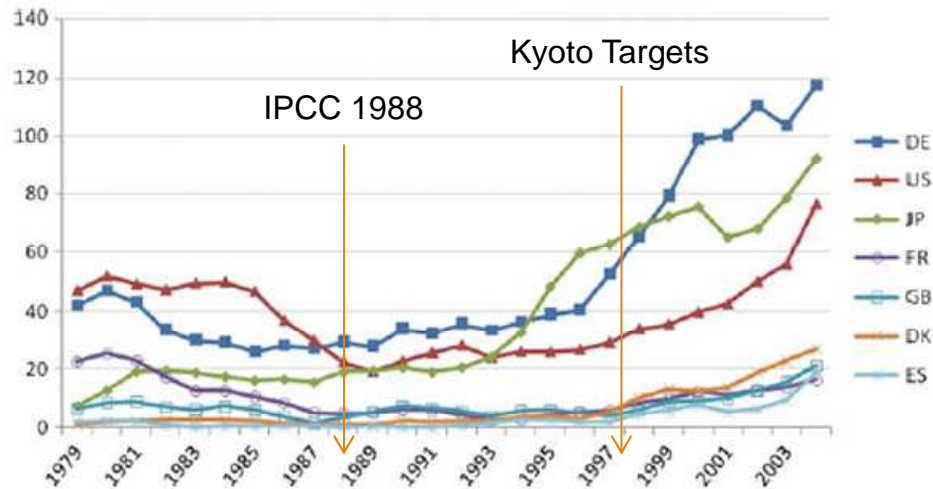
Based on Stanhill (2001)

Figure 1 shows how two important developments come together: a very rapid increase in the number of publications and the building of a consensus that climate change is real and that the main cause is the accumulation gases in the atmosphere, especially CO<sub>2</sub>. This should be seen as the start of a common understanding of the challenge. Since 1977 the number of published papers doubles every 11 years and the trend continues to date (Stanhill 2001) as confirmed by recent searches in Google Scholar. To come to a shared understanding of the challenge and the causal mechanisms required an enormous amount of fundamental research. Matching a logarithmic increase over a decade of three orders of magnitude in the number of publications, in 1988 the United Nations Intergovernmental Panel on Climate Change was created. The creation of such an institution required massive debate in multilateral organisations.

The road to the first agreement on limiting global emissions took about nine years. In 1997 the first agreement on the Kyoto Protocol was signed by some nations. The signature of the protocol and later the targets negotiations legitimated the need for actions at a global scale to mitigate the potential effects of climate change. Although the debate continued the development of technology solutions reflected in patenting activity in renewable energy technology increased significantly after the agreements of the Kyoto targets to limit CO<sub>2</sub> present in the atmosphere. Figure 2 shows the evolution of patenting activity in the period 1979-2003 in relation to two major events which led to the creation of new institutions in charge of promoting an agenda that would have global impact in

the enactment of national policies supporting the development and diffusion of alternative sources of energy.

Figure 2 Patenting activity and climate change debate evolution

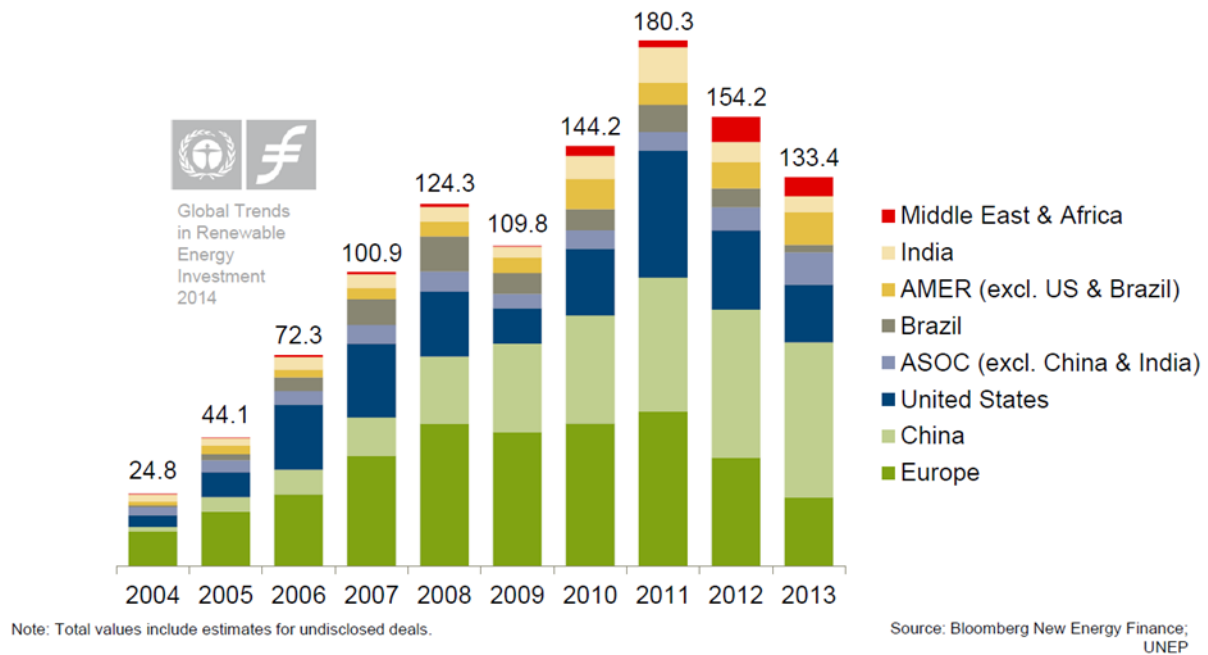


Based on Johnstone et al. (2010)

Although there are still sceptics concerning the climate change projections (Whitmarsh, 2011; Poortinga et al., 2011) the need for action to reduce CO<sub>2</sub> emissions has entered in the discourse and policy agendas and thus gained legitimacy for the “urgent” need for action. Similarly markets have reacted to the challenge and economic opportunities this brings for (global) business. With a time lag of just a few years following the increase of the patenting rate as shown in Figure 2, the level of reported investment in the production and installation of renewable energy technologies has also significantly increased. Figure 3 below shows sharp increases in the levels of investment in renewable energy technologies from 24.8 billion USD in 2004 to 180.3 billion USD in 2012<sup>7</sup>. Major investors are Europe, China and the U.S.

<sup>7</sup> The decline after 2011 is attributed to a major drop in prices of solar equipment and to continuing political uncertainty and related austerity following the financial crisis.

Figure 3 Global investment trends in renewable energy investment (US\$ Bn)



The business interest and economic impact are becoming clear from the large increase of capital flowing into energy related innovations. For example, Ethical Markets Media reported already in 2011 a \$2.4 trillion cumulative worldwide investment in eco-innovation<sup>8</sup> during the period 2007-2011, while the expected cumulative investment by the year 2020 was estimated at \$10 trillion (Montalvo et al., 2011). Innovations contributing to facing the climate challenge (e.g. in energy, mobility, water, etc.) are now creating new global markets, they allow smart specialization in some regions and are giving governments politically acceptable long-term horizons for policy action. Seen from the perspective of innovation the process of tackling the climate change challenge reveals at least three important steps (a simplified version of the list given at the beginning of this paragraph):

1. Reaching a shared understanding of the need for action, which requires a lot of fundamental research and connecting politics with science, and which in the meantime leads to a restructuring of the research field (new institutes, new forms of collaboration).
2. Creating technological solutions, which may include unconventional approaches such as competitor companies sharing their patents in order to foster development of solutions.
3. Investing and market development, including the rise of new companies, shaping the necessary regulatory environment and the shaping of new institutions.

<sup>8</sup> This is broader than renewable energy, but likely to show similar patterns.

## 4 Discussion

Before going into somewhat more detail about the role of Horizon 2020, two questions need to be posed. The first question is whether climate change and energy indeed provides a model for other challenges, such as healthy ageing, water, food or security. Climate change/energy is a societal challenge of which the globally interdependent nature is more or less accepted from the beginning of discussions and research, even when most of its implications are unevenly felt across countries, regions, and localities. Other challenges like health, water, food and security also have such global interdependencies, but so far national and regional political agendas tend to dominate. The establishment of global research and innovation networks in science and technology can help to build an arena which links the local implications and potential solutions to the global dynamics. It can help to create an environment in which potential conflicts between regions and nations can be mediated. The strong and long standing collaborative dynamics of global innovation networks related to energy, especially in the area of R&D, might have some lessons to offer to other policy areas. In the field of healthy ageing we see broad international research networks appearing. The globally operating pharmaceutical companies might in principle play a role in extending such collaborations further into the field of innovation. Other challenges which sometimes for hundreds of years have belonged to the realm of national and regional/local governments will require an even stronger internationally collaborative research and innovation effort in order to turn these challenges in global drivers for global solutions. Such a structuration process will not be easy. The implementation of the shared vision to face the grand challenges requires the capacity to create convergence and it should enable the interoperation of complex multi-actor networks. And it requires a logic of systems integration that is often at odds with decentralised decision making and management which is presently dominant in national or sectoral approaches. Specifically in the case of Europe the present political decentralisation tendencies may raise the barriers for an effective challenge driven approach.

The second question is if and how the challenge driven approach helps Europe to make the transition to the next phase in global innovation and production systems. The international economic context has moved to a new, multipolar era in which the rules of the competitive game are being reset. Leading economies and newcomers in global markets (e.g. India, China, South Korea, Taiwan, Singapore, etc.) have mastered not only the know-how for cost driven competition (Contractor et al., 2010), but they also have become innovative in both traditional and in selected high-tech sectors (Montobbio et al., 2010). Global competition and new technologies drive the cores

of innovation and production networks closer to consumption, closer to important markets<sup>9</sup>. The transition has to take place when government in several advanced economies, and certainly in Europe, can no longer rely on a broad electorate's confidence and on the legitimacy of their policy agendas to ensure the societal welfare, employment and growth in the context of national austerity plans. But the needs driven notion of societal challenges offers the opportunity to articulate a structure of innovation and production in a new combination of global networking and local action. Such a new competitive landscape not only requires a significant restructuring of the global patterns of production, but the production of knowledge and innovation driven by societal challenges may help to build the arena in which actions can be taken. Thus innovation is to play an important role as a means for restructuring and for legitimation of new global production networks and markets.

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<sup>9</sup> See for an extensive discussion of the recent trends 6CP (2015): Can policy follow the dynamics of global innovation platforms? Delft (forthcoming).

## 5 Horizon 2020 and beyond

For Europe this transition starts with the implementation of Horizon 2020 over the years up to 2020. The largest portion of the budget of the Research and Innovation program *Horizon 2020*, almost 40%, i.e., 31 billion Euro, is dedicated to exploring and creating approaches and technologies to tackle the 'Grand Challenges' (Judkiewicz, 2014). From a political economy perspective the 2020 European Strategy underpinned by the notion of societal challenges aims to:

- 1) Develop and mature new competences, skills and technologies as defined by specific programmes contributing to the solution of a societal challenge;
- 2) Setting up new institutions, standards and regulations supporting European industrial and markets leadership, and
- 3) Create global consensus and shared visions that underpin the creation of new markets.

The first point of this agenda and vision is reflected in programs that together form Horizon 2020, and this includes a strong role for enabling competencies such as those developed under for example Factories of the Future, Future and Emerging Technologies or the excellence driven funding of the European Research Council. Such programs directly or indirectly aim to tackle the societal challenges, to underpin the building of competitive roles in global innovation networks and to set the grounds for global industrial leadership. The other two points are the topic of much broader policy actions and other policy fields. Closer to the market the process will require the creation of new institutions that apply regulations and standards across industry and nations. Those (firms or countries) which manage to set the new standards and adapt or create their institutions according the new business models required by the new rationale of bringing solutions to the societal challenges, are likely to be best positioned in the restructured regional or global value networks.

The period 2010-2020 can be considered a transitional phase in which the foundations for the period 2020-2050 are to be settled. Such foundations include facing societal challenges and the new global geopolitical and competitive landscape. Developments in tackling the climate change and energy challenge and its structuration are now continuing in an increasing pace (e.g. setting standards, technological competition, varied national support, new collaboration models, etc.). In the process European companies play a major role. Competition is moving on from present markets to the creation of the future ones. The precompetitive activities are not only focusing on R&D and innovation but also on norms and institution building. In this sense, the climate change-energy model seems a promising approach as it provides a tractable example of the dynamics of massive



alignment of vision and multilateral agendas akin to global issues. The potential economic and social impact as already shown by the rise of the energy markets is large. Learning the lessons offered by this model and its application in other areas of grand challenges may promise similar outcomes. But at the same time it should be noted that one cannot expect quick results. Solutions will have to be moderated in a lengthy structuration process. The period 2010-2020 should be seen a preparatory period where a broad scope of pre-competitive activity is taking place. Following the timing and logic offered by the climate change-energy model and the Kondratiev waves of economic development we could expect then that global markets and economic expansion are to take off well beyond 2020.

## 6 References

- 6CP (2015): Can policy follow the dynamics of global innovation platforms. Delft (forthcoming)
- Cagnin C., E. Amanatidou and M. Keenan (2012): Orienting European innovation systems towards grand challenges and the roles that FTA can play, *Science and Public Policy*, 39 (2): 140-152.
- Contractor F.J., V.Kumar, S.K. Kundu and T.Pedersen, (2010): Reconceptualizing the Firm in a World of Outsourcing and Offshoring: The Organizational and Geographical Relocation of High-Value Company Functions, *Journal of Management Studies*, Special Issue: Offshoring and Outsourcing, Volume 47, Issue 8, pages 1417–1433, December.
- Ethical Markets Media, (2011): Green Transition Scoreboard, August 2011 Update. Ethical Markets Media, St. Augustine.
- European Commission, (2010): EUROPE 2020: a Strategy for Smart, Sustainable and Inclusive Growth, Brussels, 3.3.2010. Communication from the Commission, COM (2010) 2020.
- European Parliament (2011): The Lisbon Strategy 2000-2010: AN analysis and evaluation of the methods used and results achieved; Brussels: European Parliament Directorate for Internal Policies. IP/A/EMPL/ST/2008-07: PE440.285
- Foray, D., (2009): Research, Innovation and Economic Growth: What does Really Matter? Paper Presented at the Conference Futuris, Public Support for Innovation: Efficiency and Future Prospects, 1 April, 2009, Paris.
- Gassler, Helmut, Wolfgang Polt and Christian Rammer (2008), Priority setting in technology policy: historical developments and recent trends, in: Claire Nauwelaers and René Wintjes, *Innovation Policy in Europe, Measurement and Strategy*, Cheltenham, UK, Northampton, MA, USA, 203-224
- Johnstone, N., Haščič, I., & Popp, D. (2010). Renewable energy policies and technological innovation: evidence based on patent counts. *Environmental and Resource Economics*, 45(1), 133-155.
- Judkiewicz, D.M (2014): 2014 and beyond, R&D Trend Forecast in Europe: Horizon 2020. EIRMA R&D trends Forecast, EIRMA
- Leijten, J., Roseboom, H., Hofer, R. (2010): More Frontier research for Europe, A Venture Approach for Funding High Risk – High Gain Research; Report to European Commission, Brussels, JIIP
- Leijten, J. e.o. (2012): Investing in research and innovation for Grand Challenges; report to the European Commission, Brussels, JIIP
- McGrath C.L., Horvath V., Baruch B., Gunashekar S., Lu H., Culbertson S., Pankowoska P., and Chataway J. (2014): The international dimension of Research and innovation cooperation addressing the grand challenges in the global context: Final Policy Brief Prepare for the European Commission Directorate for Research and Innovation, Brussels: RAND Europe
- Montalvo, C., Diaz-Lopez, F., Brandes, F., (2011): Eco-innovation Opportunities in Nine Sectors of the European Economy. European Sector Innovation Watch; European Commission, Directorate General Enterprise and Industry, Brussels.
- Montalvo, C., Tang, P., Mollas-Gallart, J., Vivarelli, M., Marsilli, O., Hoogendorn, J., Butter, M., Jansen, G., Braun, A. (Eds.), (2006): Driving Factors and Challenges for EU Industry and the Role of R&D and Innovation. European Techno-Economic Policy Support Network, Brussels (ETEPS AISBL Report to the European Commission Directorate General Joint Research Centre e IPTS, Seville.
- Montobbio F., E. Bacchiocchi, L. Cusmano, F. Malerba, F. Puzone, D. Fornahl, H. Gruppy, J. Stohr, T. Schubert, C.A. Tran (2010): National Specialisation and Innovation Performance, Final Report Task 4 Horizontal Report, Europe INNOVA Sectoral Innovation Watch; Brussels, European Commission, Directorate General Enterprise and Industry.
- Poortinga W., A Spence, L Whitmarsh, S Capstick, (2011): Uncertain climate: An investigation into public scepticism about anthropogenic climate change, *Global Environmental Change* Volume 21, Issue 3, Pages 1015–1024
- Stanhill, G. (2001): The growth of climate change science: A scientometric study; *Climatic Change*, 48: 515–524, Springer
- Withmarsh, L. (2011): Scepticism and uncertainty about climate change: dimensions, determinants and change over time, *Glob. Environ. Change*, 21, 6