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Grand Challenges Discussed in Selected EFP Briefs.

Collection on the Occasion of the EFP Final Event.

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Grand Challenges Discussed in Selected EFP Briefs.

Collection on the Occasion of the EFP Final Event.

September 2012

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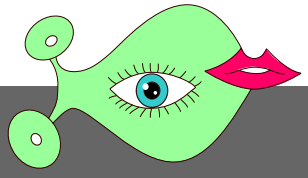

PREFACE

One of the topics dominating the European discussion on Forward Looking Activities in the last three years has been the notion of “Grand Challenges“. The “Grand Challenge” concept has been developed and refined by a range of individuals in specific organisational contexts over the past decades, becoming a more prominent term recently especially at European Commission level. In Europe, the prevailing definition is that Grand Challenges need to be dealt with on a multilateral or global level, since the factors behind these challenges and their consequences are transnational and cross-border in nature, sometimes even of global scale. Accordingly, institutional coordination and collective action are required, in order to efficiently cope with these challenges. From an EU perspective, Grand Challenges occur in many areas and call for a new policy approach or even a change in governance.

The selection of Briefs in this publication wants to shed light on some of these areas under discussion. We do not attempt to give a complete picture. However, we hope that the readers will catch a glimpse on crucial issues and will be inspired to do further reading and research in this direction. The 20 Briefs presented here are a selection of more than 220 currently available on the EFP website and they address some of the Grand Challenges most poignantly.

Among these areas exposed to Grand Challenges in the EU, the economy is a very prominent one. A Brief on the future of innovation (INFU, No. 175) presents one side of this coin. The other side is reflected in the discussion on Future Jobs & Skills (No. 160). The future state of Europe’s competitiveness relates not only to innovation capacities but also to Creative Foresight Space for Enhanced Work Milieux (No. 229) to meet the challenges posed by the transition from the information society into the ‘meanings society’.

An era of scarce resources threatens economic development and poses tensions to the environment and sustainability. Several of our Briefs take up these tensions e.g. in the energy sector (EFONET No. 163), Agriculture and the Challenges of Energy (No. 190), Food Security by 2050 (No 196), Technologies for EU Minerals Supply (No. 181), Future Scenarios for the Spanish Sustainable Development Model (No. 172), and Transportation & Logistics 2030 (No. 191).

By the same token, competitiveness always relates to the EU’s position in the world and how the EU economy will perform in the future competing with emerging economies as well as with traditional great powers. A Brief on Global Technical Revolution China (No. 165) takes a look into these international developments.

Emerging technologies present one way to compete at global scale and are therefore often seen as a solution to future challenges. EFONET (No. 163) presents a case in point for energy; Transportation & Logistics 2030 (No. 191) on mobility, Digital Europe (No. 194) on IT as additional examples of FLAs concerned with future technological options.

The project Citizen Visions on Science, Technology and Innovation (presented in No. 204) took a decisive societal perspective and developed a cost-effective mechanism for involving citizens in the formulation of European science, technology and research policy.

A number of Grand Challenges for European S&T were identified, leading to a set of recommendations for future European framework programmes.

Some holistic FLAs take a bird's eye perspective, cross-cutting the most crucial issues for the EU to occur in the near future. The World in 2025 (No. 167), Forward Looking Activities in Support of ERA Vision 2020 (168), Facing the Future (No. 179), Towards Transformative Innovation Priorities (No. 211) generate and analyse alternative scenarios of Grand Challenges based on specified assumptions about economic, political, social, environmental and technological developments in order to assess their consequences for the EU or at national scale and to examine which policy responses could be appropriate. Grand Challenges from a micro-perspective as well as from a meta-perspective pose new requirements on governance and responsibility. The Future of European Innovation Policy (No. 182) is an example of a cross-cutting policy area that affects different policy levels – from European to regional.

At the same time Grand Challenges need to be recognized not only from a European angle but also from a national angle. We chose to include the German BMBF Foresight (No. 174) in this selection to present the discussion of future technical and societal issues involving different partners in the innovation system, and the Spanish Sustainable Development Model (No. 172), displaying possible alternative economic, energy-related, technological and environmental perspectives under the sustainability premise.

Is Technology Still Enough? (No. 186) and Dark Scenarios (No. 145) are taking up critical issues implied in current trends. These Briefs are questioning the dominant innovation system and whether Forward Looking Activities can take a more responsible role to introduce radical changes.

The EFP Briefs are concise presentations of Forward Looking Activities of various sectors, different formats and scope in almost all EU countries and many other regions of the world. They give account of the plethora of activities that developed over the past eight years making FLAs an important means of stakeholder and societal engagement for visioning Grand Challenges of mid-term and long-term range and presenting an open forum for discussing solutions. EFP continued the tradition of the predecessor project EFMN (European Foresight Monitoring Platform) and both EFMN and EFP Briefs have been extremely successful within the FLA community and beyond as personal feedback and download statistics prove. Briefs are generally authored by organizers of FLAs and owed to the commitment of colleagues showing a lot of dedication and passion for their projects. We would like to express our deepest thanks to these authors and to the European Commission which made the EFP possible by funding as part of the Seventh Framework Programme!

Susanne Giesecke, project coordinator of the European Foresight Platform 2009-2012

Vienna, September 2012

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Constructing Dark Scenarios for Privacy Policy Formulation

EFP Brief No. 145

Authors: David Wright david.wright@trilateralresearch.com
Sponsors: European Commission / DG Information Society and Media
Type: Field/sector specific
Organizer: B-1049 Brussels, Belgium
Duration: 2005 – 2006 **Budget:** € 399,797 **Time Horizon:** 2017 **Date of Brief:** July 2008

Purpose

In the last few decades, scenarios have provided a way of analysing the implications of alternative futures, especially as they might be impacted by new technologies. This has been no less true of ambient intelligence (AmI), which may be embedded everywhere in the not so distant future. Most of the scenarios developed by AmI enthusiasts have been rather "sunny", showing how new technologies promise to make our lives more productive and enriching. A European project called SWAMI (Safeguards in a World of Ambient Intelligence) deliberately developed "dark scenarios" to highlight the threats to privacy, identity, trust and security and inclusiveness posed by new technologies. This brief describes the SWAMI scenarios and the methodology used to construct and analyse them.

SWAMI Dark Scenarios

While most AmI scenarios paint the promise of the new technologies in sunny colours, there is a dark side to AmI as well. In a way, this dark side is inherent in the very nature of AmI, for instance, the fact that AmI technologies will deliver personalised services to users means that somewhere a lot of personal information needs to be stored about the user. That being the case, there are risks that the user's personal information can be abused, either accidentally or intentionally. These risks have been recognised by policy-makers and researchers, and were at the heart of the SWAMI project, funded by the European Commission under its Sixth Framework Programme.

The project began in February 2005 and finished 18 months later. The SWAMI consortium had five partners: the Fraunhofer Institute for Systems and Innovation Research (Ger-many), the Technical Research Center of Finland (VTT Electronics), Vrije Universiteit Brussel (Belgium), the Institute for Prospective Technological Studies (IPTS, Spain) of the EC's Joint Research Centre, and Trilateral Research & Consulting (UK).

One of the tasks of the project was to create and analyse four dark scenarios that highlight the key socio-economic, legal, technological and ethical risks to privacy, identity, trust and security posed by new AmI technologies. They were called "dark scenarios", a term coined to signify things that could go wrong in an AmI world, because they present visions of the future that we do not want to become reality. The objective of the scenarios was to expose threats and vulnerabilities as a way to inform policy-makers and planners.

The process in constructing the scenarios began with an extensive review of existing AmI-related projects and studies. Following a workshop with other AmI experts to discuss the most important threats and vulnerabilities posed by AmI, the SWAMI partners had a brainstorming session until we agreed on the rough outlines of four contrasting scenarios. We then developed these outlines into scenario stories or scripts. To ground the scenarios in reality – to ensure that they were not too far-fetched – we did a "technology check" (are the technologies referenced in the scenarios probable?) and a "reality check" (are there press reports of events similar to those mentioned in the scenarios?). Then each partner reviewed all of the scenarios in order to eliminate doubtful points, unnecessary wordage, irrelevancies, etc., and to sharpen them to illustrate the points to be emphasised. Once the scenarios were "stable", we per-formed an analysis

of them, including a legal analysis. The scenarios and associated analyses were presented at a second SWAMI workshop in order to benefit from the comments of other experts. This scenario-construction process can be depicted as follows: (The set of identified goals of the programme – e.g. identifying the 100 most critical technologies in the next 15 years, or the most important factors influencing the development of a particular technology and/or most important players.)

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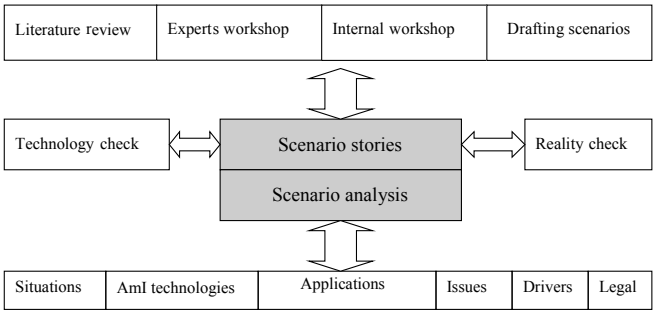

The resulting four scenarios, elaborated in our book, *Safeguards in a World of Ambient Intelligence* (see the references below), are the following:

Dark scenario 1: A typical family in different environments – presents AmI vulnerabilities in the life of a typical family moving through different environments. It introduces dark situations in the smart home, at work and while taking a lunch break in a park.

Dark scenario 2: Seniors on a journey – also references a family but focuses more specifically on senior citizens on a bus tour. An exploited vulnerability in the traffic system causes an accident, raising many different problems related to both travel and health AmI systems.

Dark scenario 3: Corporate boardroom & court case – involves a data-aggregating company that becomes the victim of a theft of personal AmI-generated data that fuel its core business. Given its dominant position in the market, the company wants to cover this up but ends up in court two years later. The scenario also highlights the disparities between countries with AmI networks and those without.

Dark scenario 4: Risk society – from the studios of a morning news programme, this scenario portrays the AmI world as a risk society. It presents an action group against personalised profiling; the digital divide at a global scale and, related to environmental concerns, the possible vulnerabilities of AmI traffic systems and crowd management.

Elements in SWAMI Scenario Methodology

The SWAMI consortium devised a methodology, an analytical structure for both constructing and deconstructing scenarios, not only the SWAMI scenarios, but many other technology-oriented scenarios. The analytical structure comprises the following elements or activities:

Framing the scenario

This first step summarises the scenario in question and explains its context – who are the main actors in the scenario, what happens to them, what they do, how far into the future is the scenario, where does it take place and in what domain (home, office, on the move, shopping, etc). It identifies the type of scenario (trend, normative, explorative) and key assumptions (e.g., intelligent technologies will be embedded everywhere in rich countries, but not in poor countries).

Identifying the technologies and/or devices

Next, the most important AmI technologies and/or devices used and/or implied in the scenarios are identified.

Identifying the applications

The analysis then considers the applications that emerge in each scenario and that are supported by the technologies mentioned in the previous step.

The drivers

The analysis identifies the key drivers that impel the scenario or, more particularly, the development and use of the applications. Drivers are typically socio-economic, political or environmental forces, corporate ambitions or personal motivations (e.g., greed).

Issues

Next, the major issues raised by the scenarios are identified and explicated. A discussion of the issues considered the threats and vulnerabilities exposed by the scenario, their impacts and legal implications.

Conclusions

The final step is a reality check of the scenario itself (how likely is it?) and a consideration of what should be done to address the issues it raises.

Large-scale Data Availability Multiplies Threats and Vulnerabilities

The SWAMI scenarios highlighted many of the threats and vulnerabilities that we foresee afflicting the AmI world. The principal difference (in our view) between an AmI world and that which we know today is the scale of the data available. When everything is embedded with intelligence, when AmI is pervasive and invisible, when everything is connected and linked, the threats and vulnerabilities that we know today will multiply. In an AmI world, we can expect to be under surveillance ("transparent") wher-

ever we go because the permanent and real-time registration and processing of our presence and behaviour is the precondition – the "code" – of ambient intelligence.

The threats to our privacy, however we define it, can come from many different sources. Here are some of the principal ones that affect us today and we can assume will still be threats in an AmI world:

- hackers and attackers,
- function creep,
- surveillance,
- profiling,
- lack of public awareness or concern about privacy rights,
- lack of enforcement and oversight of privacy rights,
- erosion of rights and values,
- uncertainties about what to protect and about the costs of protection and privacy erosion,
- government and industry are less than forthright about the personal data they collect and/or how they use that data.

Is Protection Feasible? – Safeguards

The multiplicity of threats and vulnerabilities associated with AmI will require a multiplicity of safeguards. We grouped safeguards into three main approaches:

- technological,
- socio-economic,
- legal and regulatory.

Technological Safeguards – Need for Sophisticated Methods for Controlling Data Collection and Use

The main privacy-protecting principles in network applications are anonymity, pseudonymity, unlinkability and unobservability. The main difference between existing network applications and emerging AmI applications is two-fold: first, in the former case, the user has some understanding of which data about him or her are collected, and has some means to restrict data collection: e.g., to use a public computer anonymously to access certain web pages; to switch off his or her mobile phone, to pay cash instead of using a web service, etc. In the latter case, with the environment full of numerous invisible sensors (and video cameras), it is difficult, if not impossible, for users to understand and to control data collection and to achieve unobservability, anonymity and pseudonymity. Intelligent data processing, limiting linkability and implementing strong access control to collected data seem to be the main ways of protecting privacy in such applications. However, such applications present potential privacy threats anyway if the police, intelligence agencies, family members or criminals can search through devices that store personal data.

A second important difference between existing network applications and emerging AmI applications is that neither mobile devices nor web usage penetrates through such strong privacy-protecting borders as walls and the human body, but physiological, video and audio sensors, proposed for AmI applications, will have much stronger capabilities to identify a person and to reveal personal activities and feelings.

Consequently, future AmI applications will require stronger safeguards, many of which are not yet fully developed. Hence, we proposed research on developing privacy-protecting safeguards such as:

- communication protocols which either do not require a unique device identifier at all or which require authorisation for accessing the device identifier;
- network configurations that can hide the links between senders and receivers of data;
- improving access control methods by multimodal fusion, context-aware authentication and unobtrusive biometric modalities (especially behavioural biometrics, because they pose a smaller risk of identity theft) and by liveness detection in biometric sensors;
- enforcing legal requirements and personal privacy policies by representing them in machine-readable form and attaching these special expressions to personal data, so that they specify how data processing should be performed, allow a privacy audit and prevent any other way of processing;
- developing fast and intuitive means of detecting privacy threats, informing the user and configuring privacy policies;
- increasing hardware and software capabilities for real-time data processing in order to minimise the lifetime and amount of raw data in a system;
- increasing software intelligence by developing methods to detect and to hide sensitive data;
- developing user-friendly means for recovery when security or privacy has been compromised.

Socio-economic Safeguards Require Cooperation

Co-operation between producers and users of AmI technology in all phases from R&D to deployment is essential to address some of the threats and vulnerabilities posed by AmI. Among the socio-economic safeguards we proposed were these:

- standards,
- privacy audits,

- codes of practice,
- trust marks and trust seals,
- reputation systems and trust-enhancing mechanisms,
- service contracts with strong privacy protections,
- guidelines for ICT research,
- raising public awareness,
- including privacy, identity and security issues in the professional education curricula of computer scientists,
- media attention, bad publicity and public opinion.

Legal and Regulatory Safeguards – Transparency Is Key

SWAMI identified some serious legal problems when applying the existing legal framework to address the intricacies of an AmI environment. We found that most of the challenges arising in the new AmI environment should be addressed by transparency tools (such as data protection and security measures). Transparency should be the default, although some prohibitions referring to political balances, ethics and core legal concepts should be considered too.

A set of rules needs to be envisaged to guarantee procedural safeguards similar to those currently applicable to the protection of our homes against state intervention (e.g., requiring a search warrant). Technical solutions aimed at defending private digital territories (the private sphere of the individual no matter where he is) against intrusion should be encouraged and, if possible, legally enforced. The individual should be empowered with the means to freely decide what kind of information he or she is willing to disclose. Such protection could be extended to the digital movement of the person, that is, just as the privacy protection afforded the home has been or can be extended to the individual's car, so the protection could be extended to home networks, which might contact external networks.

All employees should always be clearly and a priori informed about the employee surveillance policy of the employer (when and where surveillance is taking place, what is the finality, what information is collected, how long it will be stored, what are the (procedural) rights of the employees when personal data are to be used as evidence, etc.).

The status of pseudonymity under the law needs further clarification, whether pseudonyms should be regarded as anonymous data or as personal data falling under the data protection regime.

The obligation of data protection law to inform the data subject about when and which data are collected, by whom and for what purpose gives the data subject the possibility to react to mistakes or abuses, and enables him to enforce his right in case of damage. It would be desirable to provide the individual not only with information about what data are processed, but also what knowledge has been derived from the data. This might imply a rethinking of data protection law.

A means to prevent data laundering could be envisaged which would create an obligation for those who buy or otherwise acquire databases, profiles and vast amounts of personal data, to check diligently the legal origin of the data. An obligation could be created to notify the national data protection authorities when personal data(bases) are acquired. Those involved or assisting in data laundering could be subject to criminal sanctions.

Profiling practices and the consequent personalisation of the ambient intelligence environment lead to an accumulation of power in the hands of those who control the profiles and should therefore be made transparent.

Simply identifying safeguards is not sufficient, of course, so the SWAMI consortium went further and specifically addressed recommendations to the European Commission, member states, industry, academia, civil society organisations and individuals. The reader interested in more details should consult the references below.

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Future jobs and skills in the EU

EFP Brief No. 160

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Sponsors: European Commission – DG Employment, Social Affairs and Equal Opportunities
Type: European futures study on jobs and skills
Organizer: TNO, the Netherlands (Frans van der Zee), SEOR, the Netherlands & ZSI, Austria
Duration: 12/2007-04/2009 **Budget:** N/A **Time Horizon:** 10-15 years **Date of Brief:** Dec 2008

Purpose

The renewed Lisbon strategy stresses the need for Europe to place more emphasis on anticipating skill needs. Globalisation, technological change and demographic developments (including ageing and migration) in that respect pose huge challenges, comprising both risks and opportunities. At the same time, a lack of information on future skill needs has been a long-standing concern in Europe With specific targets set in the Lisbon strategy, the need for regular forward looking assessments has gained impetus. Subsequently, this resulted in the recent New Skills for New Jobs initiative by the European Commission, and related European projects aimed at identifying future job and skills needs using quantitative modelling approaches. While having advantages of robustness, stakeholders as well as the European Commission identified a clear need for complementary more qualitative forward-looking analysis. Consequently, the European Commission (DG EMPL) earlier this year commissioned a series of 17 future-oriented sector studies (horizon 2020) on innovation, skills and jobs following a qualitative methodology. The final results of these studies will become available in spring 2009, and will be followed by a number of other initiatives over the oncoming year and beyond.

Future of European Employment

The future of European employment is shaped by two over-arching developments: globalisation as well as an ageing population. With both determining demand and supply of future skills, they provide the background to this study. The large number of “baby-boomers” retiring over the coming decade will cause the working-age population to decline. At the same time, many industry sectors in Europe are currently exposed to pressures from globalisation forcing substantial restructuring processes. These developments should be placed in the broader context of securing and improving the EU's competitiveness, redeploying the European economy to new activities with new and better jobs. In order to be successful, this redeployment should be underpinned by a strategic management of human resources, encouraging a more dynamic and future-oriented interaction between labour demand and supply. Otherwise there is the risk that bigger shortages, gaps and mismatches of skills will result in structural unemployment.

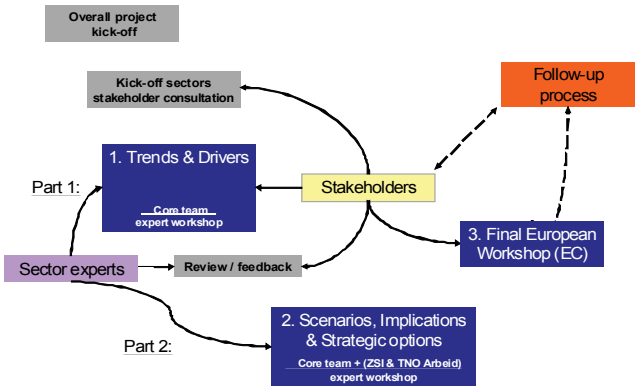
17 sector studies, one methodology

As a first step, the results of this study aim to serve as a guide in launching further EU and other actions to promote the strategic management of human resources and to foster stronger synergies between innovation, skills and jobs, encouraging adaptations to national and regional level. The study comprises 17 sector studies, including a pilot, analysing emerging competences and economic activities. Of these, 11 were executed by a consortium led by TNO (Delft, the Netherlands), SEOR Erasmus University (Rotterdam, the Netherlands) and ZSI (Vienna, Austria).

To validate, add and complement the findings of the project and to increase impact, results are disseminated as broadly as possible across Europe. Relevant stakeholders including relevant social partners were involved in the project from the beginning, asked to provide in-

formation during the research phase and for feedback in the interim review process. Furthermore, they participated in addition to experts from industry and academia in a final workshop organised by the EC to validate the results and develop recommendations. The sectoral partners will also play a key role in the follow-up process.

Overall project setup



With studies being executed by different contractors, a uniform methodology designed by Prof Rodrigues and further developed by the consortium led by Dr van der Zee and his colleagues, was employed to ensure comparability of results. The methodology consisted of two parts: a mainly backward looking part, identifying trends and drivers, and a forward looking part, including scenario building, identification of emergent skills and strategic implications. Throughout results were discussed with internal and external experts and stakeholders. A final workshop organised by the Commission and Euro found staff, functioned for validation and refinement of recommendations, bringing together European experts from industry, academia and sector organisations.

Based on the basic methodological framework, each contractor executed 8 defined steps, starting with the mapping of main trends, key drivers of change, emergent competences, leading to scenarios and their implications and subsequent recommendations. Many of the steps were based on predefined tables filled in by experts to allow comparisons across sectors, but also to update results easily over time. Further-more, such a pre-defined structure allows other actors in the future to repeat and adapt this exercise to local needs.

From backward- to forward-looking

Trend, Developments and State-of-play

The main purpose of this analysis was to provide the factual background to identify key drivers for the subsequent scenario development. Consequently, Part 1 of the Report analysed recent sector developments and trends and, at the same time, depicts the current state of play in the sector with an emphasis on innovation, skills and jobs. It was based on an analysis of available time series data and relevant existing studies and is both backward- and forward-looking in nature. It analysed 1) structural characteristics (production, value added, employment in various dimensions, and related factors); 2) the value chain; 3) technological change and innovation; 4) trade and international competition as well as 5) regulation.

The results of all sections were summarised in a SWOT analysis and were used as input for a workshop to identify key drivers. During the workshop experts were asked to assess a generic list of 26 drivers grouped in DESTEP categories (demographic, economic, social, technological, environmental and political). Experts were asked to assess drivers in regards to their relevance, uncertainty, their impact on the level of employment, the composition of employment, and the impact on new skills. Additionally, for each driver the expected short, medium and long term impact, as well as differences between country groups and subsectors were assessed. Where adequate, also sector specific drivers were identified to complement the generic list.

Knowledge, skills and competences defined

knowledge - refers to the outcome of the accumulation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual;

skills - refers to the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments);

competence - refers to the proven ability to use knowledge, skills and personal, social and/ or methodological abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility

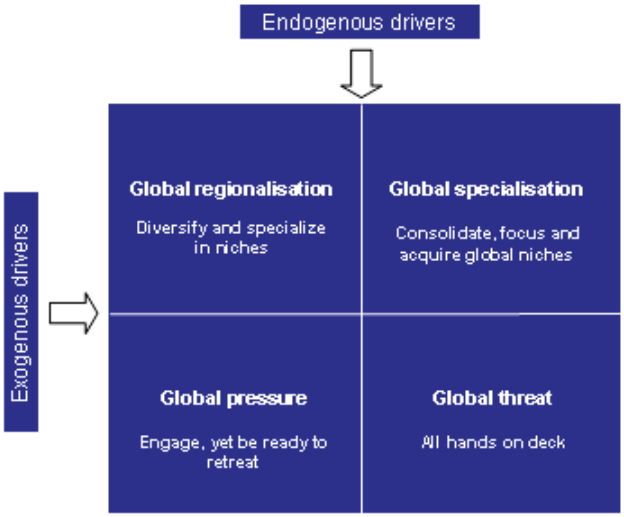
Qualitative Scenarios

This second part of the study consisted of scenario development and their implications for different occupations between 2008 and 2020. In a first step the drivers identified in the workshop were clustered in relevant exogenous and endogenous drivers to construct the scenarios. Endogenous drivers were defined as to represent factors that can be directly influenced by EU policies. For each sector 3-4 scenarios were developed (see example from the chemicals, pharmaceuticals and rubber and plastic products sector below).

Implications of scenarios

Scenarios were built to assess the implications for the level (absolute demand) and composition (relative de-

mand compared to other job functions) of employment. Additionally, new and emergent skills required by different job functions were identified using, as before, standardised tables to ensure comparability between job functions and sector studies.



Rather than producing a full and exhaustive list of all competences required for each job function, the key focus was on identifying and describing key and critical competences for the future. For that, job functions were derived from the Eurostat Labour Force Survey (LFS) based on four criteria: employment shares; closely related job functions; the strategic role in the sector; as well as emergent job functions not yet covered and/or brought fully to light by current statistics. In a further step, tables for each job function inquiring about emergent skills were assessed by sector experts. These formed the basis for the strategic choices subsequently identified.

Strategic choices to meet emergent competence needs

Each sector study assessed possible strategic choices in terms of feasibility and actor involvement, based on a standardized list of 13 options. The options comprised recruiting workers from other sectors, countries (EU & non-EU), recruiting graduates, training employed workers as well as changing work organization. Additionally, options requiring action from sector organisations, educational institutions and governments, included adapting vocational education and training, provide better information and improve cooperation between actors, were assessed.

Generally, rather than focusing on one single solution, a set of linked strategic choices is prime in most cases. Prioritising both in time and in allocation of resources is necessary to guarantee that skill needs are targeted and solved. Skill needs can be identified at various levels, ranging from assessments at the national or even European sector level - which are by nature rather general - to more precise assessments at the regional and company level. Especially for large enterprises not only the identification of skills needs but also the search for adequate solutions will be an integral part of an overall longer-term business strategy. Some solutions will be found within the company itself, for instance by reorganising functions within or between plants, by offering (re)training trajectories and by active global sourcing of personnel. For SMEs, and especially for micro-enterprises, such longer-term, more strategic human resource management often will be more difficult to put in practice. It is to emphasize that at all levels, a range of actors need to act, preferably in close concert.

Skills needs, skills shortages and skills gaps defined

Emergent skills needs are defined here as the change in skills that is needed to adequately fulfil a certain job function in the future. Addressing emergent skills is needed in order to avoid skills shortages and/or skills gaps in the future.

Skills shortages exist where there is a genuine lack of adequately skilled individuals available in the accessible labour market. A skill shortage arises when an employer has a vacancy that is hard-to-fill because applicants lack the necessary skills, qualifications or experience.

Skills gaps arise where an employee does not fully meet the skills requirements for a specific job function but is nevertheless hired. This skills gap needs to be closed through training. Skills gaps can arise where new entrants to the labour market are hired and alt-

Recommendations

Each sector study contains specific recommendations to the sector to be published by the EC in spring 2009. But with the studies analysing Europe as a whole, the recommendations remain general and need further action at national and regional level. The intention of the project especially in the follow-up phase is to stimulate stakeholders at lower territorial levels to work out results in more detail, rather than providing standardised solutions. However, with many industry sectors experiencing similar pressures from globalisation, some general tentative recommendations can be distilled:

Intensify co-operation between relevant stakeholders

The challenge to overcome sectoral skill gaps and shortages will only be met sufficiently if industry, re-

search institutions, training providers, social partners and public authorities act in close concert, both at the national and the European level.

Invest strongly in human capital

Enhanced investment in human capital is required. Cost sharing mechanisms between actors, such as public authorities, companies and individuals, need to be developed and lifelong learning throughout the life cycle promoted: learning must be made more attractive to all, e.g. via tax incentives.

Standardize regulations

Environmental, health and safety regulation (sector dependent) differ in many European countries lowering the possibilities for job mobility (migration) and posing additional training costs for workers moving between countries. Standardization potentially increases labour mobility within Europe.

Attract top international talent through universities

European universities enjoy a good reputation, attracting considerable international talent. This opportunity should be used to keep top talent in Europe in research and industry. The search for excellence in university education and research should be continued and further stimulated. Strict immigration regulation currently makes it difficult for the sector to keep the wanted talent. An effective EU 'blue card' could enhance further mobility of top talent in Europe. At the same time, attracting asnd keeping top talent requires more flexibility from national governments and cooperation between universities and the sector (firms).

Enhance VET to increase social mobility

Social mobility in many European countries is low with the VET system playing a key role for people to move up the social ladder. It is especially important to exploit the potential of late developers that in the first instance did not reach tertiary education. For that the VET system should be enhanced to facilitate the option for people to continuously up-skill especially in light of lifelong learning.

Coordinate National and European Vocational Qualifications

With different VET systems in Europe having their own merits they are not possible to standardise. But there is s strong need for coordination to increase labour mobility. One option is to complement the European / National framework already in place with a sectoral framework.

Diversify personnel and take positive action

Female workers as well as ethnic minorities are still greatly underrepresented in certain sectors (e.g. chemicals). A main recommendation therefore is to implement an active strategy of diversification of personnel in all job functions. This goal is to be met through a broadening of the recruitment scope.

Next steps

While this project provides a full sectoral analysis on future jobs and skills, the most important thing is to implement actions. For that it is crucial to see the results so far only as a first step in a much longer ongoing process. Several actions are foreseen for the dissemination of the results:

1) As part of the Restructuring Forums organised by the European Commission, a large **forum** in the 2nd half 2009 will present key findings to European social partners and public authorities at all levels;

2) **"National" seminars** in each EU country will bring together stakeholders of the sector. About 100 representatives of education and training institutions, national, regional and local authorities relevant for the sector as well as national social partners will be invited. The seminars will provide the opportunity to discuss the results of the studies and have an exchange of views on their possible adaptation to national and local contexts.

Beyond specific steps, in the long run these forward looking assessments should be performed regularly, with the key stakeholders of the sector (e.g. companies, social partners, local authorities) building partnerships and develop joint actions with a common goal of adapting the management of human resources to face future needs. Furthermore, in addition to the sector studies, as a follow-up links between sector activities will be identified to depict possible labour movements between sectors. This study will be launched in 2009, once the sector studies have been completed.

Sources and Links

It is planned to publish studies on the DG EMPL website *Anticipedia*, the new tool to pool all relevant information related to the anticipation of change as well as a forum for stakeholders concerned by this issue.

TNO – New Skills and New Jobs
http://www.tno.nl/content.cfm?context=markten&content=markt_nieuwsbericht&laag1=280&item_id=2008-07-17%2018:15:53.0&Taal=2

European Commission links

New Skills and New Jobs: http://ec.europa.eu/social/main.jsp?catId=568&langId=en
Responding to economic change - Restructuring: http://ec.europa.eu/social/main.jsp?catId=103&langId=en

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EFONET: Assessment of Energy Foresight in the EU

Foresight Brief No. 163

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Type: Energy Foresight Network
Organizer: ISIS – Istituto di Studi per l'Integrazione dei Sistemi
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Purpose

Within the EFONET Coordination Action, an analysis of the state of the art of energy foresight activities in the EU countries has been carried out in order to assess the transferability of the "good practices" learnt from the national foresight experiences towards energy foresight on the European level.

State of the Art of Energy Foresight in the EU

EFONET set out to assess the contribution that current knowledge on energy foresight methods and their practical application can provide to policy making to support the EU vision(s) for a medium and long-term transition to a sustainable, secure and low carbon energy system.

To this end, EFONET also aimed to provide an overview of foresight cultures and dynamics across the EU by reviewing the state of the art of energy foresight in selected European countries. Accordingly, national experts prepared a series of country reports (CR) to provide an updated picture of the energy foresight approaches and practices in the respective countries by illustrating lessons learnt and highlighting strengths and weaknesses identified in applying energy foresight methods and tools.

Coverage of Twelve EU Countries

The countries were selected in order to ensure a good geographical coverage of the EU, taking into consideration the heterogeneity of foresight culture and practices across European countries and that current energy systems as well as future technologies vary considerably from country to country.

Ultimately, twelve CR have been provided. Specifically, reports are available for Czech Republic, France, Germany, Greece, Ireland, Italy, Lithuania, Norway, Poland, Romania, Spain and the UK. Moreover, an overview of the different energy foresight studies and processes at the EC level has been carried out.

Heterogeneity of National Foresight Experiences

In the last few decades, a strong dynamic in the energy foresight activities across the EU has been noted **together** with a growing role of energy foresight in strategic national planning, although foresight competencies and experiences vary considerably across the individual countries mostly due to different cultural, historical and social backgrounds. In particular, some countries feature a lack of energy foresight experience or in any case of strategic energy planning while for several countries future-oriented studies in the energy field have been regularly performed and their results broadly used for the elaboration of national strategies. The UK seems to display the best available practice in running foresight studies and implementing their results.

Early national foresight exercises aimed mainly to identify future developments in science and technology while the most recent foresight practices are based on a much wider approach that attempts to integrate a broad range of aspects (i.e. environmental, economic or social) that nowadays are deemed to be included into the process although rather difficult to quantify.

Significance Not Yet Acknowledged at EU Level

The European Commission started supporting research on energy foresight in the early 1970s. Those works mostly focused on modelling techniques (e.g. optimization, partial equilibrium, bottom-up and back-casting models). In spite of nearly four decades of foresight activities, energy foresight-based policy making has not yet reached the desired state of application at the central EU level. On the other side, the objectives and rationale behind the EU-level foresight exercises vary, notably including rational decision making, identification of new technologies and communication.

Cross Country Evaluation

Based on the CR provided, a cross country evaluation analysis of energy foresight studies and methodologies has been carried out with the twofold goal of

identifying success and failure factors emerging from national energy foresight experiences and

determining good practices in view of the possible transferability of proven approaches both at the European level and for the benefit of the individual member states (MS).

To this end, a workshop "Lessons learned from national energy foresight exercises" was organized in April 2009 at the University of Athens to gather consensus on the main issues arising from the review of country reports and consequently to provide inputs for the transferability analysis. About 30 experts participated in the debate.

Looking for Best Practice

The cross evaluation procedure was based on selected evaluation criteria aimed at covering the five foresight dimensions of the foresight process that have been considered important:

Background: an overview of the cultural and institutional background and the authority initiating the foresight exercise (i.e. private or public, government/ministry).

Objectives and decision support: the specific purpose of the foresight exercise and the related decisions to be supported (e.g. R&D policy, climate change policy etc.).

Topics covered, for instance, technology costs, energy costs, environmental effects of energy use, security of supply, geopolitics, social questions etc.

1. Methodology applied (e.g. quantitative, qualitative, participatory; forecasts vs. scenarios, explorative or normative) and the level of decision makers' involvement.
2. Success: shortcomings and success factors of the exercise. Viability of the methodological concepts.

Motivation for Energy Foresights

Setting the framework for future energy sector developments seems to be the most frequent reason stimulating energy foresight initiatives. Notably, the identification of technologies is of strategic importance to a given country. Ireland, Greece and Poland have largely carried out energy foresight studies focusing on technological developments. Specifically, this issue is strongly related to problems of security of supply across the European countries, depletion of fossil fuels reserves and the subsequent risk of an unstable energy supply.

In recent years, the increasing environmental awareness, especially in the field of global climate change caused by the high carbon footprints of the European national economies, is also becoming a crucial factor in launching energy foresight processes (e.g. two UK foresight studies focus on the decarbonisation of the economy[1]). On the other side, economic objectives usually refer to the optimization of the costs of energy production and the costs to be faced in the transition to a low-carbon economy; other issues concern, for instance, attracting foreign investors for the development of the energy sector (e.g. emerging countries like Romania).

Moreover, the need for policies and strategies at a more general level can support not only the elaboration of the national energy plans but can also provide relevant input for the formulation of other policies and the investigation into future R&D strategies. Finally, mapping the current energy market situation usually creates the base ground and the starting point of all energy foresight exercises, but the survey carried out indicates that it can also be a specific objective of the foresight study itself. Mapping for exploratory purposes has been conducted in Greece.

Shortcomings and Success Factors

The review of the national energy foresight experiences showed a number of shortcomings and success factors that provide useful input for the planning and running of future foresight activities. They main findings are the following:

Process initiation and institutional setting: a clear and appropriate institutional setting is a prerequisite for robust foresight exercises that otherwise can incur many methodological and organizational problems and lead to biased outcomes (i.e. "scienticism" when too many scholars are involved and "corporatism" when too many participants representing interests of a particular group of stakeholders are involved). An inappropriate institutional setting, mostly due to inexperience, can also result in poorly structured

1 Decarbonising the UK – Energy for a Climate-Conscious Future (Tyndall Centre for Climate Change Research, 2005) and UK Hydrogen Futures to 2050 (Tyndall Centre for Climate Change Research, 2004)

coordination, insufficient collaboration and a lack of continuity of the foresight process. At present, there is no country in Europe that has established independent bodies within the policy-making system explicitly in charge of foresight.

In many cases, government or national agencies are responsible for launching energy foresight exercises. Notably, the level of authority mainly depends on the topics and fields of interest; at the same time, the wide scope of energy-related issues can lead to process initiation involving different ministers and governmental agencies (e.g. Poland, Czech Republic and Spain). In some countries, an official national foresight programme exists, like in the UK, and has been directly instrumental in creating a common platform for a wide range of foresight activities. When the foresight process aims at setting R&D strategies, it is primarily initiated by the scientific and education ministries (e.g. Spain, Germany).

Involvement of stakeholders: the lack of involvement of external stakeholders appears to be the most evident weakness. The direct engagement of stakeholders starts from the exercise design process through workshops and panels to final document preparation. The indirect participation usually takes place by partial process participation, e.g. as experts in Delphi surveys. Engagement of the decision makers seems to be necessary throughout the whole foresight process, including panel discussions and other participatory activities. It leads to a comprehensive perception and understanding of the issues arising during the foresight process, thus providing a basis for sharing responsibility for the final outcomes and their implementation. Participatory foresight experiences have been mainly identified in the UK, Ireland and Greece case studies. Policy and decision makers were involved in some of the exercises as sponsors or members of expert panels. In other cases, stakeholders were involved through workshops and consultation processes.

Methodological aspects: Explorative and normative approaches are the most common ones that have been used. Each of them employs different techniques for gathering initial input data, integrating them into scenarios and checking for consistency. Among the wide range of methodological approaches applied, some relied on purely quantitative modelling using tools like MARKAL, GEM-E3, WASP and MESSAGE, which generally apply the normative backcasting scenario building technique. The inclusion of such an approach in foresight activities is being discussed due to the fact that quantitative modelling usually results in linear (or at least continuous) predictions of future developments in which other factors also play a crucial role. However, the results of the quantitative modelling are more understandable and the visions generated are usually more complete compared to qualitative approaches.

Undoubtedly, the inclusion of social and economic changes as well as geo-political aspects into foresight is a very challenging task; nevertheless feasible options already exist, like the Delphi surveying techniques already used in the Greek and Polish national energy foresight exercises and on the EU level in the Eurendel project.

Most of the foresight exercises analysed have employed methodologies integrating quantitative tools with qualitative methods, like expert panels, brainstorming, workshops, literature review and SWOT analysis. In some examples common semi-quantitative methods, that is Delphi surveying and cross-impact or structural analysis, were also applied. The benefits of the integration of qualitative forecasting with quantitative modelling are immediately evident when evaluating foresight exercises carried out in the UK and Ireland.

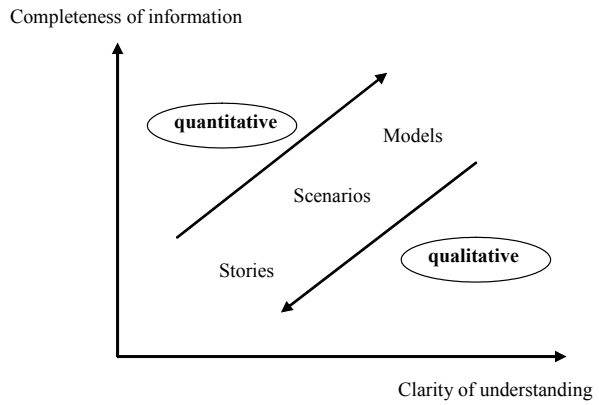

Fig.: Quantitative vs. qualitative modelling

It is important to highlight three other evident methodological weaknesses: i) the use of (pre)existing scenarios can produce duplications of mistakes made in the studies the scenarios were taken from; ii) a fair amount of subjectivity in the methodology applied by purposeful exclusion of specific groups of technologies or thematic areas; iii) national experiences indicate that models are frequently used beyond the limits of their validity, whereby short-term models are often applied to generate long-term forecasts and vice versa.

As far as data availability is concerned, poor data quality seems to be particularly significant for countries with quite weak foresight experiences (e.g. Czech Republic, Lithuania); most of the energy and economic data used in the models originate from EUROSTAT or similar systems (IEA, Enerdata). The review also shows that energy efficiency and renewables are not properly covered by the databases and that there exist only weak interconnections between regional and national policy documents.

Consensus on conclusions constitutes a necessary element for a successful implementation of the project findings. In general, a lack of consensus stems from different points of view of the particular groups of participants on the targeted issues.

Appropriate implementation and dissemination activities are crucial for the concrete utilisation of the results. On the other side, UK experiences show that a project including an action plan can be expected to produce more concrete results and to provide a real chance of monitoring its implementation. The main reasons behind implementation failures across the EU national experiences analysed can be classified as follows:

- Lack of synthesis of final conclusions and recommendations.
- Lack of procedures that would make it possible to transpose results into concrete decisions.
- Lack of continuity after new elections.

Foresight Results Deserve More Acknowledgement at Policy Level

An important observation is that the energy foresight activities as well as foresight-based energy policy making have not yet reached the desired state of application at the central EU level.

Due to accelerated technological and social changes, a new European culture of future-oriented thinking aimed at providing frameworks for strategic policy making is necessary. The new culture should be based on participatory and flexible foresight initiatives in the face of the complexity and large variety of energy issues and objectives.

As far as the institutional setting is concerned, no common EU foresight institution has been designated so far. The open question remains whether a EU energy foresight institution should be formally established at one or the other institutional level of the EU (i.e. Council, Parliament or Commission) or whether the aim should be integrating and engaging all of them in the foresight process.

It seems to be clear that no "one-fits-all" methodological approach exists while it is quite obvious that the methodologies have to be rigorously linked to the foresight objectives. On the other hand, the success of a foresight exercise can only be measured against its specific objective.

Appropriately adopted foresight methodology determines the quality, validity and robustness of its results. The past EC efforts in supporting quantitative tools development should now be consolidated by ***merging qualitative scenarios with quantitative modelling*** since it seems to be the most effective energy foresight option.

It is worth underlining that availability, ***high quality and robustness of databases*** on energy, economic as well as technological aspects, especially for what concerns energy efficiency and new emerging technologies (i.e. renewables) are needed. Accordingly, further efforts are required to free results as much as possible from bias arising from limited assumptions and to develop data standardization, which is crucial to keep the information derived from different sources homogenous.

Clear methodological assumptions of the whole foresight process should be transparent both for the foresight exercise participants and for all people interested including the final foresight outcomes' users.

An important issue highlighted in this cross analysis is that the foresight activities seem to be becoming ***increasingly participatory.*** The involvement of a broad range of stakeholders from different scientific, industrial or societal sectors and civil society has led to significant changes in the methodologies applied and in the nature of foresight results. The interaction between the participants can stimulate the development of new and innovative ideas and thematic synergies by building interdisciplinary perspectives. The collaboration of different "competitors" can lead to several conflicts; therefore the challenge remains of how to optimize their interaction while avoiding irritation, redundancy, blockades and language or cultural barriers in transnational exercises. This is particularly significant when thinking about EU-level foresight initiatives.

The various energy-related foresight activities across the Europe show that the ***implementation of the foresight results*** should not only be considered as the phase mechanically following formulation, rather it should be conceived as an integral part of the whole foresight process. Strong engagement of policy makers in the whole foresight process is essential also for the execution of its results due to the fact that the implementation of the foresight outcomes inevitably requires legislative measures.

On the same hand, ***monitoring of foresight results*** should be an integrated feature of foresight initiatives to fully assess the suitability of the applied approaches and to avoid mistakes in future activities. To this end, disseminating foresight results as widely as possible is a crucial element. Finally, ***learning processes*** are important to raise awareness of many relevant aspects both at the national and European level. While expertise on quantitative modelling appears to be rather well developed, it is evident that issues connected with "soft" aspects of tools and methodologies for foresight process (i.e. scenario planning, combining quantitative and qualitative approaches, methods and management of the relationship to decision making) are rather poorly developed and show many gaps.

Sources and References

This article is based on the EFONET Deliverable "Summary Country Reports: State of the art of MS energy foresight – transferability to European energy foresight" drafted by GIG - Glowny Instytut Gornictwa in cooperation with IZT - Institute for Futures Studies and Technology Assessment and ISIS – Istituto di Studi per l'Integrazione dei Sistemi.

Other documents and presentations are available on the EFONET website www.efonet.org.

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Global Technology Revolution China

Foresight Brief No. 165

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Type: Technology foresight within the local and regional context

Organizer: RAND, Richard Silberglitt richard@rand.org

Duration: 2007-2008 **Budget:** N.A. **Time Horizon:** 2020 **Date of Brief:** Dec 2009

Purpose

The purpose of this study was to identify emerging technology opportunities that the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA) in Tianjin, China could incorporate into their strategic vision and plan for economic development through technological innovation, to analyze the drivers and barriers that they would face, and to provide action plans for implementation.

China's Next Regional Engine for Economic Growth

The Tianjin Binhai New Area (TBNA) consists of 2,200 square kilometres along 150 kilometres of coastline in the municipality of Tianjin in northeast China. Tianjin municipal authorities first established this locality in 1994. At that time an arid, undeveloped area, TBNA was given the ambitious task of spurring industrial growth in Tianjin. In little more than a decade, it has become home to 1.4 million people, northern China's largest container port, and a broad base of industry and manufacturing.

In 2006, China's State Council named TBNA a "special pilot zone" with a mandate to become the country's next regional engine for economic growth. Now reporting directly to the State Council, TBNA is expected to invigorate the economy of the northeastern Bohai Rim region in the same manner as Shanghai and Suzhou did in the Yangtze River delta area and Guangzhou and Shenzhen in the Pearl River delta area.

The Tianjin Economic-Technological Development Area (TEDA) is one of three administrative zones in TBNA. It is also TBNA's industrial and manufacturing base and the centre of TBNA's financial and commercial activities. TEDA is to play a key part in the economic growth envisioned for TBNA. Established in 1984, TEDA is today a bustling industrial-park complex. It possesses a robust manufacturing base, with pillar industries in electronics, automobiles and parts, food processing and biopharmaceuticals. Many of the world's Fortune 500 companies, top Chinese firms, and other leading multinationals have strong presences in TEDA.

A Vision of the Future for TBNA and TEDA

The State Council envisions TBNA becoming a centre in north China for leading-edge research and development (R&D) and technology incubation, first-class modern manufacturing, and international shipping and logistics. At the same time, the State Council intends for TBNA to lead efforts to address many of China's most urgent national problems, such as rising energy demands, a growing scarcity of usable water supplies and gravely escalating urban pollution. Thus, TBNA is to present an alternative to the traditional industrial economy, shaping a model of sustainable development and eco-friendly industry.

Innovation in science and technology (S&T) stands at the core of this vision of economic and environmental development, particularly of cutting-edge R&D. TBNA will need to take definitive steps to pursue this goal, and TEDA will be at the forefront of this effort. Building on its existing manufacturing base, TEDA aims to transition from a successful industrial-park complex into a state-of-the-art science and engineering (S&E) centre for high-impact emerging technologies. Other enterprises with relevant capacity located elsewhere in TBNA will follow

suit. The desired end result is innovative R&D that meets international standards and positions TBNA as a global technology leader.

The Role of this RAND Study

Early in the process of developing a strategic plan for this ambitious transformation, senior managers from TBNA and TEDA found a 2006 report by the RAND Corporation, The Global Technology Revolution 2020: Bio/ Nano/ Materials/ Information Trends, Drivers, Barriers, and Social Implications. (Referred to hereafter as GTR 2020. See EFMN Foresight Brief No. 90). This report presents a comprehensive foresight analysis that identifies technology applications (TAs) most plausible by 2020, those countries capable of acquiring them and their likely effects on society.

Having reviewed GTR 2020, TBNA and TEDA managers approached RAND to conduct a foresight study designed specifically for their purposes. They commissioned RAND to do the following:

- Identify promising emerging TAs for TEDA and other high-tech centres in TBNA to implement as a pivotal part of TBNA's overall strategic plan for economic growth.
- Identify the capacity needs to implement these TAs as well as the critical drivers and barriers that might facilitate or hinder implementation.
- Develop a strategy and action plan for each TA.
- Provide guidance on how these TAs might fit into an overarching strategic plan for TBNA's economic development.

Incorporating Local Context and Current Realities

The analysis leading to the selection of TAs and, eventually, the strategies and action plans for them took into account four principal factors:

- TBNA and TEDA's missions as mandated by China's State Council,
- China's pressing national needs,
- drivers and barriers to technological innovation in China as a whole and for TBNA more specifically and
- relevant capacity currently available to TBNA and TEDA both locally and more broadly in R&D, manufacturing and S&T commercialization.

The starting point was the 12 TAs identified in GTR 2020 as those that China could acquire by 2020. This was combined with a rigorous study of the realities, circumstances and issues in TBNA and in China more broadly, drawing on a diverse array of Chinese- and English-language sources:

- Chinese- and English-language documents describing the mission, history and current status of TBNA and TEDA,
- Chinese- and English-language literature on China's social, environmental and economic needs, and measures that the Chinese government has taken to date to address them,
- on-site interviews in TBNA, TEDA, the Tianjin Port, the municipality of Tianjin more broadly and the city of Beijing,
- visits to S&T institutions that could provide capacity outside TBNA and TEDA, such as Tsinghua University and the Chinese Academy of Sciences and
- a two-day workshop in TEDA with key figures from TEDA scientific institutions, firms and management.

Emerging Technology Opportunities for TBNA and TEDA

- Based on analysis of the above sources, the authors narrowed the 12 TAs identified in GTR 2020 down to a final selection of seven. These either come directly from GTR 2020 or are hybrids combining one or more of the original 12.

1. ***Cheap solar energy:*** Solar-energy systems inexpensive enough to be widely available to developing and undeveloped countries as well as disadvantaged populations.
2. ***Advanced mobile communications and radio-frequency identification (RFID)***: Multifunctional platforms for sensing, processing, storing and communicating multiple types of data. RFID involves technologies that can store and wirelessly transmit information over short distances.
3. ***Rapid bioassays:*** Tests to quickly detect the presence or absence of specific biological substances with simultaneous multiple tests possible.
4. ***Membranes, fabrics and catalysts for water purification:*** Novel materials to desalinate, disinfect, decontaminate and help ensure the quality of water with high reliability.
5. ***Molecular-scale drug design, development and delivery:*** The abilities to design, develop and deliver drug therapies at the nanoscale to attack specific tumours or pathogens without harming healthy tissues and cells and to enhance diagnostics.
6. ***Electric and hybrid vehicles:*** Automobiles available to the mass market with power systems that combine internal combustion and other power sources.
7. ***Green manufacturing:*** The development and use of manufacturing processes that minimize waste

and environmental pollution and optimize the use and reuse of resources.

Drivers and Barriers to Implementation

Widespread, sustainable implementation of any TA depends on the balance between the drivers that facilitate implementation and the barriers that hinder it. The factors considered that will most influence China's ability to successfully pursue cutting-edge R&D and technology innovation were:

- the country's needs,
- its national R&D policies,
- other national policies that could generate demand (or, as appropriate, reduce demand) for certain TAs,
- intellectual property rights (IPR) protection,
- finance and banking laws and regulations,
- local policies, laws and regulations that could directly affect the ability of individuals and organizations to conduct cutting-edge R&D and commercialize innovative technologies,
- human capital and
- culture of R&D and innovation.

These same eight factors will most affect TBNA's ability to develop and implement the selected TAs. Some of these are clearly either a driver or a barrier throughout most of China. But occasionally, local circumstances make them stronger or weaker drivers or barriers in a particular organization or region (or for a specific TA) than they are elsewhere in the country.

Several of these factors are unmistakable barriers in TBNA and hold for all seven TAs. IPR protection, for example, remains a barrier in TBNA, as in China as a whole, to both homegrown innovation and the involvement of foreign capital and talent in new R&D and technology ventures. Finance and banking laws and regulations are also a barrier in TBNA, as they are in China generally, because they discourage investment of venture capital. But, for certain of the seven TAs, sources of venture capital available to TBNA for specific technologies mitigate this barrier to some degree. Lack of a culture of R&D and innovation is a third barrier in TBNA, as it is in China as a whole. It discourages the risk-taking in new ventures that is essential to pursuing and commercializing groundbreaking R&D.

TBNA has one driver that all seven TAs share: human capital. This stems from the strength of TBNA's current manufacturing base, the corresponding workforce and the concentration of academic institutions in the municipality of Tianjin. However, young Chinese people are tending to shy away from technical and vocational training, and domestic competition for S&E talent is heated. Both of these could be mitigating factors.

Capacity Currently Available to TBNA and TEDA

To fulfil the State Council's mandate, TBNA and TEDA will need capacity in three areas: (1) R&D, (2) manufacturing and (3) S&T commercialization. Both local capacity—in TBNA, TEDA, and the municipality of Tianjin more broadly—and that from elsewhere in China and internationally will play a part.

In terms of R&D capacity, TBNA and TEDA have a growing number of institutions that provide cutting-edge research facilities and a professional cadre of highly trained scientists and engineers. But they face intense competition, both within China and abroad, for human capital of this calibre.

With regard to manufacturing capacity, TBNA and TEDA have a substantial industrial base that has been growing for the nearly 25 years since TEDA's inception. Investment by an array of Fortune 500 companies, a track record of increasing industrial output and a rising gross domestic product (GDP) indicate the strength of this base. TBNA is also steadily improving the physical infrastructure—utilities, cargo facilities and waste-management processes—that are vital to manufacturing capacity. But a potential shortage of the skilled labourers and technicians needed to work in manufacturing and, again, heightened competition for those on the job market are real challenges.

As for S&T commercialization, TBNA and TEDA operate a well-established network of research parks and technology incubators aimed at supporting emerging high-tech enterprises. Ample financial incentives help spur development and attract human capital. Yet, these enterprises face considerable challenges due to China's need to better protect IPR and reform finance and banking laws and policies. They also lack strong linkages between R&D institutions and commercial industry to facilitate the transfer of high-tech products to the market.

Strategy for Building TBNA's Future

Implementation Strategies for the Selected TAs

China already has a well-developed first-generation solar-electricity industry. Consequently, the best opportunity for TBNA and TEDA in ***cheap solar energy*** lies not in entering the first-generation market but rather in becoming an R&D and manufacturing centre for second- and third-generation systems, initially for the global export market.

TBNA should aim to become an R&D and manufacturing centre for ***mobile communication devices and RFID sys-***

tems. It should focus initially on the domestic Chinese market and then broaden to the global market. In addition, it should build state-of-the-art R&D programs in two component technologies: displays and power sources.

The long-term strategy is for TBNA to become a leading player in the global marketplace for state-of-the-art rapid bioassays. But its initial focus should be on using licensing and partnership agreements to attract leading companies to TBNA and TEDA.

Long-term goals for TBNA are: (1) to become a centre for R&D in nanoscale ***membranes, filters and catalysts*** and (2) to become a leader in manufacturing state-of-the-art membranes for purifying water. It is vital for TBNA to foster close relationships between research labs and private companies to facilitate commercialization.

TBNA should aim to become a centre for R&D and manufacturing of ***drugs developed through bio-nanotechnology***. It should focus initially on attracting investment from foreign enterprises and, in tandem, on aggressively building homegrown R&D capacity. Eventually, it should direct R&D activities toward commercializing novel medical treatments and techniques.

Given the strong market potential of electric- ***and hybrid-vehicle*** components, TBNA should develop and expand collaborative R&D on subsystems and component technologies. At the same time, it should develop the capacity to manufacture hybrid vehicles and components for hybrid and electric vehicles. It should target the growing global market first and the Chinese market later.

TEDA should become a centre for green manufacturing in China. The initial focus should be on attracting to TBNA those companies at the leading edge of green chemistry and engineering. Over time, TBNA itself should start conducting R&D on new green manufacturing processes and, eventually, implement them in TBNA and TEDA.

An Overarching Strategic Plan

The seven TAs should form a pivotal part of TBNA's strategic plan for economic growth through technological innovation. All of the TAs are in line with promising global trends; they are well suited to current capacities in TBNA, TEDA and the municipality of Tianjin and build on existing pillar industries; and they support Chinese government priorities.

Part of the overarching strategic plan should be geared toward addressing broad general challenges that currently stand as barriers to all seven TAs. The plan should include measures to help TBNA and TEDA enforce existing laws in the IPR domain. TBNA and TEDA should incorporate into the plan ample opportunities for cross-fertilization between research facilities and industry. Finally, it is vital that TBNA build a culture of R&D and innovation. The plan should contain elements that promote flexibility and risk-taking in TBNA and TEDA's funded ventures. TBNA could use a three-pronged framework to integrate the specific action plans for the seven TAs into an umbrella strategic plan:

- Develop state-of-the-art R&D capacity in relevant areas.
- Update and expand the existing manufacturing base.
- Build capacity for S&T commercialization.

These three activities would need to be carried out in parallel. Each requires using and expanding existing local capacity and introducing new capacity. Novel advances should stem from and extend the existing capacity base while fresh R&D programs are started and new companies with state-of-the-art capabilities come in to bring overall capacity up to world-class standards. Each will also support the others.

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The World in 2025

Foresight Brief Nr. 167

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Sponsors: European Commission – DG Research – Directorate L – Science, Economy and Society Unit L2 – Research in the Economic, Social Sciences and Humanities – Prospective

Type: European/international – covering issues from a European or even global perspective

Organizer: European Commission – DG Research – Directorate L – Science, Economy and Society Unit L2 – Research in the Economic, Social Sciences and Humanities – Prospective

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Purpose

DG Research's Directorate for Science, Economy and Society in collaboration with the Bureau of European Policy Advisers launched a foresight exercise on "The World in 2025", which resulted in a report published in January 2009.

The World to Come – Global Trends & Disruptions

The report "The World in 2025" highlights the main trends up to 2025 (demography, urbanisation, macro-economic projections, education, science and culture) and underlines the pressures on natural resources and the new production-consumption patterns while attempting to identify the so-called "wild cards". The role for European foresight and forward-looking activities are presented focussing on a multi-polar world and beyond technological innovation. The report has benefited from the discussions of the group of experts set up by the European Commission in 2008 (see box below).

It has taken stock of the most recent publications in the field of foresight and forward-looking activities and includes most of the reflections of different Commission Directorates-General.

Group of Experts & Scenario Process

DG Research's Directorate for Science, Economy and Society in collaboration with the Bureau of European Policy Advisers (BEPA) launched a foresight expert group on "The World in 2025", which met on five occasions in 2008 and 2009.

The objectives of this group were, first, to assess and measure global trends over recent decades to serve as a basis for forward projections while distinguishing the different major economies and regions, including the European Union, and identifying the main economic, geopolitical, environmental and societal relationships and interconnections.

Secondly, the group was asked to generate and analyse alternative (even disruptive) scenarios of world trends up to 2025 based on specified assumptions about economic, political, social, environmental and technological developments in order to assess their consequences for the EU and to examine which policy responses could be appropriate.

Members of the Expert Group "The World in 2025"

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"The World in 2025" group was composed of experts with a profound understanding of global challenges and developments as well as a solid knowledge of foresight in specific countries or regions. Group members included representatives from think tanks, universities, industry, the European Commission and governmental bodies. Meeting five times in 2008 and 2009, the group produced two publications: one collects the experts' individual contributions and the other called 'The World in 2025 – Rising Asia and Socio-ecological Transition' highlights the conclusions.

The experts identified principal trends, tensions and transitions while highlighting strategies that may help policy stakeholders make informed decisions. They also say that competition for natural resources and shifts in wealth, industrial production and populations may lead to tensions over natural resources (food, energy, water and minerals), migration and urbanisation.

Each expert produced an individual contribution to the discussions and, collectively, they generated a set of indicative scenarios for the world in 2025. The experts covered a wide range of issues, including demography, migration, urbanisation, cohesion, macro-economics and trade, employment, services, environment and climate change, energy, access to resources, education, research, technology, innovation, economic governance, defence, security and intercultural dialogue.

The key messages concern the main challenges to be faced in the next fifteen years, the main drivers that could impact on the future, the main strengths and weaknesses of Europe by 2025 and finally the wild cards that may radically change the different situations that are foreseen.

Europe to Face Marginalization

The report "The World in 2025" underlines the major future trends: geopolitical transformations in terms of population, economic development, international trade and poverty. It elucidates the tensions – natural resources (food, energy, water and minerals), migration and urbanisation – and draws transitional pathways towards a new production and consumption model, new rural-urban dynamics and a new gender and intergenerational balance.

Shift towards Asia

By the year 2025, the centres of gravity, wealth and industrial production may shift towards Asia, and the United States and Europe could likewise lose their scientific and technological edge over Asia. India and China could account for approximately 20% of the world's research and development (R&D), that is more than double their current share.

Within 16 years, the world population will reach eight billion, the experts in the report say. Some 97% of world population growth will occur in developing countries. The analysis of demographic growth for 2025 indicates that the European population will only constitute 6.5% of the world population.

2025 Trends

Geopolitical Transformations

Population growth in 2025 up to 8 billion worldwide
61% of world population in Asia, EU: 6.5%
35% of the European population will be older than 60

Geopolitical economic power

30% of GDP produced by Asia, EU: 20%
Asia will be the first world exporter: 35%, EU: 32%
Asia on par with US & Europe in the field of R&D

Scarcity of Natural Resources

Increased population, according to the expert group, may lead to greater scarcity of natural resources and impact the environment. This can result in tension and

shifts in production and consumption patterns and the availability of natural resources.

From these demographic and resource challenges, the report sees a new 'socio-ecological' production and consumption model arising. New technologies (renewable energy sources, capture and storage of CO2, nuclear power, hydrogen and fuel cells) as well as changes in social behaviour, supported by economic incentives, will contribute to a reduction in energy consumption (better house insulation, replacement of environmentally damaging cars with greener options, and increased use of public transport).

The report says that while numerous scientific and technological advances will give rise to controversies in society, Europe, with its wealth of various debate and participative governance experiences, is well equipped to manage them and involve civil society in research. Global access to knowledge, though, together with the development of joint global standards and the rapid worldwide diffusion of new technologies will have a great impact on Europe's future welfare.

It is assumed that by 2025 Europe will be specialized in exporting high-tech products. Although the specific products are currently still unknown, they can be expected to benefit from the rapid growth in Asia whose growth will probably be accompanied by an increasing inequality in the purchasing power of the population. "The increase of the population is already a good indication of the future opportunities of the market, of the consumer aspirations that have not been covered, better than the Gross Domestic Product (GDP)."

Potential Conflicts, Threats and Wild Cards

The report also points to the possibility of future social conflicts emerging in Europe around scientific and technological advancements in areas like cognitive sciences, nanotechnology, security technologies, genetic manipulation, synthetic biology and others.

Among the unforeseeable turbulences that could shape the next two decades, the report identifies seven "wild cards":

1. Persistence of the financial and economic crisis beyond 2010.
2. A major war (for the years 2010-2020 of strong turbulence).
3. A technological disaster that could influence the choices of priorities of governments (e.g. a nuclear accident like Chernobyl blocking the nuclear option for many years).
4. Pandemics with devastating effects.
5. The collapse of a major urban area in a developing country.
6. The blocking of the European Union as a result of the difficulties of establishing new economic governance and political decision mechanisms;
7. A breakthrough in the field of renewable energy production;
8. A new wave of technological innovations and a new rapid growth cycle driven by emerging countries;
9. Sudden or even brutal acceleration of the (nonlinear) impacts of climate change;
10. Progress in the adoption of a world governance system due to the extent of the problems to be dealt with and to the pressure of public opinion.

What Experts Recommend to EU Policy Makers

Key RTD Areas

11. The EU should struggle for maintaining its leadership in key RTD areas, such as technologies of energy saving, research into sustainable development and climate change, health and the containment of diseases, food safety and security in general.

Europe Must Not Fall Behind in R&D

Experts suggest that Europe become a model based on emphasizing quality of life, which might involve maintaining global access to knowledge and guaranteeing or contributing to establishing international standards in science and technology. "To ensure access to knowledge through the global networks also means to be attractive for the researchers and the investment that comes from the outside", the report points out.

From 'Brain-drain' to 'Brain-circulation'

There will be a switch from 'brain drain' to 'brain circulation', and young researchers will be moving to various regions of the world, which will become educational and scientific centres. It is estimated that in 2025 there will be 645,000 Chinese students and 300,000 Indian students outside their countries. In turn, the number of European students that transfer to these two countries can also be expected to grow.

Effective Governance

Europe needs good policy in order to retain its traditionally strong position in developing cutting-edge innovation

that goes beyond incremental improvements of existing technology. It will be essential that some key governance issues are solved. For instance:

1. Set a new 3% target. One in which the EU member states commit themselves to spending 1% of GDP from public funds for research and 2% for higher education by 2020. Its implementation will be under the full control of the national governments.
2. Consider the "Grand Challenges" – a term denoting major social problems that cannot be solved in a reasonable time, under acceptable social conditions, without a strong coordinated input requiring both technological and non-technological innovation and, at times, advances in scientific understanding. In a way, the central issue is the other side of the coin of the previous one. Can resources, not just in terms of research but also procurement and other investments, be shifted across European stakeholders to more productive "societal uses" to influence not only the pace but also the direction of technical change and innovation?
3. Create a strong coordination between research and innovation policies in order to orient innovative activities towards the needs of society. A stage gate approach is suggested, including adequate provision for innovative procurement and pre-commercial procurement practices.
4. Discuss European versus national research policy approaches. The global financial crisis represents a window of opportunity for more radical reflections on the relationship between Community and national research policies. As fiscal pressures mount in each member state, the question of increasing the efficiency of national research funding agencies and of higher education and public research funding is likely to be raised in coming months and years in many countries.

The opportunities for further deployment of new Community instruments will only be realized if they can demonstrate their particular value for Europe in terms of administrative flexibility and best practice governance. Only then will they play a central role in structuring a new, post-crisis augmented European Research Area (ERA).

Will the Looming Crisis Be Averted in Time?

If issues of effective governance at EU level are not addressed as ones of absolute priority, the crisis shock might actually go the other way: increasingly questioning the value of Community research and leading to a future ERA that is much more based on the member states' national efforts at attracting research talent within their own borders.

Outlook: Socio-economics & Humanities Re-considered

The stimulating contributions and discussions of this expert group have paved the way for a broad debate at European and world level. This prospective analysis contributes to understanding, anticipating and better shaping future policy and strategy developments in the European Union.

Forward-looking approaches help in building shared visions of the future European challenges and evaluating the impacts of alternative policies. A qualitative and participatory method ('foresight') combined with quantitative and operational methods ('forecast') allows better long-term policies to develop, like the post-2010 European strategy and the European research and innovation policies. Through its Seventh Framework Programme (FP7) with its 'socio-economic sciences and humanities' theme, the European Union is funding forward-looking activities with around EUR 30 million.

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Forward-looking Activities in Support of ERA Vision 2020

Foresight Brief No. 168

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Organizer: European Commission – DG Research – European Research Area

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Purpose

As a part of the Ljubljana Process of governance of ERA, which was launched by the EU Commission and Council in May 2008, a common 2020 vision for the European Research Area was adopted on 2 December 2008. This vision stipulates that: "[…] by 2020, all actors should fully benefit from the free circulation of researchers, knowledge and technology."(see http://ec.europa.eu/research/era/2020_era_vision_en.html) Forward looking activities are indispensable for promoting the policy process of the ERA vision 2020 in order to speak with one voice, to jointly promote consistency between their R&D cooperation activities, and to develop joint initiatives that give Europe leadership in addressing global challenges and reaching sustainable development goals.(see http://ec.europa.eu/research/era/2020_era_vision_en.html)

ERA Vision 2020

The 2020 Vision for the European Research Area (ERA) was developed in partnership by all member states and the European Commission and in consultation with associated countries. When adopting the 2020 Vision, the Council of the European Union invited member states and the European Commission to communicate it widely to stakeholders and society at large and to quickly focus policies and actions to make it a reality.

By 2020, all players are supposed to fully benefit from the Fifth Freedom across the ERA, which refers to the free circulation of researchers, knowledge and technology. The Fifth Freedom is derived from European Union law where the Four Freedoms is a common term for a set of treaty provisions, secondary legislation and court decisions, protecting the ability of goods, capital, services, people and labour to move freely within the internal market of the European Union. More precisely, they are the free movement of goods, the free movement of capital, the free movement of services and the free movement of persons. The ERA is intended to provide attractive conditions and effective and efficient governance for carrying out research and investing in R&D intensive sectors in Europe. It seeks to create significant added value by fostering scientific competition throughout Europe whilst ensuring the appropriate level of cooperation and coordination. It is envisaged to be responsive to the needs and ambitions of citizens and to effectively contribute to the sustainable development and competitiveness of Europe.

The ERA Vision 2020 is predicated on the insight that good European governance must be based upon strategic forward thinking. This involves defining major societal challenges, underpinning the selection of themes in joint programming and helping to prioritise and focus re-

search, thus laying the groundwork for future-oriented strategic thinking. The ex-ante analysis of societal trends in the world and the European Union on the basis of scenarios and identifying potential breakthroughs ("wild cards") are all elements that allow decision-makers to highlight their choices under a new perspective.

Forward-looking Activities to Promote ERA

The EC, following up on its commitment to help member states better coordinate their research efforts, organised a conference session on forward-looking activities in October 2009 that underpinned the ERA vision 2020. (http://ec.europa.eu/research/conferences/2009/era2009/programme/programme_22-10_en.html)

Experts, representatives of the public sector and directors of DG Research attempted to identify the needs in this field. The participants discussed how a continuous process of forward-looking and horizon scanning activities for ERA could be organised in the future, how to ensure that this approach would lead to a better support and further integration of national research policies in ERA, and what could be the drivers to determine potential "grand challenges" and joint programming priorities.

Three-dimensional Strategy

During the session, Anneli Pauili, the deputy Director-General of DG Research, reflected on the main principle guiding forward-looking activities promoted by the EC, which is to combine three dimensions in these activities: ensuring that the abundance of information provided by experts is taken into consideration, involvement of stakeholders (researchers, companies, NGOs and public organisations), and involvement of relevant politicians to increase the likelihood of results being considered in policy-making.

Added Value through Joint Programming

At European level, there exist various networks, tools and systems to follow up on forward-looking activities. Consensus is growing that European research policy needs to be based on more systematic, continuous, forward-looking and pan-European activities. It is particularly important that member states and associated countries combine their research efforts through "joint programming", which must not be content with simply finding the lowest common denominator but should rather strive to merge different perspectives and multiple visions of the future. Here is the clear link with the Lund declaration[1] that stipulates, "The identification of major challenges must involve the relevant stakeholders, including European institutions, business, public sector, NGOs and the scientific community, and foresee the interaction with international partners."

Tradition of Forward-looking Activities in the EU

Forward-looking activities, whether reflexive or operational, qualitative or quantitative, participative or based on expert opinions, have a long tradition in the European Commission and in many national governments.

In the UK, the government has developed a future-oriented culture in all its departments. The Finnish case (Tekes) is exemplary in its stakeholder participation approach that is linked to Tekes' strategy process. Several other countries in Europe are also engaged in forward-looking activities, including the Swedish Foresight, the French "Futuris", "AGORA 2020" and "France 2025", the Danish "Research 2015" and the German "Foresight Process". These national initiatives range from technology-focussed and expert-driven activities to more socially oriented ones with broader stakeholder participation. They also vary in their objectives, from identifying strategically important technologies for the companies implanted in their countries to more general questions about the role of public authorities and the institutional and societal conditions for socio-economic change.

Forward-looking Activities Support Innovation Policies

In recent years, forward-looking activities have been used intensively to support impact assessment for climate action policies, and there have been unprecedented levels of employing such activities in day-to-day policy-making in many countries and in the EC[2]. Within research and innovation policies, forward-looking activities have a corrective role (addressing deficiencies and systemic failures and policy lock-ins), a disruptive role (encouraging an emphasis on crisis or breakthrough events that can completely change the current status quo), a creative role (stimulating the conditions whereby new networks and structures can evolve and grow) and a more embedded role as an instrument of articulating, structuring and delivering research and innovation policy.

[1] The Lund Declaration (SE), adopted on 9 July 2009 at the "New Worlds – New Solutions" conference, stipulates that the EU must identify the major challenges for which public and private research need to develop sustainable solutions.

[2] Interview with Anneli Pauili, the deputy Director-General of DG Research, Special Issue – Research EU – November 2009, http://ec.europa.eu/research/research-eu/era/article_era40_en.html

Barriers to Networking

The major barriers to networking in the related fields and thus to the integration of national approaches of forward-looking activities are the uncertainty surrounding sufficient funding, the unnecessary rivalry among modelling teams for access to funds and the frequent lack of sufficient size, variety and multi-disciplinarity of modelling teams.

New Wave of Interest in Foresight

The context of crisis and challenges has led to a new wave of interest in foresight, as alternative solutions and promising ways of moving forward are sought. Foresight has now become a pervasive activity at the institutional level to inform programme planning and to support structural change. Its role in EU Framework Programmes (FP) and ERA needs to be grounded in a greater involvement of stakeholders and users to encourage them to take ownership of the exercises. On the supply side, there is a need to maintain and extend the foresight community through support for research and community building activities and to help carry the results beyond their initial audience.

Common Understanding of the Potential of Forward-looking Activities

The ERA Conference 2009 resulted in a common understanding that forward-looking activities can be used in defining the future research activities, the annual work programmes, joint programming and international cooperation. In order to further shape the ERA vision 2020, forward-looking activities will have to

- help reinforce the governance culture by integrating the long-term perspective and giving more space to cross-cutting issues,
- help improve the quality and impact of European, national and regional research policies by comparing findings and methods and, consequently, by contributing to improved policy design and implementation at the European, national and regional level,
- support model development, human capital of modellers and long-lasting capacity and network of models, modellers and databases on a transnational basis.

To be successful, forward-looking activities need the commitment and involvement of the initiator.

Improving Foresight in Research and Policy

Better Networking and Sharing of Resources

For the future of the European Research Area (institutional, organisational, methodological, etc.), networking and sharing of resources (data, mathematical methods, policy advice experience and skills) are very important, provided that the network has some degree of variety and stability over time.

Better coherence – which does not mean harmonisation or standardisation – among forward-looking exercises at various levels, better access to each other's knowledge, sharing and networking would support future decision-making. European forward-looking activities should not be limited to the aggregation of national forward-looking activities but should be set up as a truly European project, preferably putting together interoperable visions that can be exploited by decision-makers.

Interoperable Visions: European Technology Platforms

The forward looking approaches of some European Technology Platforms are good examples for such interoperable visions. The European Technology Platforms provide a framework for stakeholders, led by industry, to define research and development priorities, timeframes and action plans on a number of strategically important issues where achieving Europe's future growth, competitiveness and sustainability objectives is dependent upon major research and technological advances in the medium to long-term. They play a key role in ensuring an adequate focus of research funding on areas with a high degree of industrial relevance, by covering the whole economic value chain and by mobilising public authorities at national and regional levels. As such, they are proving to be powerful actors in the development of European research policy, in particular in orienting the FP7 programs (including the “Cooperation Programme”) to better meet the needs of industry.

The Concept of Technology Platform

“Technology Platform (TP) is a mechanism to bring together all interested stakeholders (public research, industry, financial institutions, users, regulatory authorities and policy-makers) to develop a long term vision to address a specific challenge, create a coherent, dynamic strategy to achieve that vision and steer the implementation of an action plan to deliver agreed programmes of activities and optimise the benefits for all parties.” (Investing in Research: an Action Plan for Europe, COM (2003) 226, cited in Jurimae 2009)

The following are some examples of technology platforms with a forward-looking approach for 2030 and beyond:

- European Biofuels TP (EBTP)
- European Construction TP (ECTP),
- European Steel TP (ESTEP)
- Forest-based sector TP (FTP)
- European Photovoltaic TP
- European TP on Sustainable Mineral Resources (ETP SMR)
- Sustainable Nuclear Energy TP (SNE-TP)
- European Wind Energy TP (TPWind)
- Water Supply and Sanitation European TP (WSSTP)

Maintain Continuous Process

- A continuous process of integrated forward-looking activities should be organized (joint programming), comprising cooperation between policy-making EU Directorate-Generals and ERA in order to make sure that forward-looking analytical capacity is established, well networked and disposes funding to ensure high quality and state-of-the-art methods. It is important thereby to ensure continuity and stability to modelling teams. Optimise Integration of Foresight in Governance Processes
- A lot of work has been done at the European level in the "research" component of forward-looking activities but a lot has still to be done in the "policy" component of those activities; that is, "foresight" done by researchers and experts should be better integrated into the policy-oriented foresight process where policy-makers and stakeholders (including citizens) should participate.
- Forward-looking methods have to be combined and integrated as much as possible in the "policy cycle", taking stock of appropriate structures for defining research agendas, such as the European Technology Platforms and Social Platforms. Policy-makers, stakeholders (ministries, universities, industries, research centres and civil society organizations) should participate and work together. Both bottom-up (researchers, experts) and top-down (policy-makers) involvements are needed. Endogenous technology dynamics including their complex interactions with society, economy and energy have to be applied.

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Future Scenarios for the Spanish Sustainable Development Model

Foresight Brief No. 172

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Purpose

This brief report describes a scenario design exercise undertaken to study the future evolution of the sustainable development paradigm and its possible implications for the Spanish development model. For this purpose, three scenarios were built for a time horizon extending to 2025, displaying possible alternative economic, energetic, technological and environmental contexts. Finally, scenario implications were determined for the social, economic, territorial and governance models in the Spanish context.

Is Spain Ready for a Sustainable Lifestyle?

Since the Brundtland Commission defined sustainable development (SD) as "the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987), this concept has gained universal acceptance among the general public. Moreover, a growing number of socio-economic and political agents are said to be conscious about the need of pursuing more sustainable urban development. However, the relative novelty of this concept and the fact that it has only recently gained widespread social acceptance have not yet permitted to assess with rigour the reciprocal relations that might develop between the sustainable development paradigm and general behaviour in society.

Although nowadays many public administrations and private companies are assessing the implications of sustainable development in their daily activities with more or less intensity, there is not much relevant research about future citizen behaviour toward the SD concept. The lack of studies on this issue may be explained by two major difficulties: unmanageable complexity and high uncertainty.

The first difficulty is due to the diverse and complex behaviour of social groups toward sustainable development in their daily or sporadic vital activities. This level of complexity is aggravated by the fact that the sustainability paradigm also influences and transforms patterns of social behaviour. In other words, we are faced with a circular relation where social attitudes affect sustainable development while the paradigm in turn induces certain types of social behaviour. We must therefore recognise the unquestionable difficulty of assessing the impact of the concept of sustainability on our development models.

The second difficulty refers to the existing high level of uncertainty whenever the future evolution of social behaviour is to be predicted with regard to the sustainable development issue in advanced and prosperous societies. Even if we know the principles and values that presently guide the vital functions of social

groups in a certain territory, they can fairly easily change in a short period of time, breaking with historical patterns. Additionally, there is a tendency to ignore the future evolution of environmental factors such as climate change or the availability of energy resources, which surely will significantly influence social behaviour. Therefore, any attempt at anticipating a single and officially accepted scenario of the future of socio-cultural behaviour patterns, economic systems, governance models, and land use patterns in contemporary societies suffers from a lack of plausibility.

What Business Opportunities Can Sustainability Bring?

The study pursued three major objectives:

(1) to design global scenarios for the future evolution of social behaviour toward the sustainable development paradigm in a 15-20 year horizon;

(2) to determine the implications of the scenarios for Spain's development; and

(3) to identify new business opportunities involved in providing goods and services related to the concept of sustainability.

Constructing Future Scenarios

From the existing foresight tools, scenario design was chosen to carry out this research project because it most adequately allowed taking the complexity and uncertainty of social behaviour toward sustainable development into consideration while it at the same time enabled unfolding alternative futures. A scenario may be defined as a tool for arranging perceptions of the future, thus helping to shape an outlook with a wide perspective in a world of great uncertainty. This foresight technique is eminently qualitative; it combines intuition and rational analysis, and it usually requires the collaboration of a group of experts.

The chosen method for this foresight exercise was organised sequentially in four stages (see Figure 1): (1) characterise the sustainable development concept; (2) identify and assess the most relevant change trends that may affect sustainable development; (3) design future scenarios for the evolution of sustainable development; (4) determine scenario implications for development models. This approach rested on an ongoing and systematic process of participation and evaluation by experts in areas related to sustainable development.

Engagement of Experts

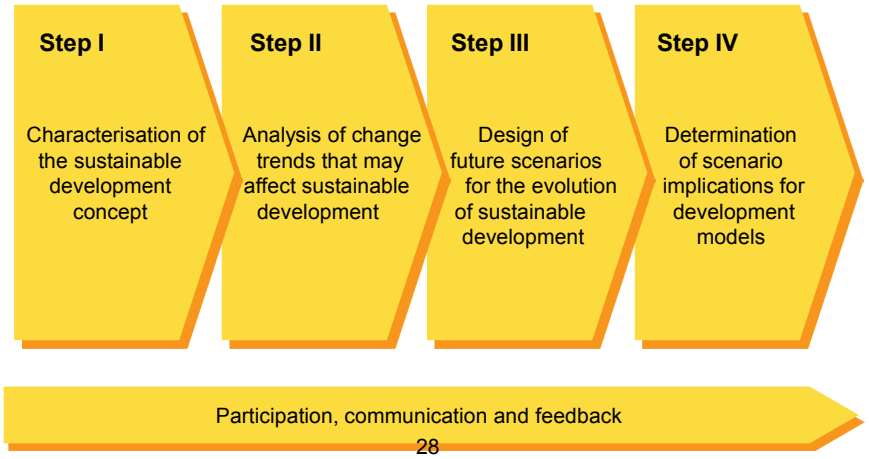
In the course of the study, more than 30 experts from private companies and public organizations participated in assessing trends and determining the implications of scenarios for the sustainable development model. Expert involvement either took the form of personal interviews or participation in focus groups.

Three Scenarios for Spain

In an initial step toward scenario design, various critical uncertainties were grouped around two axes:

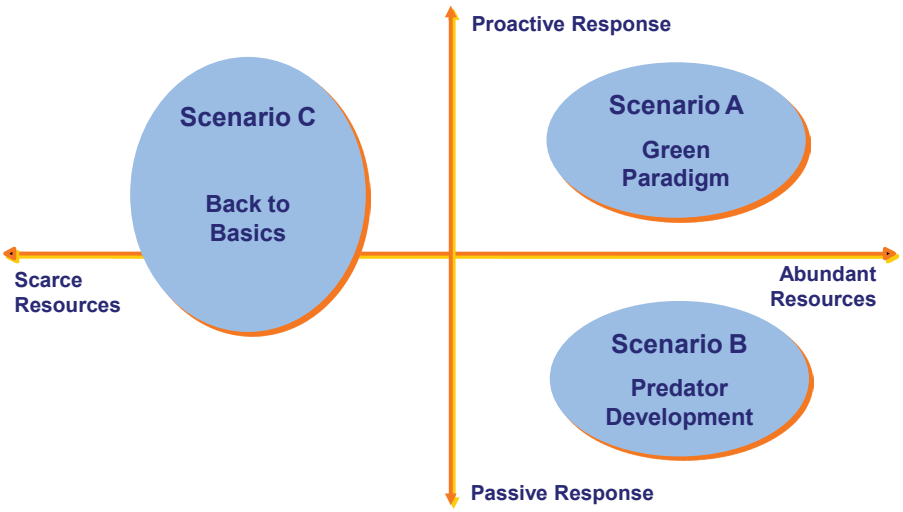
- The ***vertical axis*** represents possible alternative responses of society to the concept of sustainable development in the future. This axis encompasses all future uncertainties related to social behaviour, economic models and public policies toward SD.
- The ***horizontal axis*** shows the availability of resources to achieve the goals of sustainable development in the future. This axis includes all critical uncertainties regarding the abundance or scarcity of technological, economic, human, institutional and natural resources.

Figure 1: Scenario design methodology



In the space defined by those axes, we can identify three distinct scenarios, which pose a number of challenges to the Spanish development model (see Figure 2).

Figure 2: Future scenarios for sustainable development



Scenario A: Green Paradigm (circa 2025). This scenario can be expected when, on the one hand, there is a proactive and favourable response from public and private agents toward SD and, on the other, there are abundant resources of all types to achieve sustainable development. "Green Paradigm" assumes an environmentally conscious society in which most citizens participate in public decision-making.

Spanish society would have to meet a number of ***challenges*** in order to prosper in this scenario. First, an education system capable of promoting sustainability, innovation and solidarity values is required. Second, a diversity of new social demands of a very heterogeneous population have to be satisfied but without risking sustainability principles. Third, an economic model based on respect for the environment and supported by responsible consumption must be developed. Fourth, measures promoting cooperation between business and government must be implemented in order to make an easier transition toward less polluting and more eco-efficient technologies. Fifth, mobility patterns have to be transformed by applying technological innovations to transport systems. Sixth, an advanced and transparent governance model is required favouring citizen participation, co-ordination among different administrative levels and public-private co-operation. Seventh, planning and implementing advanced territorial policies are needed that support Spanish society in developing toward more sustainable arrangements. Eighth, management of companies and public bodies must be improved so that they internalise environmental costs by applying sophisticated environmental evaluation tools.

Scenario B: Predator Development (circa 2025). This scenario unfolds in a context in which resources of all types are abundant, but at the same time public and private agents are either slow or passive in reacting to sustainability challenges. "Predator Development" represents a society that disregards environmental issues as not critical compared to its economic and consumption needs. The successive emergence of technological innovations seems to conjure away environmental threats and tends to relax a society indulging in exuberant consumerism.

Scenario B ***challenges*** underline the need to correct the strong environmental and social impacts generated by an economic model based on a philosophy of growth. First, formulas need to be established for satisfying social needs in an environment where individualism and intolerance prevail. Second, an ample array of products and services must be provided to facilitate day-to-day tasks in a society geared toward a culture of rapid change and instant satisfaction. Third, Spanish companies must be competitive enough to successfully operate in global markets. Fourth, the Spanish economy's dynamism has to be fed by providing abundant and inexpensive energy sources. Fifth, effective technological innovations have to be developed to take full advantage of nuclear energy and to exploit coal reserves. Sixth, strong demand for passenger and goods mobility must be accommodated by construction of new transport infrastructures with low environmental impact. Seventh, public administrations need to make widespread use of new technologies to guarantee transparent decision-making, streamline administrative

procedures and facilitate citizens' access to public services. Eighth, effective legislation in the field of urban development is required in order to counterbalance real estate excesses.

Scenario C: Back to Basics (circa 2025). According to this scenario, there is a significant shortage of all types of resources due to a prolonged recession, but, at the same time, Spanish society as a whole is inclined to support sustainable development models. "Back to Basics" elaborates a scenario of failure of the current development model that leads to social tension and frustration.

Scenario C confronts Spanish society with a number of ***challenges*** that call for a radical transformation of the old development model. First, new initiatives must be launched to restrain immigration flows by promoting development in third world countries. Second, family structures and other social networks have to be reinforced to counterbalance the negative effects of the economic crisis. Third, a new education system must be set up to foster new social and environmental values. Fourth, commercial marketing has to be aligned with new social and environmental values. Fifth, strong structural measures have to be adopted to get the economic system on track toward a more sustainable paradigm. Sixth, energy consumption per capita needs to be reduced by changing patterns of demand. Seventh, a clear and strict normative framework needs to be established forcing companies and public bodies to internalise environmental costs. Eighth, a strong government with broad public backing must be formed to implement effective policies against the economic and environmental crisis. Ninth, citizen participation and co-ordination among public administrations must be required by law and be additionally supported by public pressure. Tenth, joint action by public administrations, the third sector and the private sector are needed to cover growing social needs provoked by a systemic crisis.

Bringing Change to Social and Cultural Behaviour

This foresight exercise on the future evolution of the Spanish sustainable development model has produced some interesting findings from the point of view of development policies.

Irrespective of whatever scenario materialises in the near future, whether the sustainability paradigm in Spain will be achieved to lesser or greater degree depends on the fulfilment of a number of prerequisites:

1) Climate scenarios must be designed to anticipate and discuss the possible impacts of climatic change on the country's key economic activities, such as tourism, construction or the automotive industry.
2) Technology's capabilities of solving future environmental and energy problems must be assessed with rigour and realism.
3) Strategically comprehensive and multi-sectoral territorial plans must be elaborated for achieving sustainability with a wide scope.
4) All public administrations – European, national, regional or local – must assume responsibility and make a profound commitment to implementing sustainable development at their level of authority.
5) Social consciousness and collective intelligence toward sustainability must significantly increase if social-cultural and consumption behaviour is to be changed in the desired direction.

In brief, Spain faces a big challenge to change social and cultural behaviour toward sustainable development, which involves improving citizen education and providing more information on the issue. Meeting this challenge implies significant changes in our day-to-day habits as in our governance and business models. Nevertheless, these changes will create new economic, social and environmental opportunities for Spanish society as a whole.

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The German BMBF Foresight Process

EFP Brief No. 174

Authors: Kerstin Cuhls kerstin.cuhls@isi.fraunhofer.de

Sponsors: Federal Ministry for Education and Research, Germany, Referat 113

Type: National foresight exercise

Organizer: Fraunhofer Institute for Systems and Innovation Research (ISI), Kerstin Cuhls, together with the Fraunhofer Institute for Industrial Engineering (IAO)

Duration: 9/2007–7/2009 **Budget:** 4.5 m € **Time Horizon:** > 10 years **Date of Brief:** June 2010

Purpose

In September 2007, the Federal German Ministry for Education and Research (BMBF) launched a foresight process in order to sustain Germany's status as a research and education location. The BMBF Foresight Process aimed at 1) identifying new focuses in research and technology, 2) designating areas for cross-cutting activities, 3) exploring fields for strategic partnerships, and 4) deriving priorities for R&D policy.

The Foresight Process

"The BMBF Foresight Process", subtitled "Implementation and Further Development of a Foresight Process", started by assessing present-day science and technology and was broadened to look into the future over the next 10 to 15 years – and even further. It took into account the developments at the national as well as international level.

The process was conducted by a consortium comprising the Fraunhofer Institute for Systems and Innovation Research (Fraunhofer ISI) and the Fraunhofer Institute for Industrial Engineering (Fraunhofer IAO). Other institutions like the Technical University of Berlin, the Institute for Nanotechnology (INT) of the Research Centre Karlsruhe, the RWTH Aachen, the Austrian Research Centres GmbH (ARC), Systems Research Division – Dept. of Technology Policy, the Manufuture Secretariat Germany of the German "Verband deutscher Maschinen- und Anlagenbauer" (VDMA) supported the exercise. The process linked both foresight and monitoring in its integrated approach

Introducing New Methodologies

In order to achieve the targets, a tailor-made combination of methods was applied. Since there is not one single methodology as in a simple input-output model, a combination of methods, as is standard in most foresight processes worldwide, had to be used to meet all four objectives (see Figure 1). These objectives were defined by the BMBF when launching the call for tenders.

Objective 1 is to identify new focuses in research and technology that the BMBF must address. Objective 2 is to define interdisciplinary topics and areas, accordingly, that require broader attention and are to be tackled by various departments and groups of actors. The fields thus determined have to be addressed by different partners in the innovation system (strategic partnerships) over a longer period of time (objective 3), and measures should be devised to promote the fields in question (objective 4).

In order to achieve objectives 1 and 2, the ***foresight approach*** applied well-known search strategies as well as other methods from innovation research and international foresight activities alongside new, creative methods. The themes to be investigated at the national and international level were further developed by experts taking into account existing forward-looking roadmapping and strategy processes from the public and private sector.

The first phase stressed the national search for weak and strong signals, while the international search was focussed on the later second phase. As there is no one single methodology for search procedures, the methods involved quantitative methods like bibliometrics as well as qualitative approaches such as workshops, expert interviews, Internet and qualitative literature searches.

A new approach called ***inventor scouting*** (identifying young inventors and interviewing them) added to the methodology. For the evaluation of the topics, a set of criteria was drawn up. The criteria provided the basis for

an ***online survey*** and were also used to guide the selection process.

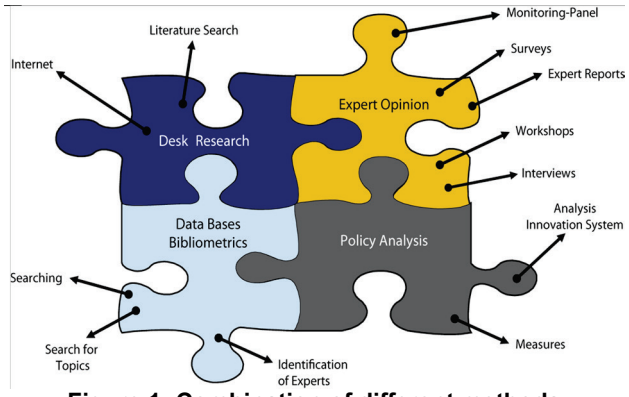

Figure 1: Combination of different methods

The foresight search activities were flanked by an ***assessment process***. With the assistance of an international panel, latest developments in various technological-scientific subject areas were analysed in order to attain a reliable description of the international "state-of-the-art". For the monitoring process, an international panel of well-known and acknowledged experts in their fields was asked about the current state and new developments in research and technology. In a second wave nearly one year later, they were once again interviewed to consolidate their opinions and give feedback on potential topics for the BMBF that met the objectives.

The topics to be identified were supposed to still be in the research or development phase. Topics that can be expected to either enter the implementation phase during the next years or be transferred to innovations in the next ten years were excluded from the lists of topics to be considered. For a first selection, a set of criteria was developed together with the BMBF.

The topics were reformulated, internally assessed and re-assessed several times via an **internal database and scientific papers**. To provide input to the first workshop in November 2007, a first set of scientific papers describing the developments in the fields was written and distributed as a basis for the discussions.

Topic coordinators (sometimes two persons) were nominated for every field that were responsible for defining and working out the details in the respective fields but also for coordinating with other topic coordinators in areas of overlap. The topic coordinators not only scrutinised the future themes but also the innovation system and identified the actors in the fields in question.

A bibliometric analysis provided further input into this process. The topic coordinators defined key words for a stakeholder analysis. The key words were used for counting literature indexed in the Web of Science and for a qualitative analysis. The (Internet, literature and other) searches and first selection processes were complemented by expert interviews and informal talks to gain an impression of the importance and potential impact of the huge number of topics under consideration.

Golden Topics

Topics in which BMBF or German research institutions were already very active at that point in time were labelled 'golden' and in most cases were no longer pursued.

The second phase of the searches ended with a first assessment of the topics found. An **online survey** among experts from the German innovation landscape was performed in September 2008 for a broader assessment of the topics, their importance and their time frame.

In parallel, the **corresponding innovation systems** were analysed in order to identify candidates for potential strategic partnerships, which were to be proposed in 2009 at the end of the whole process (objectives 3 and 4). In the last phase of the process**, recommendations for R&D policy** were also derived. The last phase ended with a conference. It marked the beginning of integrating the topics thus identified into the German innovation system and the BMBF agenda. It was a **bridging conference** rather than a final act.

The workshop participants differed widely (experts from science, society and the economy), and various channels of surveying were used: "experts" and "lay-people" via the interviews, young persons by inventor scouting, and a wide range of persons with broad or specific knowledge through the online survey (more than 2,659 persons). The international monitoring panel consisted of about 35 persons.

Established and New Future Fields

In the process, 14 established future fields were worked out in detail. They were derived from the German High-tech Strategy. In these fields, future topics were identified, re-clustered and assessed via a set of criteria. Seven new cross-cutting fields were arrived at by clustering the most important issues from the established fields. They are rooted in science and technology but have major impacts on society and the economy as well.

Established Future Fields

- Life sciences and biotechnology
- Information and communication technologies
- Materials and their production processes
- Nanotechnology
- Optical technologies
- Industrial production systems (automation, robotics, mechanical engineering, process engineering, etc.)
- Health research and medicine
- Environmental protection and sustainable development
- Energy supply and consumption (generation, storage, transfer etc.)

- Mobility: transport and traffic technology, mobility, logistics (land, water, air and space)
- Neurosciences and research on learning
- Systems and complexity research (including research on technological and scientific convergence; security research)
- Services science
- Water infrastructures

New Future Fields

Human-technology cooperation: This new future field provides an integrated research perspective on the complex interplay between human and technological change. In view of our increasingly dense technological surroundings and the expanding technical structure of human life, novel configurations of humans and technology must be embraced in all their complexity. Technological innovation can only be achieved in connection with a deep understanding of human thought, feeling, communication and behaviour to provide a new quality of seamless human-technology cooperation. A reorientation of human beings against the background of technological change is therefore just as central as reviewing the concept of the machine in terms of new machine agents. Further research must cover the relationship of these two parties, whether in the form of human-technical teams or in the wider perspective of human-machine culture.

Deciphering ageing: Ageing continues over our entire life span and is a multifactorial process. Some ageing processes cause disorders or disease. The biological processes of ageing and brain development (e.g. changes to neuroplasticity) that occur over the course of a lifetime have so far only been partly explained. Future findings in the areas of cellular and molecular developmental biology will provide new insights into cognitive, emotional and psychomotoric processes.

Sustainable living spaces (the field "infrastructures" was split into "water infrastructures" and "infrastructures for human living spaces"): Living spaces will in future be different in terms of structure and organisation. Driven by the reorganisation of ways of life and technological possibilities, chronological, spatial residential, and living patterns are changing. Together with demands for sustainable spatial development, these changes require innovation and adaption in various research areas.

In order to react to continuing social trends in the long-term, settlement-structural concepts will have to be made more dynamic to better manage basic conditions and, for example, flexible, more environmentally friendly spatial and settlement structures will have to be established. Efforts to meet these demands, which are still in flux, are obstructed by current settlements and infrastructures, which can only be changed at high cost and involving a considerable expenditure of resources in the short to medium-term. All infrastructures, for providing energy, transport, water and even information and communications, must be made more flexible at a technical level, and the possibility of reconstructing or dismantling them in the future must be taken into account at their construction.

ProductionConsumption 2.0: This future field aims at establishing long-term sustainable production and consumption paradigms and involves research into new ways of supplying products and services according to need in the face of changing global conditions. At the same time, it addresses one of the greatest challenges of the future: maintaining the ecosphere, which is also vital to human survival. Research in this area focuses on sustainable industrial and social patterns of materials usage. Researchers in established areas in production research, services research, environmental research, biotechnology and materials sciences are all working with great drive on aspects of sustainable practices. However, they alone cannot adequately accomplish the necessary systemic transformation of the entire structure.

Modelling and simulation: New methods of handling complexity based on modelling and simulation require multidisciplinary approaches. Working out the similarities in different applications may be a first step toward adapting the instruments and tools in other disciplines so that new simulations are possible in the future, even in technical and social science contexts.

Time research: Time is a bottleneck factor in many developments. Research into time is a central aspect and includes issues such as the chronological order of complex processes in making applications faster and more efficient, cost-effective and intelligent, or in paralleling and synchronising processes (e.g. Internet servers, production processes). The issue of dynamic and chronological development on various time scales, especially of non-linear processes, can only be dealt with in the long-term. One very dynamic future topic within time research is chronobiology, an area in which there are already initial findings on precisely-timed medication delivery. A central research aspect of time research is understanding and being able to specifically control the factor of time with the help of time efficiency research, the precise measurement of time (e.g. for GPS applications, such as precision agriculture and the remote maintenance of machines) and time-resolution (e.g. 4D precision).

Energy solutions with a) ***energy concert***: Securing an affordable, safe and climate-compatible energy supply is a central global challenge and an outstanding leading future market with high relevance for the economy and quality of life and a powerful, influential impact on many research fields. Sustainable, coordinated solutions for production, distribution and use are all equally important in this context. But there is still a cacophony. As many actors are involved and many disciplines contribute, energy is a field that needs a symphony.

b) ***Energy from the environment***: Energy harvesting is already known, but its use limited. New ideas are expected that make it possible to harvest energy from different kinds of environments and transfer it to miniaturized machines. This is especially necessary for devices

that are out of reach (implants, built-in domestic appliances and others).

Challenges for Science, Technology and Innovation Policy

New future fields can only be realised if there are advocates and if action is taken to that end. As all fields are different, new challenges for science, technology and innovation policy will arise. An international workshop in early October 2008 provided a platform for generating ideas for recommendations concerning policies and research alliances (objectives 3 and 4) to be further elaborated in 2009. The workshop took place in Hamburg and gathered international and German experts with experience in promoting new or cross-cutting issues. The purpose of the workshop was to discuss what kinds of measures are successful in implementing new or cross-cutting topics, along the lines of examples from the past outside of the BMBF Foresight Process. The guiding questions were therefore:

- How can future issues and topics with a time horizon of 10 to 15 years and longer be rapidly and efficiently absorbed into an existing innovation system?
- How do organisations or companies in other countries deal with cross-cutting issues and future topics with a time horizon of 10 to 15 years and beyond?

High-ranking Discussions and Impact on Policy

New approaches in innovation policy are necessary to implement and realise new cross-cutting fields of the future. The approaches vary and need to take into account the different stakeholder groups involved. Therefore, in the last phase of the foresight process, the actors of the current innovation system were identified and potential actor groups named who could further foster the different topics or fields.

The results of the BMBF Foresight Process were presented during a conference in Bonn in the presence of the Undersecretary of State, high-ranking persons, decision-makers and interested experts. Two hundred persons participated in this conference held at the former parliament building. Part of the conference was organized into so-called “topic islands” where the new fields were presented and discussed in an interdisciplinary manner. All topic islands had a different programme, and the participants were free to choose where they wanted to go. The discussions were very lively.

Talks in BMBF revealed large interest in the new fields so that follow-up activities were launched. The first such activities were “follow-up workshops” to bring together different BMBF departments and enable them to exchange views. In 2010, the BMBF started strategic dialogues as an opportunity for looking into the new future fields of the BMBF Foresight Process from different perspectives. This is necessary, on the one hand, for the further development of content and, on the other, to ensure that important aspects are included in the integration and translation of results into funding policy at an early stage.

Another policy result is the foundation of a new division (*Referat 524* – Department 524) at the BMBF in June 2010, which has been named “*Demografischer Wandel; Mensch-Technik-Kooperation*” (Demographic Change; Human-Technology Cooperation).

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Innovation Futures: A Foresight Exercise on Emerging Patterns of Innovation

Foresight Brief No. 175

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Duration: 06/09-01/10 **Budget:** 0.5 Mill. € **Time Horizon:** 2020 **Date of Brief:** Aug. 2010

Purpose

The Innovation Futures (INFU) project deals with the emergence of new innovation patterns, such as open innovation, user innovation, community innovation, social innovation, and design innovation. Based on a foresight exercise, the project examines different patterns of how innovation is organised and studies implications for business and policy making. For the first time, a foresight project is conducted to analyse and discuss systematically the emergence and diffusion of new innovation patterns and their implications for European policy.

Emerging Patterns: How Innovation May be Organised in the Future

There a number of indications that the way economic actors interact in order to transform knowledge into new products and services is currently undergoing substantial changes. The emergence of new innovation patterns with new actors, different roles and new modes of interaction implies re-configurations in European innovation systems with far reaching implications for European S&T in the long run.

While a few radical visions have been taking up these signals and are predicting disruptive change for economy and society there is little systematic exploration of possible future innovation landscapes and their implications for economy and society. However, in order for research and other policies to be prepared for challenges arising from these changes and to be able to benefit from them, a more solid understanding of possible innovation futures and their implications for society is needed. At the same time there is a need for debate among innovation actors creating awareness, shared visions and momentum for change.

Despite growing debates in academia, industry and policy, many **questions** remain to be addressed such as:

- implications of new innovation schemes for **production patterns** (distribution and location of production),
- **environmental impact** of new innovation patterns in particular user innovation,
- implications of new innovation forms for **regulatory framework** conditions (both enabling and controlling these innovations),
- the role of current innovation **agents** (companies, researchers, engineers, designers, architects… the so called "creative class" etc.) within new innovation patterns,
- people's **attitudes** towards innovation activities and their dependence on cultural context (e.g. Innovation fatigue and passive consumer mentality versus individualisation and experience economy).
- the relation of new innovation models towards well-known **global megatrends** such as demo-

graphic change, environmental threats, urbanisation …

Within this context, the INFU project has defined the following **objectives**:

- **scanning of weak signals** indicating changing innovation patterns with a potentially disruptive impact for European S&T in the long run,
- **systematic exploration** of relevant and plausible future innovation landscapes through participative scenario building,
- **assessment of scenario implications** for the content of academic and industrial research, and key policy goals such as sustainability,
- **deriving strategic options and guidelines** for European research policy and relevant multipliers,
- initiation of an interdisciplinary, boundary-spanning stakeholder **and expert debate** on new innovation patterns.

The project combines various **foresight methods** and builds on the existing academic literature on new innovation patterns. The INFU dialogue starts by identifying emerging signals of change in current innovation patterns and then progresses by increasingly integrating diverse perspectives and knowledge sources towards consolidated innovation futures scripts. These bottom-up visions are then confronted with different possible socio-economic framework conditions and global mega-trends to finally synthesize consistent scenarios which integrate micro, meso and macro elements of possible innovation futures with particular emphasis on changes in the nature and content of research. Finally, policy strategy options are developed to prepare for the identified changes in innovation patterns.

In the different stages a wide range of experts and **stakeholders are involved**, e.g. within panel discussions, interviews, scenario workshops and online-debates.

63 'Signals of Change'

Based on an analysis of various sources such as the academic literature, internet, newspapers and magazines signals for arising innovation patterns have been identified in the first year of the project. In total, 63 'signals of change' were identified and structured information was collected for every signal of change. In our context, a weak signal indicates a change in an innovation pattern with a potential of disruptive impact, which is not established as a common way of doing innovation (in a sector).

The identified examples and cases often combine existing ideas, concepts and strategies (which are also described in the academic literature) in innovative ways, show new applications and thus expand our thinking about possible innovation futures.

New Innovation Pattern

Describing "new innovation patterns" requires a definition or at least an understanding of what is new. With "new innovation patterns" we mean novel emerging concepts, ideas and strategies of how innovation is organised, but also well-known trends such as open source software development, which are already of importance in specific industries or areas, but may have a larger impact or potential for other areas in the future. In this sense, specific concepts and strategies may be "new" for specific industries.

20 Innovation Visions

The set of identified weak signals served as base for the development of 20 innovation visions, which, in a creative way, amplify and combine some signals in order to develop coherent, plausible and sometimes provocative pictures of possible future forms of innovation. Thereby the team transferred an idea already applied to other sectors or generalised a signal considered to become a mainstream practice The visions have also been visualized by a video which can be seen on the project web page: www.innovation-futures.org. In the next stage of the INFU project the various impacts, likelihood, opportunities and threats of selected innovation futures will be discussed and elaborated in more detail.

We will pick out seven of these visions which may have a potentially strong impact on socio-economic development to illustrate the possible future development and briefly introduce them:

The Open Source Society

This innovation vision assumes that open source development is no longer limited to software development but becomes an all compassing innovation pattern. Many products and services are provided by people contributing bits and pieces to various technological and social innovation projects. Open source business models and coordination mechanisms abound.

What are possible socio-economic impacts? Competition on the market could slowly be replaced by 'strategic co-opetition' between companies. The critical question of a balanced 'co-opetition' is to regulate that a certain level of competitiveness ensures constructive improvement between monopolistic inertia and market competition. In the long term, we may also see a stagnation of innovation activities within firms as everyone is waiting for the others to move, hence, companies might more evolve towards closed innovation, and open source may finally stimulate also closed innovation. From a social perspective, the democratisation of product knowledge might give benefit to poorer societal groups and societies, and

the increase of 'copy and paste' might lead to less safe products and thus higher societal costs.

Innocamps

Imagine that innovation camps, where people gather for a few days to innovate together, become widely established as a means of problem solving. Innovation camps are used by companies, the public sector and civil society to solve problems ranging from high-tech challenges to innovative neighbourhood facilities. Certain groups of people regularly join innovation camps.

What are possible socio-economic effects? Innovation camps are an established format to collect ideas of young talented people. They are systematically integrated in the education system as a new means to foster innovation culture and to increase interest in science and research in order to meet the demand from knowledge-based industry. The participation is organised as a reward for young people that have participating in contests before. The camps also give way to future perspectives and personal development (careers, grants, jobs, education, etc.) chances.

Innovation marketplace

What if companies no longer innovated themselves but fully externalised innovation to an open innovation marketplace? Nomadic innovators bid on innovation tenders and contests in constantly changing teams. They gather in co-working spaces some of which are top-favourite employers for creative people.

What are possible socio-economic impacts? Companies may be able to draw on a much broader range of ideas and perspectives. They can manage their innovation processes more flexibly and efficiently. Co-working spaces provide an interesting alternative to nomadic isolated worklives of self-employed knowledge workers. They may also become seeds of social entrepreneurship and help integrate marginalised groups.

Relocated Innovation

This innovation vision can be sketched by asking the following question: What if the bulk of successful and disruptive innovations came from today's emerging markets? Thus, in this vision, the West adopts the role of a follower and has to face products primarily designed for a different cultural context. Western companies wishfully look to Asia, often with the help of industrial espionage. Creative people migrate to the new innovation hot spots in Asia and send back their money home to the US and Europe.

What are possible socio-economic impacts? Western companies would lose market shares and significance in international markets. There is a need for restructuring of Western markets: economies focus on local needs and local products with a high quality standard and no longer on front running products. The current tendencies of "globalisation of wisdom", and "technological convergence" would be limited by specialised regional innovation clusters. In addition, Western Nations would lose wealth while people in the Middle East and Asia would benefit. Social welfare systems in the West would no longer be fundable due to tax losses and a rise of "unproductive" shares of people in society (ageing population and unemployment). The migration of highly educated people as well as industrial workers to new markets would increase. European societies would age even more rapidly than projected. Thus, social tensions and crime could increase, as the West suffers economically.

Innovation Imperative

What if the current emphasis on innovation and creativity among designers, programmers and engineers spread to all workplaces? Hence, all employees, from the janitor to top management are constantly involved in innovation activities. Creativity is part of any daily job routine and is a key in performance measurements.

If more and more people suffer from the constant innovation pressure, innovation could become something undesirable and negative. Increasingly, people may feel compelled to use their spare time to meet the innovation demands – which could have negative effects on people's health. Creativity drugs could become common and a loss of orientation due to the continuous change might be a consequence. Designers and engineers may feel threatened by the distributed innovation approach. At the same time, a counter trend may be that innovation fatigue takes over and "No-Innovation" is en-vogue in certain areas. Thus, managing that we end up with a "balanced innovation culture" is a challenge in this scenario context.

Waste-based Innovation

Think about the following: What if the principle of "Waste equals Food" (cradle-to-cradle) was widely adopted? Raw material databases with used components and materials serve as a starting point for innovations. The whole world becomes one eternal circle. Everything that is made of something is part of making something.

A change towards waste-based innovation would lead to a highly environmentally friendly economy. However, if recycling makes sense depends on the specific product, as in some cases recycling or reuse may have higher environmental costs. Some products might have to be banned entirely. Waste-based innovation would probably lead to a radicalisation of material awareness and could open the door for the advancement of recycling technologies and production. Trading of waste would become an even more highly profitable business.

City-driven systemic innovation

In 2009, the city of Munich launched an idea contest to animate as many people as possible to generate and

advance innovation concepts on energy efficiency in the fields of mobility and habitation. We could ask: What if cities became stronger actors in the field of innovation by proactively pushing for needed and demanded solutions? Cities could take on the investment risks for the development and implementation of needed innovations and use these as a new economic factor by patenting and marketing their solutions to other cities.

Possible impacts: City-driven innovation initiatives could increase the probability for people to find solutions for social and environmental problems which are beneficial for all. They could also lead to ideas which otherwise would have never been realised by private actors. At the same time, as a public customer, they can also open new market opportunities for suppliers and therefore help to reduce market risks.

Future Drivers of Innovation

The innovation visions presented span a wide field of possible innovation patterns, and, as briefly illustrated, lead to various effects in the social, economic and environmental dimension.

An analysis of the innovation patterns reveals that a significant driver in the economic dimension is the increasing global competition. The pressure to innovate is rising due to ever-shorter product life cycles, growing product piracy, and the transition of industrialised societies into knowledge economies. The key question is: How can we develop better ideas, implement them faster and spend less money while doing so? Another economic driver of changing innovation patterns are changes in the work world: Flexible working patterns, outsourcing and the increasing number of professional freelancers foster and enable the emergence of new innovation concepts. Moreover, companies have started to realize the direct (money) and indirect (reputation) economic value of social and environmental innovations, so there is a growing interest in both of these areas. Geographical changes in innovation patterns, in particular the shift of innovativeness to developing countries, is driven by cost advantages and the rapid economic catch-up in those countries.

In the social dimension, many innovation futures are driven by people's growing ability and willingness to deal with social media and collaboration tools. This driver is closely connected to the repeatedly mentioned aspect that the younger generation is about to enter the business world, bringing with them new ways of thinking about (free) knowledge sharing, collaborating and inventing. Another trend is the spread of individualisation, which, as one effect among others, increases people's ambitions to express themselves by influencing the design of products and / or to change the functionality of solutions and services according to their individual needs. Finally, there is also evidence that there is a change in the way innovators and being innovative is regarded socially: Being innovative is becoming more and more socially desirable for a growing number of people.

From an environmental point of view, the growing awareness of climate change, social grievances and the inefficient use of resources are driving forces for emerging innovation patterns. However, new innovation concepts could fail for precisely these reasons if they turn out to be resource-inefficient or to produce tons of new waste. From a technological perspective, especially new Web 2.0 applications are bringing about changes in innovation patterns, as they make knowledge sharing and collaborating easier and more affordable, also on a global scale. Furthermore, many new innovation concepts are expected to result from the upcoming technology wave (sustainability technology), and general technological progress, i.e. cheaper, more powerful and usable devices.

In the final stage of the INFU project, the various impacts, likelihood, opportunities and threats of selected innovation futures will be discussed and policy implications will be elaborated in more detail.

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Facing the Future: Time for the EU to Meet Global Challenges

EFP Brief No. 179

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Purpose

The aim of this project is to provide a comprehensive picture of the main trends ahead and possible future disruptive global challenges, and to examine how the EU could position itself to take an active role in shaping a response to them. The work described in the final report contributes with a fresh perspective on the future, linking widely accepted quantified trends towards 2025 and beyond with the opinions of experts and policy makers on the likely consequences of these trends and wild cards. This work has been undertaken in cooperation with the Bureau of European Policy Advisors of the European Commission.

The World in 2025

What will the world look like in 2025 and beyond? What are the possible future disruptive global challenges? And how can the EU position itself to take an active role in shaping a response to them?

There is a clear and growing need for the ability to anticipate change to be embedded in policy. This is critical not only to be able to respond and adapt to new situations before they occur, but also to shape the future, building upon mutual understanding and common visions to be jointly pursued. For policy responses to address all the pressing current global challenges, especially when these are seen separately from one another, is clearly a demanding task. Institutions face greater complexity and difficulty in providing solutions in due time. In particular, this is true when the policy focus extends beyond the challenges that societies face today, seeking to anticipate future challenges and transform them into opportunities.

This is the rationale for the study "Facing the future: time for the EU to meet global challenges" carried out by the European Commission's Joint Research Centre, Institute for Prospective Technological Studies (JRC-IPTS) for the Bureau of European Policy Advisors of the (BEPA).

From Analytical Review to Robust Portfolio Modelling

The methodology used combines an extensive analytical review of more than 120 recent future oriented studies, followed by a wide online consultation of almost 400 identified issues in 6 policy-relevant areas, and use of multi-criteria quantitative analysis (Robust Portfolio Modelling) to prioritise the resulting issues. Key issues were then presented and discussed in a workshop with selected experts and policy makers. The main objective of the expert workshop was to organise the findings of the literature review and the analysis of the online survey into novel cross-cutting challenges, which need to be tackled now by the EU in order to secure a better future for all, and to translate them into policy messages. As a wide variety of challenges emerged related to the future of the world in 2025, the criteria of urgency, tractability and impact were used to prioritise and select the most relevant ones.

Main Challenges for the EU

Following the above methodological approach, three key challenges with a global scope were identified at the end of the expert workshop. Their multiple dimensions are articulated below.

Need to Change the Current Ways in Which Essential Natural Resources are Used

This global challenge relates to the human over-exploitation of basic natural resources, which are essential for societies to function and evolve in a sustainable manner. Current conditions and patterns of behaviour need to be reflected, and policy actions supporting the shift towards **sustainable ways of living** could be fostered and strengthened. The long term sustainability is key to ensure not only economic growth but also a better quality of life for all, current and future generations. This depends on the intelligent use, conservation and renewal of natural resources and ecological systems.

All human activities both depend on and have an impact on natural resources. **Food production**, for example, is highly dependent on water and land, and its processing and distribution dependent on energy. All industrial activity starts by extracting natural resources and then assembles them in different ways to add economic value, while using energy and generating waste along the chain. The chain ends with the disposal of final goods. The provision of services also impacts on natural resources.

Economic growth has largely relied on the **overexploitation of essential natural resources** and hence ultimately caused the disruption of natural cycles. Techno-institutional lock-in may be an important factor which compounds and intensifies human impacts on nature since it creates barriers to the search for sustainable alternatives to existing processes and infrastructures as well as to behavioural change. The most well known effects are:

- **Climate change** and its manifold effects on: water and other natural resources, agriculture and food security, ecosystems and biodiversity, human health and migration patterns (IPCC, 2007; UNEP, 2007).
- A dramatic increase in **water scarcity** in many parts of the world partly due to climate change and partly due to excessive withdrawals and contamination of surface and ground water, with profound implications for ecosystems health, food production and human well being (WEF, 2009; WWF, 2008).
- The **decline in geographical distribution**, abundance or both with regards to land, freshwater and marine biodiversity is more rapid than at any time in human history, with humanity being in the direction of crossing tipping points since changes in the biophysical and social systems may continue even if the forces of change are removed (WWF, 2008).
- A possible **global energy shortage** due to an increasing demand and consumption which will lead to a rise in global competition for energy resources as well as a greater dependency between nations, with energy in general and oil in particular playing a key role in future power relations and defence policies (European Commission, 2008; OECD, 2008).
- **Increased demand for food** due to growing world population, rising affluence, and the shift to Western dietary preferences (World Bank, 2007); and this will place more pressure on water for agriculture and have a strong effect of high food prices.
- Climate change, water scarcity and lack of food at affordable prices will be important factors in the **increase of illness and death rates** in developing countries (IPCC, 2007), which will lead to a deepening in poverty and exclusion linked to an unsustainable exploitation of the natural resources still available, mass migration as well as threats in the form of radicalisation and terrorism (United Nations, 2008).

Need to Anticipate and Adapt to Societal Changes

For the EU to fully become a **knowledge society** there is a need to anticipate and adapt to political, cultural, demographic and economic transformations. Business, demography, migration and societies are generally changing at a much higher speed than public institutions and related decision-making processes. Legal frameworks, social security systems, education and the models of healthcare have difficulties to keep up with the pace of these transformations. This hampers innovation and economic growth, and puts high pressure on natural

resources and on the ability of institutions to cope with societal transformations. Beyond the consequences already mentioned in challenge 1, there are now increasing concerns on **how to provide equal access** to healthcare and how to become a so-called knowledge society. The multiple dimensions of this challenge are:

- Rising employment rates will no longer be sufficient to compensate for the **decline in the EU working population** due to ageing and a change in skills needed to function in knowledge societies, leading to economic growth being mainly dependent on increases in productivity.
- **Ageing societies** are placing increasing pressure on pension systems, social security and healthcare systems (European Communities, 2008).
- Increase in continuing **flows of migrants** from developing to developed countries due to environmental hazards and armed conflicts, as well as the aspiration to a better quality of life.
- Education and ICT innovations could lead to a shift towards **citizen empowerment** and e-governance with citizens holding governments accountable due to an increase in transparency, but this is at risk of becoming reality since the majority of the world population is still excluded from having access to the knowledge society.
- Innovations limited by social acceptance due to **lack of education, transparency** and societal understanding of technological possibilities.
- **New converging technologies** that emerge from multidisciplinary collaboration are expected to drastically change all dimensions of life (RAND, 2001).
- In relation to globalisation it is expected by 2025 that the world will comprise **many more large economic powers**. China, India, Japan, Korea, Malaysia, Indonesia will take on greater significance in the global economy (EIN, 2007) and their huge consumer-driven domestic markets become a major focus for global business and technology.

Need for Effective and Transparent Governance for the EU and the World

This challenge comprises the need for the EU to create more transparent and **accountable governance** structures and processes that can adapt to and anticipate the future, and to use this capacity to do likewise at global level in order to address global and common challenges and to **spread democracy** and transparency all over the world. Addressing the multiple effects of both challenges mentioned above requires **new forms of governance** and that as many nations and stakeholders as possible join forces. The multiple dimensions of this challenge are:

- Single policy governance approaches can no longer cope with global issues, leading to **fragmented responses to common challenges** which are complex and interconnected. This is linked to the lack of nation's ability to keep up with the speed of socio-economic changes and the consequent development of reactive, individual, unaligned and inflexible strategies (Florini, 2005).
- The **problems faced by developing countries** increasingly become also the problems of developed economies, such as of EU Member States, with an increasing fading of borders between nations due to migrations caused by pandemics and poverty, and due to terrorism and conflicts (i.e. over natural resources).
- Mainly thanks to **ICT related innovations** there is an increasing shift towards empowerment in governance. The use of internet is now moving towards the use of Web 2.0, with applications such as social networking, blogs, wikis, tagging, etc and this supports a move towards networked computing and e-governance systems (Accenture, 2009).
- Many rising superpowers such as Russia, China, the Middle-East and some Latin American countries have widely **differing traditions in democratic governance**, which may cause pressures to democracy also elsewhere. Western norms and values as the foundation of the global system could also be challenged by radical religious identity politics that could emerge as a powerful counter ideology with widespread appeal.
- The growing strength of emerging economies increases pressure to integrate them more closely into international coordination processes. **Unbalanced representation** of nations in global fora, such as the UN, WTO and IMF, makes it impossible for many developing countries to participate in global decision-making processes and to implement or adopt strategies that are decided only by those economically powerful countries (Amanatidou, 2008).

Reduction of Resource Dependence, Equal Access to Knowledge Institutions and Social Care...

Based on the above challenges, the main policy issues to be considered at EU level are:

- **Policy alignment towards sustainability** – including the need to align all relevant policy domains to achieve: reform in the agri-system; a reduction in the EU's dependency on resources; an increase in levels of education and social awareness; appropriate and effective management of migration flows resulting from climate change, the aspiration to a better quality of life, and labour market needs of especially ageing societies; and a change in the policy paradigm based

on GDP to an updated system which also considers ecological flows and stocks.

- **Social diversity and ICTs towards citizen empowerment** – including the need to: build new incentives to facilitate and strengthen relationships between different social systems; develop the necessary means to enhance education on the use of ICTs in conjunction with other technologies; improve the quality of education, by, among others, fostering competition within and between EU national education systems; regulate the healthcare system, tapping into new technologies to allow equal access for all; develop radically new and far more efficient forms of social protection; and enhance regional specialisation through the formation of regional RTDI clusters.
- **Anticipation of future challenges to turn these into new opportunities** – including the need to: embed forward looking techniques in EU policy making; foster mutual understanding through ongoing and inclusive dialogue both within the EU and worldwide to build shared values, common visions, actions, and smart regulations, and enable effective and adaptive international organisations to become a reality; establish partnerships between industry-government-society; clarify at global fora the role and status of the EU and balance its representation in international organisations; and foster (e)participation and (e)democracy through the use of web 2.0.

The foresight approach employed in this study contributes to policy making by supporting a continuous and shared approach to understand the present in all its complexity, to look at different future possibilities and to shape a joint direction to follow, considering different stakeholders' points of view. This can be coupled with a periodic evaluation of what has or has not been achieved to enable policy to correct deviations and to continually adapt to and re-shape upcoming new situations. It is believed that such an approach, linked to other forward-looking techniques and tapping into evidence-based research and quantitative elements, would be critical to enable EU policy making to become more adaptive and able to anticipate and address change.

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Breakthrough technologies to secure the supply of critical minerals and metals in the EU economy

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Purpose

This exercise was part of an EU FP7 Blue Skies Project aimed at piloting, developing and testing in real situations a foresight methodology designed to bring together key stakeholders for the purpose of exploring longer term challenges and building a shared vision that could guide the development of the relevant European research agenda. This approach was applied to the theme of "Breakthrough technologies for the security of supply of critical minerals and metals in the EU economy".

The Minerals Challenge

Minerals and metals are essential to almost every aspect of modern life and every economic sector. Aerospace, agriculture, culture, defence, energy, environmental protection, health, housing, transport and water supply are all highly dependent upon them. Plans for economic recovery and the development of new industries also depend on their availability – for example "green" energy production from solar cells and wind turbines, the green car of tomorrow and many more all require a range of rare minerals and metals for their production.

Although essential to our economies, development of this sector has been neglected in Western Europe during the past 25 years. This was mainly because of the very low price of these commodities – a consequence of abundant reserves discovered in the 1970s. As a result, the mining and metallurgical industry as well as related research and education almost disappeared from the present European Union, making our economies totally dependent upon imports.

Raw Material	Emerging Technologies
Antimony	Antimony Tin Oxide, flame retardant, micro capacitors
Cobalt	Li-ion batteries, synthetic fuels
Gallium	Thin layer photovoltaics, IC, WLED
Germanium	Fibre optic cable, IR optical technology
Indium	Displays, thin layer photovoltaics
Platinum	Fuel cells, catalysts
Palladium	Catalysts, seawater desalination
Niobium	Micro capacitors, ferroalloys, high speed low alloy steel
Neodymium	Permanent magnets, laser technology
Tantalum	Micro capacitors, medical technology

Demand for these minerals and metals is likely to increase dramatically. Much of this new demand will come from rapidly growing, highly populated emerging countries, such as China, which have attracted large parts of the world industrial production due to cheap labour, regardless of raw minerals and energy issues. Already strong competition for access to natural resources, including mineral resources vital to any economy, is likely to accelerate further in the coming years with possible severe environmental and social impacts. The EU economy is more than any other exposed to these developments, as it produces very little of the minerals it consumes and almost none of the critical minerals it needs to develop its green technologies.

Against this background, the creation of a new research and innovation context in Europe has become essential, not only to reduce the EU's dependence on imported minerals and metals but also to chart the road ahead, to develop a win-win cooperation with developing countries and to stimulate the competitiveness of EU technology, products and service providers to the global economy.

However, these solutions can take a long time to be implemented, and it is important to identify today's priorities for knowledge generation and innovation so that action can begin. This in turn creates a need for a foresight approach that brings together the knowledge and interests of the main stakeholders. It is in this context that the FarHorizon project invited leading experts in the area from government agencies, industry and academia to take part in a success scenario workshop. The aims of the exercise were

- to identify the key challenges for raw materials supply in Europe;
- to identify breakthrough technologies or other innovations that could transform the picture, including substitution, new sources, ways to change demand and new applications; and
- to define in broad terms the research and innovation strategies needed to develop and make use of such technologies.

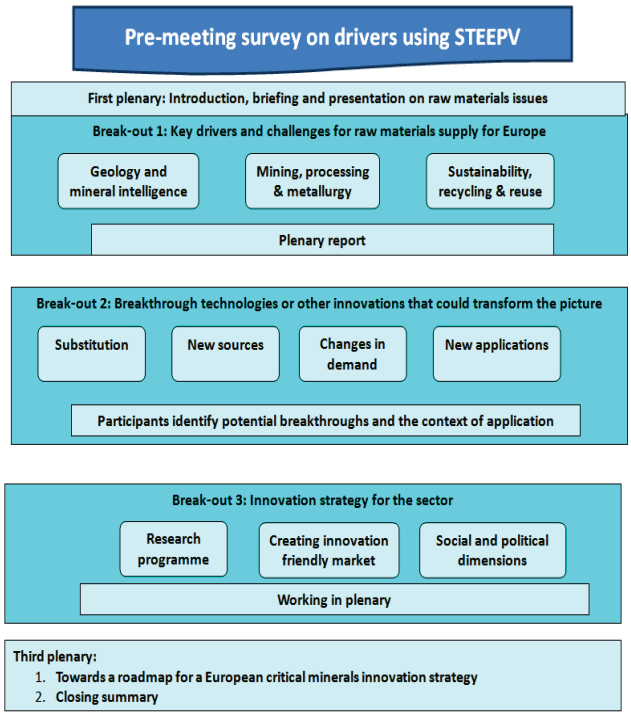
Success Scenario Approach

The "Success Scenario Approach" is an action-based approach where senior stakeholders develop a shared vision of what success in the area would look like, together with appropriate goals and indicators, which provide the starting point for developing a roadmap to get there. The purpose of having such a vision of success is to set a 'stretch target' for all the stakeholders. The discussion and debate forming an integral part of the process leads to developing a mutual understanding and a common platform of knowledge that helps to align the actors for action.

Important outcomes of these workshops are the insights they provide in terms of the level of maturity in policy design and development and the viability and robustness of long-term policy scenarios to guide policy-making. The workshops also provide indications on whether there is a need for further discussion to refine thinking and policy design and/or to bring additional stakeholders into the discussion.

The theme was developed in partnership with the French geosciences institution BRGM. The workshop brought together twenty representatives of scientific organisations, industry and government agencies to identify the role of technology in addressing the socioeconomic and political challenges facing Europe in this sector. Briefs on key issues were prepared before the workshop, and participants took part in an exercise to identify key drivers using the STEEPV framework (social, technological, environmental, economic, political and values). Common themes were increasing demand and growing sustainability requirements. Geopolitical themes were also touched upon.

The basic structure was to identify the key challenges facing the sector and then to explore the potential role of breakthrough technologies in addressing those challenges. A third main session examined the key elements needed for a sectoral strategy for innovation.The figure below gives an outline of the methodology:



Challenges in Three Dimensions

Informed by the drivers, participants were tasked to identify the key challenges for raw materials supply in Europe and to prioritise these. If these challenges can be met, we can expect to achieve a situation as defined by the successful vision for the sector in 2030 and realise its benefits to Europe. Three dimensions of the challenge were addressed:

Geology and Minerals Intelligence

1. Access to data on mining, production and geology
2. Knowledge of deeper resources
3. Better knowledge due to improved models of how deposits are produced
4. Better exploration
5. Systematic data sharing
6. Exploitation of 'exhausted' mines

Mining, Ore Processing and Metallurgy

1. Exploiting deeper deposits
2. Accessing seabed deposits
3. Better health and safety; prediction of seismic events and natural or man-made hazards
4. Using less water and energy
5. Reducing CO_2 footprint
6. By-product handling
7. Social and business organisation

Sustainable Use, Efficiency, Recycling and Re-use

1. Downstream resource efficiency
2. Better citizens' understanding/attitude
3. Building capabilities and providing training
4. Transforming waste into mines/urban mining
5. More systemic view of different critical minerals
6. Better use of other resources, e.g. water and energy
7. Global governance of new extractive activities

Against these challenges, breakthroughs were sought in four areas: new applications, substitution, new sources of materials and rare metals, and changes in demand.

Four Key Actions toward a Comprehensive Policy for Securing Raw Materials Supply

Policy recommendations geared toward securing the supply of raw materials in Europe were summarised in terms of four necessary key actions:

Key Action 1: Establish an integrated strategy for raw materials supply and support it by providing continuous funding.

Research in the area of raw materials supply needs to be clearly linked to creating the right conditions for successful innovation. There is some concern that the European Commission has no competence in minerals as such but rather in matters of environmental protection, trade or economic competitiveness. This limits the development of a holistic, complementary approach needed to tackle the various issues related to securing Europe's mineral resources supply within the sustainable development context. The sector needs a more horizontal approach – otherwise we may do research, but there is no innovation behind it. An innovation-friendly market can be created by developing stringent environmental and recycling regulations. Europe is at the forefront of a number of technologies in these areas. Regulators need to understand that part of their job is to stimulate innovation if not for today at least for tomorrow. Engaging them in foresight, along with technologists and users, is important for developing this horizon. There is a 7-8 year challenge to develop a new lead market.

Key Action 2: Move from stop and go to a lasting approach with three central aspects for a research, technology and innovation programme.

Support up to now has been project-based and provided only to a limited extent on a stop and go basis while continuous policies and knowledge development would be necessary.

2.1 There are three broad research priorities:

- Research dealing with mineral resources intelligence. This is research of a totally different kind, i.e. mainly interdisciplinary. It is needed to keep up with a dynamic situation where even what minerals and metals are critical changes over time.
- Research leading to new or better technologies with a focus upon whatever is needed by industry. The large scale South Korean national initiatives provide a good example of speed, scale and pragmatism and also represent the competition that Europe has to face. The US investment on rare earths in the Ames laboratory is another example.
- Research on mitigation and understanding of environmental impacts.

2.2 Adopt a holistic approach to the innovation cycle. Support for research should be long-term and structured so that most publicly funded research is open and shared internationally. The full range of mechanisms is needed: basic R&D, integrated projects or their equivalent and joint technology initiatives. However, 80% of the effort should be in large applied projects and the rest focused on longer term work. Partnership with the US, Japan and possibly South Korea could be meaningful in a number of areas.

2.3 Adopt a joint programming approach. Currently there is little or no coordination between European-level and national research. Some governments are in a position to take the initiative in this area – notably Germany, the United Kingdom, France, Finland and Poland.

Key Action 3: Increase the flow of trained people.

A supply of trained people is a significant constraint. The lack of investment in research and teaching in this area over the past 20 years has depleted the availability of expertise to undertake the necessary research and teaching. Training initiatives are needed and within the European framework a pool of excellence should be developed – a platform that coordinates the supply and demand for education and training in the area with some elements being in competition and some complementary. There is also a need to attract interest from researchers outside the area; many of those doing research in this field have a background in the minerals sector, but breakthroughs may be more likely to come from people currently working in other fields.

Key Action 4: Governance issues are critical.

Securing raw materials is a task that goes beyond the competence and capability of the individual member states and is inherently European. Even current European initiatives in other fields are dependent on action in this sector – rare metals are behind all the EU's proposed Innovation Partnerships. Collaboration beyond Europe is also necessary, but a collective voice for Europe is more likely to be heard in the international arena. There are also opportunities to exert a positive influence to halt environmentally damaging or politically dangerous approaches in other parts of the world, notably in Africa and parts of the CIS. The momentum from the current EU Raw Materials Initiative, aiming to foster and secure supplies and to promote resource efficiency and recycling, needs to be carried forward into the EU's Eighth Framework Programme, its innovation policies and also its wider policies including those concerning interaction with the African, Caribbean and Pacific States.

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The Future of European Innovation Policy

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Purpose

This foresight activity was part of the EU FP7 Blue Skies Project aimed at piloting, developing and testing in real situations a foresight methodology designed to bring together key stakeholders for the purpose of exploring the longer term challenges facing their sector and building a shared vision that could guide the development of the relevant European research and policy agenda. One of the four topics chosen in this project was future innovation policy in Europe, as an example of a cross-cutting policy area that affects different policy levels – from European to regional. The exercise was received with great interest by stakeholders and policy actors, leading to high-level participation from member states and at the EU-level.

Preparing European Innovation Policy for the Challenges of the Future

The Europe 2020 agenda has moved innovation to the centre stage of European policy. In the area of innovation, the EU aims to launch a flagship initiative entitled the Innovation Union, outlined in an EC communication in September 2010 (EC 2010).

Stepping up innovation performance is regarded as key for overcoming the current economic crisis, for increasing productivity and creating new markets. It requires improving Europe's attractiveness for investments in research and innovation, which is hampered by the low efficiency and effectiveness of these investments, even though major differences exist across EU member states and regions. This is an issue of major concern in the light of the changing patterns of global competition, with new countries, such as BRICS, which are entering the stage and quickly strengthening their innovation potential.

At the same time, it is increasingly recognised that, apart from these immediate economic goals, a more long-term concern with the sustainable development of European societies has emerged to demand greater attention. We are confronted with a number of societal 'Grand Challenges', which require major innovative, often systemic solutions in order to be tackled successfully: climate change and food supply, scarcity of valuable resources (e.g. water, raw materials, biodiversity) and the changing age structure of our societies, social disparities and healthy living, education systems to meet the demands of the knowledge society, to mention just a few.

These two core drivers of innovation, i.e. the interest in overcoming the economic crisis and tackling the Grand Challenges, which are to be addressed through investments in research and innovation, point to a delicate balance to be struck between the benefits that an individual entrepreneur can expect from his or her investments and the societal costs and benefits from such investments and related spill-over effects. Future innovation policy needs to devise the right framework conditions to reconcile these two important but sometimes contradictory cost-benefit considerations and to do so against the background of changing patterns, practices and models of innovation.

The changing nature of and demands on innovation require rethinking the existing rationales for policy intervention in the light of the EU 2020 agenda. An incremental improvement and upgrading of conventional innovation policies will not do the job; current innovation policy is riddled with too many fundamental flaws and deficits. A major overhaul is needed of the governance structures and processes in the field of innovation poli-

cy. It is not only a question of what future innovation policy should look like but also how to move towards a new organisational model for innovation policy. It should enable a coherent policy approach and thus ensure that counterproductive effects of different policy areas are avoided and that innovation is paid due attention also in other policy areas than those directly devoted to research and innovation. Moreover, it is crucial to establish a transparent and coherent division of labour between regional, national and European policy levels as well as efficient cooperation between member states, for instance, on issues such as access to research funding or the engagement of national organisations across borders.

Success Scenario Approach

Based on a comprehensive background paper, a workshop was organised in Brussels on 27/28 May 2010 with about 30 high-ranking experts and decision-makers. It focused on identifying perceived gaps in innovation policy to be tackled to support Europe on its way towards an Innovation Union.

The purpose of the workshop was to bring together experts from different policy areas and levels of relevance to innovation in Europe with experts from research and industry to analyse the relationship between sectoral, cross-cutting and innovation policy agendas and their implementation at the European and national level, and to explore the means and actions for improving their coherence. A first step in the process was to develop a vision how European institutions can take shared responsibility for innovation and formulate requirements and key challenges for the future of innovation policy. A second session aimed at identifying key policies to support effective innovation, with an emphasis on the European policy level. The results were condensed into a success scenario framework for future European innovation policy. As a third step, the workshop focused on matters of innovation policy governance; an issue that has not received much attention in recent EU innovation policy debates. The time horizon of the exercise was 2020.

Apart from its contribution to current innovation policy debates, the exercise was also to pilot and test in real situations a foresight methodology designed to bring together key stakeholders to explore the longer term challenges that face their area. The methodology is inspired by the notion of success scenario. The purpose of such a scenario is to set a 'stretch target' for all the stakeholders. In this specific case it aims to build a shared vision capable of guiding the development of the relevant European research and innovation policy agenda. This includes anticipating changes of the European research and innovation landscape, of national and European policies and of associated governance mechanisms, which would be needed to take forward that agenda.

Gearing Innovation Policy toward Grand Challenges

The combination of interactive success scenario development and desk-based innovation ecosystem mapping brought up a number of important findings. Three of them merit particular attention:

A Broader Understanding of Innovation

The workshop underlined that future innovation policy will have to be based on a much broader understanding of innovation than at present. Four main features will have to receive much greater attention than today:

- Innovation takes place in an ecology of different actors and activities, comprising research, market and societal demands, finance, and institutional frameworks, i.e. it is based on a network of relationships between innovation actors and the environment structuring those relationships. The ability to source knowledge developed elsewhere or to be a knowledge supplier, as captured in the terminology of 'open innovation', has started to transform business models and processes. This development has led to an embedding of local knowledge production in global innovation networks, but it is also recognised that the local context still matters for providing appropriate solutions.
- Users have a prominent role to play in devising innovations that are in line with specific and local requirements. Greater concern for the needs and interests of users is reflected in the growing recognition of the importance of innovation in services. While representing around 70% of GDP in most European countries, services have long been neglected by innovation policy. The public sector plays a much more important role for innovation than has been recognised in the past, as a user and shaper of innovation as well as by stimulating the capabilities of potential users to specify their demands on innovation.
- This shift in attention also extends to what constitutes innovation in the first place. Social and organisational innovations are not only complementary to technological innovation but equally important novelties in their own right. Often, they cannot be dissociated from each other and require a stronger role and thus empowerment of people (OECD 2010). R&D is just one contribution to innovation. This is particularly obvious in the service sector where innovation takes place despite the lack of explicit and dedicated R&D.
- Finally, it is also increasingly recognised that there is no single innovation model that fits the requirements of all fields of innovation. Greater diversity in research and innovation patterns can be observed, as

reflected in the greater attention paid to sectoral and thematic specificities of innovation.

Future Requirements for Innovation Policy and Its Governance

A total of sixteen principles or "commandments" of future innovation policy and its governance were formulated in the context of the workshop.They apply to the European as well as at member states level:

Ten principles of next-generation innovation policy

- Orientate innovation policy towards Grand Challenges
- Respond to the international embedding of innovation activities
- Balance priorities by supporting efforts to achieve productivity gains and create new markets and jobs
- Strengthen incentives to innovate but avoid hampering spill-over effects needed to tackle Grand Challenges
- Make use of Grand Challenges as mechanisms to build new forms of social and commercial collaboration
- Give priority to social and organisational innovation rather than research-led innovation only
- Ensure that cross-cutting policies promote innovation agendas and support the central role of innovation
- Gear knowledge triangle policies towards innovation
- Provide stronger innovation impulses through sectoral agendas and related demand-side policies
- Intensify efforts to tackle systemic innovation deficits

In addition to these principles of innovation policy, six principles were formulated that should guide the future governance of innovation policy in Europe.

Six principles of next-generation governance

- Innovation policy needs to be horizontally embedded and integrated
- Improve coherence in innovation policies at different policy levels
- Put emphasis on building institutions and rules rather than specific programmes
- Make Grand Challenges concrete and tangible as a precondition for setting policy priorities
- Enhance the responsiveness of innovation policy-making to new needs
- Ensure that public administration delivers more with less

A Success Scenario Framework for Future Innovation Policy in Europe

The competencies of the EU in matters of innovation policy are limited. However, to make the most effective use of the specific advantages that these limitations imply, the participants of the workshop suggested a framework that builds on three major pillars of European innovation policy (see Figure 1 in the next column).

Pillar 1: Issue-oriented innovation policy: Focus on Grand Challenges

In line with the Innovation Union flagship initiative, a reframing of innovation policy as a means not only of enhancing competitiveness is recommended but also for addressing Grand Challenges. In order to achieve this, the policy instruments available to the EC are limited, but it could nevertheless spearhead the principle of recognizing and using all forms of innovation – technological, social, organisational and institutional – as equally important means of tackling societal challenges. This principle also implies that simply combining research and innovation policy is not enough because it would imply a restriction to research-led innovation and thus ignore the importance of the other dimensions of innovation needed to meet such challenges. Instead, the EC could strive to inject innovation objectives into its sectoral and cross-cutting policies: a range of powerful demand-side policy instruments could be used to support innovation for tackling Grand Challenges.

A number of concrete examples of first pillar policy initiatives were also suggested, such as

- going beyond an integration of research and innovation policy and considering the integration of innovation agendas into sectoral policies, or
- making innovation-friendliness a standard criterion for defining "good practice" regulations in sectoral policies.

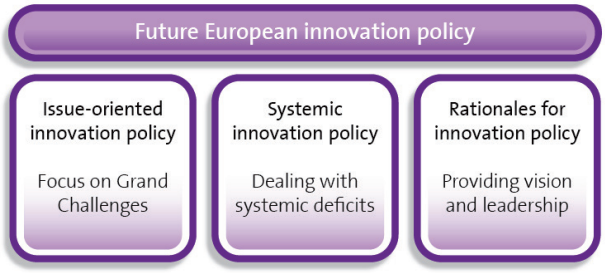

Figure 1: The three pillars of future European innovation policy; source: Weber & Georghiou (2011)

Pillar 2: Systemic innovation policy: dealing with systemic deficits

Grand Challenges should not become the sole concern of European innovation policy. There are a number of cross-cutting problems and systemic deficits that need to be addressed through a targeted innovation policy at the European level, including the Community patent, the realisation of an internal market for innovation-oriented procurement, state aid rules, or the improvement of framework conditions for enabling the fast growth of high-tech companies. If indeed innovation becomes a major concern of sectoral and cross-cutting policies, systemic innovation policy initiatives are likely to receive widespread support in related policy areas as they will be recognised as crucial drivers for realising their mission of tackling Grand Challenges through innovation.

Examples of second pillar policy initiatives comprise

- adjusting state aid rules and other elements of competition policy in order to remove inherent barriers to innovation and
- revisiting public procurement practices and regulations to enable the full exploitation of their innova-

tion-enhancing potential across borders and in the context of Structural Funds.

Pillar 3: Orientation and rationales for innovation policy in Europe: providing vision and leadership for innovation to become a horizontal concern in a multi-level policy context

The political competencies of the EU may be limited, but this apparent weakness offers the opportunity to fulfil the role of intellectual leader in the innovation policy debate in Europe. By identifying deficits, developing visions and formulating rationales for innovation policy, the EU can provide orientation and common reference points for all levels and areas of policy. This has already happened in the past; the momentum generated by the European Research Area concept is a clear example of leadership, in spite of limited formal competencies. Intellectual leadership has the potential of projecting strong messages, which can be communicated to the highest levels of decision-making as well as to the public. In this way, innovation can be assigned the highest priority on the policy agenda. The notion of Grand Challenges is very helpful in this regard because it has the potential for connecting seemingly abstract notions of innovation policy with the deepest concerns of citizens. However, in order to be convincing, European institutions must lead by example, i.e. the concept of innovation needs to be much more embedded in the actual operations of public administrations. An "entrepreneurial innovation policy", for instance, requires that risk-taking and collaborative modes of policy-making are internalised in the EC services as a starting point if member states are to follow the lead.

Policy initiatives that are in line with Pillar 3 are, for instance

- establishing a culture of co-development in public administration to enable effective procurement procedures, including the fostering of training and information exchange about experiences and good practices in co-development and
- providing incentives to encourage experimenting and risk-taking in public administration at the European level, for instance, by alleviating provisions on personal financial liability for EC staff and by supporting a risk-tolerant and trust-based approach to managing innovation.

Keys to Future Governance of European Innovation Policy

By its very nature, the results of the exercise were very much geared towards providing policy insights, both with regard to substantive policies and the governance of innovation policy. Key questions of governance will need to be tackled in the coming years if the three pillars model is to be realized. At the workshop, some ten governance questions were formulated alongside with some first tentative inroads for dealing with them, but much more effort is needed to realize a significant change in European innovation policy governance:

- How can innovation become a key concern across all sectoral and cross-cutting policies?
- How can shared future visions be established that have the necessary weight to be meaningful for decision-making?
- How can Grand Challenges be concretized to provide operational orientations that help ensure coherence and alignment across policy areas?
- How can horizontal coherence of policy development and design be ensured?
- How can a distributed model for policy implementation be defined?
- How can coherence in innovation policy be achieved in a multi-level governance setting?
- How can coherence with stakeholder opinions, interests and decisions be achieved?
- How the EC can deliver a range of outcomes with less resources?
- How can transparent and rational communication be ensured?
- How policy learning based on local experiences with new forms of innovation be improved?

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For further information on the FarHorizon project see http://farhorizon.portals.mbs.ac.uk/

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Is Technology Still Enough to Change the World?

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Purpose

The EU has a long tradition of legitimating its policies based on its "technical charisma". The European Commission's initiatives are justified economically and supported politically through a strong link between science and policy-making. In this framework, forward-looking activities and quantitative models play a critical role, even more so in the field of R&D. It thus comes at no surprise that several FTA exercises have been implemented in the industrial technologies area in order to define priorities for research and to set up the R&D agenda.

Background & Context

The European Union has a long tradition of legitimating its policies based on its "technical charisma". The European Commission's initiatives are justified economically and supported politically by establishing a strong link between science and policy-making. In this framework, forward-looking activities and quantitative models play a critical role (Rossetti di Valdalbero, 2010). Probably the most illustrative example of such a tradition is the famous "Cecchini Report" published in 1988. This report stressed the "cost of non-Europe" in a prospective way in order to underline the benefits of the single market (Cecchini, Catinat and Jacquemin, 1988). The Cecchini report constituted a pillar of the future economic and monetary union and represented a methodological breakthrough for European integration (Muns, 2003).

Nowadays, some foresight exercises are even compulsory at the EU level. For instance, each new strategy or policy must be preceded by an "ex ante impact assessment" that analyses different future policy options and their potential impact. Forward-looking studies are particularly relevant in the field of research, where scientific and technological trends, objectives and options are the basic premises to define strategies and policies in a commonly accepted framework.

Europe is facing a double challenge. It must maintain or increase its competitiveness in the globalised economy while tackling the so-called "grand challenges". This is now happening in the context of a financial and economic crisis, which implies severe budget restrictions for the public sector. These elements are clearly considered in the *Europe 2020 Strategy* (COM (2010) 2020 final), which puts forward three mutually reinforcing priorities for the current decade: '*smart growth*' (developing an economy based on knowledge and innovation), '*sustainable growth*' (promoting a more resource efficient, greener and more competitive economy) and '*inclusive growth*' (fostering a high-employment economy delivering social and territorial cohesion).

To attain these interrelated goals, research on industrial technologies should play a relevant role. According to the European Union's definition, industrial technologies cover *nanosciences and nanotechnologies, materials and new production technologies* (NMP). They are part of the "key enabling technologies" that "*will be at the forefront of managing the shift to a low carbon, knowledge-based economy*" (COM (2009) 512/3). In fact, traditional European manufacturing can hardly compete with the low wages in countries like China; yet, the current crisis has also shown that industrial economies, such as Germany, have been more resistant to crisis and/or have been quicker to grow again compared to economies strongly reliant on the service or the construction sector (Beck and Scherrer, 2010; Deutsche Bank Research, 2011). This alerts us to the still important role of industry for our economies. In any case, the only way for European industry to be competitive is through high added-value products: for instance, through the use of new materials and processes.

Forward-looking Activities on Future Research Priorities, Sustainability and Societal Challenges

In the NMP area, several actions are implemented to contribute to strategic thinking and to define priorities for research:

– ***Specific forward-looking projects*** in this respect are the FP6 Futman, NanoForest, Sust Prod Consum, Clevertex, I*Proms or Mantys amongst others. They range from forecasting exercises, roadmaps, foresights, etc. focused on specific sectors to very comprehensive analyses covering socio-economic aspects and manufacturing trends (Alquézar and Anastasiou, 2010). Some of these projects have been at the basis of other initiatives, which guarantees a certain continuity and consistency of the main policy orientations. For example, Manvis and Futman were the pillars of the European Technological Platform Manufuture.

– ***The NMP Expert Advisory Group (EAG)*** is composed of 25 international experts from the various R&D domains of the NMP research programme. Its role consists in presenting the state-of-the-art in the respective NMP fields, reflecting on the research priorities, directions and required synergies with other thematic priorities (Kiparissides, 2010).

– ***Intelligent Manufacturing Systems (IMS)*** is an industry-led, international business innovation and R&D programme established to develop the next generation of manufacturing and processing technologies. It includes companies and research institutions from the European Union, Mexico, Korea, Switzerland and the United States. IMS manages IMS2020, a project funded by the European Commission under the NMP theme, aimed at creating roadmaps towards “intelligent manufacturing systems” by 2020, in areas like sustainable manufacturing, key technologies, standardisation or education (http://www.ims2020.net/).

– ***European Technology Platform (ETP)***, such as Manufuture (2006) or SusChem (2005). They aim at proposing, developing and implementing strategies for research and innovation in the fields of manufacturing, chemical engineering and industrial biotechnology. They were both launched in 2004 with the aim of speeding up the rate of industrial transformation to high-added-value and sustainable products, processes and services and providing solutions to critical societal demands.

Smart Adaptation and Social Responsibility of Innovation Systems

What are the main conclusions of these forward-looking initiatives? Two different but interrelated dimensions merit analysis:

- Conclusions related to science and technology development of industry
- Socio-economic conclusions

From the ***technological point of view***, a competitive industry must adapt its products very quickly to changing customer needs. This means that operations and, consequently, machines and tools have to be more and more flexible. As a consequence, manufacturing must be *self-adaptive, reconfigurable, multi-functional* and *cross-technological*, with a user-friendly human-machine interaction. The role of ICT will continue to increase since industrial processes are becoming more and more complex, which implies the need for computer-aided modelling and simulations.

As mentioned above, forward-looking studies consider that the use of new materials can allow traditional industries challenged by low-wage economies to be competitive by creating new products or giving better properties to existing ones. The FP6 projects CLEVERTEX (2005-2008) and NANOFOREST (2004-2005) showed how traditional sectors, such as the textile or forest products industry, can still compete if they are able to innovate. “Smart” textiles, such as conductive materials and lighting fibres, electronic components and sensors, or materials generating energy and power supply, amongst others, can be applied in sectors such as healthcare, automotive, protective clothing, interior textiles, and communication and entertainment. Experts estimate that intelligent textiles could account for around 10% of the total textile market by 2020, especially in the clothing branch. Something similar can be said about the forest industry, where the refinement of wood-based raw materials, with improved performance and added-value, has the potential to maintain or even increase European competitiveness in this sector.

In industrial technology foresights, *integration* is the keyword: integration between different technologies and materials, integration between production and services, integration between different stakeholders towards a common goal, integration between different sectors and activities. Such integration creates a number of difficulties. For instance, suppliers are not always ready to adapt to the needs of innovative enterprises. This issue is very common in the field of nanotechnologies where suitable raw materials and equipments are still very expensive while final products often need to follow arduous legal procedures to be approved, with uncertain public acceptance.

The consequences of such a need for integration (and innovation!) go beyond the technological aspects. ***Management styles*** need to be renewed. First of all, manufacturing has to meet technical demands (adaptability, economic performance, reliability) while being environmentally friendly and taking into account safety. New business models increasingly have to take into account social and environmental responsibility while being open to innovation. On the other hand, competitiveness requires innovation, which relies on the capacity of organisations to anticipate and prepare for changes, "*looking for options and opportunities for change before the business is forced to change*" (Willenius, 2008: 67).

Skills are a basic condition for the economy and society of the future: "*Human capital will replace physical capital at the core of competitive advantage"*, the FP6 FUTMAN project stated. The importance of human capital is underlined by several foresight projects in the field of industrial technologies, mainly as an obstacle for development. From a quantitative point of view, the low attractiveness of scientific and engineering careers is often evoked (see the FP6 projects MANVIS or SMART). Consequently, capacities for high-technology manufacturing are decreasing at a time when industry's technological needs are increasing (Johnson and Jones, 2006*;* Kiparissides, 2010). Something similar can be said about vocational education and training, the attractiveness of which continues to be challenged while European industry needs highly qualified workers (Cedefop, 2010). These trends are not just European, but their impact on our economies and societies can be particularly dramatic since one of the main competitive advantages of Europe over our competitors is our educated people (Salhberg, 2010).

From a qualitative point of view, forward-looking studies on industrial technologies are not very precise. While there is a consensus about the relevance of human capital for competitiveness and sustainability, critical questions are not answered: What kinds of human capital (i.e. which skills, attitudes, values) are necessary? Which reforms, which education models are needed to move towards a sustainable economy and society? How are they to be implemented?

There is a debate amongst education specialists and practitioners on these topics, which is also more and more present in the mass media. Some consider that, to increase economic competitiveness, education and training (and even research) have to be based on market principles: competition amongst pupils, amongst schools and universities, amongst teachers, amongst researchers, and amongst education (and research) systems. Market values are therefore embedded in education and training systems. As a corollary, standardisation and accountability are proposed as solutions to improve the quality and effectiveness of education almost everywhere, under the influence of Anglo-Saxon countries (Salhberg, 2006). Probably the best example of this so-called Global Education Reform Movement is the OECD's Programme for International Student Assessment (PISA), which is presented as the main international comparison tool between "good" and "bad" education systems, leading to policy reforms in national systems (Grek, 2009). Such principles are contested by other authors, who consider that standardisation and accountability may be counterproductive for enhancing economic competitiveness. In today's changing societies, principles such as flexibility, interpersonal skills, risk-taking and creativity, essential to promoting innovation, may be more efficient than just focusing on numeracy, literacy and scientific competences (Salhberg, 2006). The basic idea rests on a paradox: to enhance the economic competitiveness of our societies, education and training systems should be based on less competition. Education should be founded on principles such as collaboration, mutual trust and social interaction (Salhberg and Oldroyd, 2010).

Forward-looking studies on industrial technologies do not participate in this debate, but they provide some clues rarely taken into account by education and training specialists. Basically, a competitive industry requires innovation, integration and adaptability. These principles hardly match with standardisation and accountability. When foresight studies mention user-friendly worker-machine interactions in industry and open management styles, a new role is attributed to workers. This new role requires their *technical* skills to be accompanied by a large set of *soft* skills, such as communication, creativity, risk-taking, problem-solving, interpersonal skills, etc.

Towards a New Social Paradigm?

The previous analysis focused mainly on competitiveness. What are the trends and challenges of industry to maintain its competitiveness? Little has been said about global challenges, amongst them sustainability. Are science and technology applied to industry enough to tackle societal challenges? This is indeed one of the arguments of climate change sceptics.

According to the NMP forward-looking studies, the answer to such a question is no. A sustainable economy is unrealistic without the development and adoption of ***new socio-political paradigms*** and, consequently, of both new production *and* consumption patterns (FUTMAN). There is a clear gap between dominant social paradigms and values (i.e. consumption sovereignty in a market economy) and sustainability (SCORE!). In sum: we need to live, work and consume in a different way. Such a ***social paradigm shift*** requires extended efforts, shared between citizens/consumers, political leaders, researchers and industry. The idea of science- and technology-supported unlimited progress and growth, the dominant paradigm since the Enlightenment, is therefore challenged. Research and innovation can help to tackle grand challenges by developing and applying resource-efficient technologies, but they can hardly solve them on their own. Without social innovation the technical developments might not be put into practice because they do not correspond to the problems generated by human behaviour. Therefore, social innovation requires bottom-up innovation and a participatory approach involving the citizens, as formulated by a business panel on future EU innovation policy:

> *"People centred innovation is crucial in our way of thinking about policy, actions and instruments. It means that public policy can link people to opportunities, infrastructures, competencies and incentives. Innovation policy to reinvent a new Europe in the future will involve many actors. It is not about the government running or doing things alone." (European Commission, 2009).*

Thus, some of the forward-looking studies focus on the emergence of social innovators, such as "creative communities", i.e. active, enterprising people who invent and

implement new ways of dealing with everyday problems – childcare, care for the elderly, alternative means of transport, shared facilities and services, etc., or the Slow Food Movement (EMUDE, SCORE!). A top-down approach or the need for leadership is also mentioned: policy-makers could create incentives to move towards new "meta-values", through higher transparency about environmental and social performance or with actions to make working patterns more flexible, facilitate the use of public spaces, devise new forms of taxes for alternative economies, etc. This emphasises the fact that the interaction between the innovators and the environment they are working in is crucial. A good example are the current "wikirevolutions" in the Arab world (Castells, 2011). Democratic movements have not been produced because of technologies, but through using them (i.e. Facebook, Twitter, Youtube) – in an absolutely decentralised way without a central strategy. Social change can come at any moment – especially, when people have not been allowed to take part in shaping their society for decades. Social innovation plays a considerable part in shaping and reshaping society as a more participatory arena where people are empowered to act as in a functioning democracy. Therefore, to close the parallel, there is a democratisation of innovation needed in order to be able to change the world.

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Agriculture and the Challenges of Energy

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Purpose

Energy in agriculture is all too often seen as a purely cyclical issue whereas it brings more complex challenges in terms of economic stability for agricultural holdings, impacts on the environment and climate, on food supply chains and spatial planning. The present brief describes the main results of a prospective study led by the Centre for Studies and Strategic Foresight (at the French Ministry of Agriculture). A group of experts used the scenario method to imagine possible futures of the agriculture-energy system in 2030 and help identify priorities and options for public action.

Energy at the Heart of French Agriculture

Energy is of major importance for the future of agriculture in France although it receives relatively little analytical attention. Control of energy consumption is an economic issue for agricultural holdings, which consume energy both directly (fuel oil, electricity and natural gas) and indirectly (energy for the manufacture and shipment of farm inputs). All in all, French farming consumes around 11 Mtoe (million tonnes of oil equivalent) a year: 5.3 Mtoe directly and an estimated 5.4 Mtoe indirectly. Taking all French holdings together, expenditure on fuel and lubricants represents 8.3% of intermediate consumption, 13.1% of the costs of fertilisers and 21.6% of livestock feed. The share of energy consumption in production costs varies widely according to the type of production: 23% of intermediate consumption relates to fertilisers and soil improvement for cereal and protein crops; 67% results from feed purchased for granivorous livestock holdings between 2005 and 2008. For an identical output, there are wide variations in energy costs at the farm level depending on production systems and practices. The prices for these inputs may also vary widely, reflecting those of fossil fuels. A high oil price may therefore have major consequences for the economic balance of holdings: the double burden of low farm prices and high energy prices may cause unavoidable and difficult situations. The issue of energy also involves logistics, the organisation of agricultural supply chains and the distribution pattern of farming activities across regions. This is so because the distances separating production areas, consumption areas and sources of input supply are reflected in energy consumption.

Moreover, energy and climate are intertwined issues. Agriculture could contribute to national targets for containing global warming by cutting its emissions, producing renewable energy and sequestering carbon in soil. On the other hand, ambitious climate and environment policies may increase fossil fuel prices.

A Collective and Systemic Approach for the Scenario Method

Since the interaction between agriculture and energy is complex, this subject was addressed using a collective approach based on the scenario method.

The 'Agriculture Energy 2030' group involved around forty participants with a wide range of skills and backgrounds from concerned ministries (Agriculture and Fisheries, Sustainable Development), public agencies (ANR, ADEME, FranceAgriMer), technical institutes (CTIFL, IFIP, Institut de l'élevage), the farming world (FNCIVAM, FNCUMA, SAF), research bodies (CEMAGREF, INRA), civil society (FNE) and the private sector (Total, ANIA).

This foresight exercise is centred on agriculture. It leaves out both fisheries and forestry, and the agrifood and retail distribution industries are only marginally considered in the exercise. In addition, climate change is only considered for its direct link with energy, that is, greenhouse gas (GHG) emissions caused by direct and indirect energy consumption and renewable energy production. Issues relating to biomaterial and bioproduct production have also been considered in the core analysis. Finally, the analysis restricts itself to mainland France because the French overseas territories have very specific agricultural and energy features of their own.

The choice of time frame to 2030 is a trade-off between the desire to capture cyclical effects and the necessity of working with a manageable, not too distant time scale. Within this basic framework, the Agriculture Energy 2030 group identified five components made up of 33 variables relevant to explaining the possible futures of the agriculture-energy system.

A study card was created for each variable to set a number of hypotheses as to its future development. This exploratory work was based on the identification of past trends, emerging trends and the main areas of uncertainty to be considered when looking forward into the future. Proceeding very conventionally, these hypotheses were combined for each component to produce micro-scenarios, which were then combined to generate global scenarios. For greater consistency and to cast a more informative light on the issues surrounding agriculture and energy, the global scenarios were quantified using a model (Climagri) to estimate French farming production, energy consumption and GHG emissions by 2030. These scenarios are not predictions of the future and reflect even less the preferences of the expert group or the French Ministry of Agriculture. They were used as conjectures to alert actors and decision-makers.

A Set of Four Scenarios to Highlight Energy Challenges in Agriculture

Scenario 1: Regionalisation and frugality to confront the crisis

A profound energy crisis undermines conventional business models. The international context is tense and focused on protection of domestic markets. Around 2020, the management of public policies is entrusted to a greater extent to regional authorities, which are seen to be closer to the development issues of their territories. By 2030, the agricultural world has changed profoundly and faces a number of external constraints: energy prices at sustained high levels, a budget crisis and loss of legitimacy of the central government, a withdrawal to home regions and a contraction in international trade. Agriculture adapts as a matter of urgency, employing a strategy focused on the local level, accompanied by major institutional reform.

The growing self-sufficiency of production systems inevitably involves input reduction, more extensive livestock farming and diversification. The search for complementarity between crops and livestock or between types of crops across holdings and regions becomes a general reality. By 2030, this transformation is not harmonised across the French territory and there are major regional disparities. Lower levels of specialisation and production lead to a limited export capacity. French farming makes major cuts in its energy consumption (down by 32%). Renewable energy produced on the farm supplies additional income, but its development depends on local potential and dynamics. Extensive use is made of biomethanation and wood-for-energy, but expansion of biofuels is held back by high agricultural prices.

Scenario 2: Twin-track agriculture and energy realism

Against a backdrop of high energy price volatility and further trade liberalisation, public support for agriculture declines with a refocusing on remuneration for the public goods provided by agriculture. These changes have very different impacts on holdings depending on whether or not they meet local demand for the local supply and provision of public amenities. Two forms of agriculture exist side by side in 2030:

- "Business Farming" (mainly on the plains of the Northern , Western and Central France): these farms manage to be competitive and to position themselves on export markets. Intensification and restructuring result in a high-precision, high-input farming system. Energy use is optimised on these farms as a response to economic drivers. Energy optimisation is benefited by private-sector market supply of technology and counselling services.

- "Multifunctional agriculture": these farms diversify their activity and are remunerated for the environmental services they provide (water, biodiversity, landscape, carbon storage). Their main activities are extensive livestock, organic and mixed crop-livestock farming. Such holdings adopt strategies focused on self-sufficiency and low energy use close to those in Scenario 1.

Overall, there is little change in energy consumption. Renewable energy production expands moderately, with investments being held back by price volatility. Biofuel production is more strongly developed in integrated and innovative industrial sectors.

Scenario 3: Health-centred agriculture with no major energy constraints

In 2030, urban consumers are more numerous and more influential. With the backing of the large retail chains, they have succeeded in imposing a major reduction in the use of pesticides by agriculture on grounds of the protection of human health rather than protection of the environment. In the absence of major energy constraints and strong environmental policies, urban sprawl continues to expand. Agricultural supply chains are shaped by their downstream components, with quality schemes and mandatory specifications becoming highly prescriptive with regard to reduced pesticide use. Producers adjust more or less. Some sectors are negatively affected by this new constraint. The most isolated rural regions experience significant abandonment of agriculture. Conversely, the major cities invest in periurban farming to meet the demand for open spaces and local food supply. A specialised and technically sophisticated agricultural model involving integrated pest management has developed. It aims at high production levels and at abating pesticide use at the same time. In parallel, organic farming develops significantly. The absence of any major constraint in terms of policy or energy pricing results in a slight fall in overall energy consumption since production inputs are partially substituted by efficiency gains in machinery. The production of biofuels expands strongly, driven by the early arrival of second generation technologies.

Scenario 4: Ecological agriculture and energy savings

Approaching 2015, the need to make sharp reductions in the environmental impact of human activity leads to a consensus both in the developed world and slowly in the emerging countries. European households adapt their consumption patterns out of concern for preservation of the environment and in response to prices that now include the environmental cost of products. The implementation in 2016 of a common EU-US CO_2 market with border adjustment mechanisms triggers a massive shift towards ecological modernisation. In this context, agriculture evolves toward new production models with smaller environmental impacts; the trend is supported by a reformed agricultural policy. This change, however, is both difficult and gradual. The initial resistance of the farming world delays the behavioural changes. Major mutations in the whole agri-food system are also required. From 2020 on, French agriculture becomes 'ecologically intensive' on the wide cereal-growing plains of the country: for example, crop diversification, general use of nitrogen-fixing crops at the beginning of rotation sequences and no-tillage become common. In hilly and mountainous lands, farmers are paid for environmental services and are encouraged to meet self-sufficiency at the farm (diversified systems based on mixed crop-livestock farming) or across whole regions (complementarity between farms). Biomethanation and renewable energy production are strongly developed.

Future Requirements for Policy

The expert group sketched out 'come what may' strategies that can be expected to remain valid in any future context. The use of fertilisers is a core element of energy balance, and the technical means for reducing nitrogen inputs are well known (long crop rotation sequences and diversified crop choices, use of green manure, organic sources of nitrogen and so on). Their general adoption requires awareness-raising and educational efforts directed at the farmers along with networking to support farmers in exchanging experiences. The need for changes may call for the use of strong normative or economic instruments.

The Agriculture Energy 2030 group has highlighted the advantages of biomethanation, on condition that the digestates are correctly recycled. The structuring and development of the relevant sector supply chains are major issues. Digestate centrifugation is one of the most promising avenues because it allows an easily transported solid phase rich in nutrients (ammonia, phosphate, potassium) to be isolated, along with a liquid phase that is rich in nitrogen but which must be used in nearby areas (spreading). Official approval for the products obtained in this way could provide a major boost. Another advantage of biomethanation is the production of renewable energy (electricity and heat). The existing support schemes for the installation of digesters on farms should be accompanied by biogas purchase prices to offer greater incentives and forward visibility to investors.

Preference for local supply of protein for animal feed was seen as an advantageous strategy. The goal is to reduce the transportation of these inputs through on-farm production or local supply and to give preference to protein sources requiring low levels of inputs for their production. Grass-based livestock farming particularly deserves to be encouraged given its self-sufficiency and the numerous amenities it provides. Strategies aimed at expanding the use of grass in livestock farming and introducing legumes into pastures are of interest and should receive appropriate technical assistance.

Agricultural machinery constitutes a major area for fuel savings and a lever for change, which could be easily used. Investment in proper adjustment and maintenance of tractors, replacement of machinery and reductions in engine power should receive financial support while giving priority to pooled uses. Elimination of the need to till the soil (notably by means of zero-tillage) could be explored for the reduction of fuel consumption. Extensive effort on training and research is, however, required.

Innovation in the organisation of the agricultural sector to improve energy balances across production regions is needed. The group recommends that production systems should be diversified and products traded between holdings. Support would be appropriate for farmers committing to innovative modes of production (e.g., crop-livestock complementarity, organic farming, high environmental value) through proactive policies on land and installations, especially in the most specialised regions. In addition, the provision of technical and financial support for the development of on-farm primary processing of water-rich products could help reduce transport-related energy consumption while at the same time diversifying farmers' income sources.

There is nevertheless a need to study case by case the energy efficiency and economic viability of this kind of development, which requires major investments and increases farm workload. The development of on-farm storage facilities and conservation technologies helps reduce wastage and thus provides another tool for action. Lastly, there are avenues to be explored for the improvement of the energy performance of short supply chains: delivery pooling, modal transfer, avoidance of empty return trips and so on.

The development of renewable energy production must be supported and channelled. Renewable energy, other than biomass can provide additional income, depending on farmers' investment capacity and local potential. Moderate purchase prices should help avoid excessive speculation and the risk of unbridled development of installations on agricultural land. Where biofuels are concerned, public support should favour the most competitive and best environmentally performing sectors. Such targeting of support would help ensure that budget leeway can be found to increase R&D efforts and assist investment in second-generation technologies. Support of this kind should be made conditional on compliance with demanding sustainability criteria. The rising importance of ligno-cellulosic biofuels will also require sustainable management and the mobilisation of large quantities of biomass. Farm fuel taxation might also be revised in order to offer greater incentives for fuel economy.

Reduction of the energy consumption of buildings is a necessity for the high direct energy consuming sectors. Large-scale investment should, for instance, be provided for the modification and effective insulation of buildings, the installation of heat economisers or biomass boilers and for lighting optimisation. Financial support in the form of grants or loans could be provided on condition of complying with thermal standards for buildings. A wide-ranging scheme could be implemented along the same lines as the PMPOA (French programme for the control of pollution of agricultural origin). Lastly, priorities for agronomic research and the dissemination of innovation in agriculture were highlighted. Indeed, considerable uncertainty remains and more knowledge should be gained on indirect energy consumption (especially for animal feedstuffs), end-to-end energy balances in agricultural supply chains, the logistics of agricultural and food products and the energy content of those logistics. In particular, current work on the development of short marketing chains for agricultural products should not neglect this aspect. Generally speaking, comparisons of the energy balances of different agricultural holdings must be continued and improved to help understand discrepancies in levels of consumption and energy efficiency in different production systems.

Varietal improvement should focus on the development of high-yield protein crops and less nitrogen-dependant cereals and oilseeds. Alongside this, research into production systems should address low-energy systems (e.g., integrated production, grass-based systems) and alternatives to tillage. Support for organic farming should go hand in hand with research into increased yields and methods for reducing direct energy consumption.

Innovation transfer is the keystone of any successful strategy. Governance of R&D should be broadened, for example, by involving practitioners in the R&D organisations. Developing a network of experimental farms is also essential for the definition and transfer of innovative techniques and technical benchmarks. Lastly, several factors are holding back useful initiatives to sustainably improve the energy efficiency of agricultural holdings and supply chains: energy price volatility, low taxation on energy products in agriculture and lack of knowledge. Efforts to communicate, raise awareness and provide training must accompany any action.

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Transportation & Logistics 2030

Transport infrastructure – Engine or hand brake for global supply chains

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Purpose

The following foresight brief presents the findings of the innovative real-time Delphi study "Transportation and Logistics 2030 Vol. 2" prepared by PricewaterhouseCoopers' transportation unit and the Supply Chain Management Institute (SMI) at the EBS Business School, Germany. Overall, 104 experts assessed 16 projected futures in terms of probability of occurrence, impact on the transportation and logistics (T&L) industry, and desirability of occurrence. By deriving conclusions organised around four general themes, possible scenarios for the future of logistics were drawn. The purpose was to identify key developments in the T&L industry by the year 2030. In addition, the effects on the transport infrastructure environment from a governmental and an engineering and construction industry perspective were assessed and opportunities for governments were derived.

The Need for Planning in T&L

The development of transport infrastructure requires a long-term planning horizon. Ports, airports, roads and railroads all share a commonality: their life cycle spans are fairly long. Thus, long-term foresight is needed to estimate the demand for transport infrastructure and assess its impact on the economy and the environment. Long-term thinking is a requirement to finance construction, operation and maintenance of infrastructure.

Scenario techniques are an essential addition to traditional forecasting methods. Trusting solely on trend extrapolations and single-point forecasts does not account for the paradoxes in transport. For example, who could have predicted that the amount of transports would decrease between 1995 and 2005 in a Western European country while politicians were talking about investing in infrastructure to meet the increase in freight transportation? What actually increased is the transport service provided for goods. Less goods were transported but over longer distances and/or in smaller batches. Governments and everyone in T&L industry faced the need to respond, and lucky were those with a contingency plan on hand.

In pursuit of such a long-term perspective, the study aims to develop a comprehensive view of the T&L industry in 2030. The outlook is developed by interpreting scenario evaluations, identifying opportunities, applying a cross-industry perspective and deriving extreme scenarios. The next sections will focus on the results of the first two issues (i.e. scenarios and opportunities).

Innovative Real-time Delphi Study

The study employs an innovative version of the Delphi survey method. The Delphi is designed as an Internet-based, almost real-time survey that increases the validity of results by streamlining the classical procedure (see Gnatzy et al., 2011; Gordon & Pease, 2006).

Overall, 16 key future projections were organised around the four general themes "Supply & Demand", "Finance", "Competitiveness" and "Sustainability" of transport infrastructure. The projections were assessed by 104 invited experts in terms of probability of occurrence (0-100%), impact on T&L if they occurred (5-point Likert scale) and desirability (5-point Likert scale). Furthermore, experts could optionally provide qualitative arguments and reasons for their answers.

Once an expert evaluated a projection, the statistical group opinion of all experts was calculated and visualised immediately. The group opinion was presented in a box-and-whisker plot. In addition, the qualitative arguments given by the other experts were also shown. In the light of this new information, the experts were able to revise their initial assessment.

Upon completing the survey, a consensus portal was activated showing an overview of all answers given and how the answers related to average group opinion at that point in time. During the survey period, experts were able to access the consensus portal at any given time in order to check whether they were in line with group opinion or deviated from it. The experts could also adjust their assessments at any time if they wished to do so.

The expert panel included a large number of designated experts from business, mainly C-level executives and decision-makers from global companies. The selection criteria for potential experts based on industry, educational background, experience and function led to the following distribution:

- 28% transport infrastructure operators/ developers
- 27% transport infrastructure users
- 24% academics
- 11% associations
- 10% politicians

Participants were based in 29 countries around the world ensuring a balanced and global view: the emerging countries accounted for a significant share of 38% and the developed countries for the remaining 62%.

Results of the Delphi

Unlikely to Close the Gap between Emerging and Developed Countries

Figure 1 summarizes the results for the area "Supply & Demand". The resulting demand for transport infrastructure is unlikely to be met by 2030. Although emerging countries are investing heavily in transport infrastructure, it is unlikely that the infrastructure provision gap to developed countries will be closed completely within this period. Megacities are likely to attract more projects since investors "follow the money". Road tolls and congestion charges are likely to have become an instrument to match supply and demand of transport infrastructure in 2030.

Figure 1: Results for Supply & Demand

Projection	Probability of occurence (0-100)	Impact on T&L (1-5)	Desirability (1-5)
2030: There is no longer a shortage of transport infrastructure since sufficient investments have been made.	30.38%	4.1	4.2
2030: Industrialised countries have lost their competitive advantage over emerging countries in terms of transport infrastructure.	41.29%	3.8	2.8
2030: Strong regulatory measures, such as road tolls and congestion charges, compensate for the increased need to invest in transport infrastructure.	60.29%	3.9	3.5
2030: Transport infrastructure development strongly focuses on urban areas, while rural areas are neglected.	68.02%	3.7	2.9
2030: Infrastructure shortages (e.g. insufficient transport infrastructure) have forced the division of megacities into decentralised, autonomous "sub-cities".	50.28%	3.6	3.1

Fiscal Constraints Impede Public Funding of Transportation Infrastructure

The second major theme relates to financing transport infrastructure. The results are shown in Figure 2. Governments, although aware of the need for major investments in transport infrastructure, are likely to face strong financial constraints over the next 20 years. For many governments, the task of maintaining the current infrastructure will leave little scope for funding investments in new transportation infrastructure. While governments are likely to remain responsible for local and national transportation infrastructure, private investors seek economies from focusing on national and international large scale transportation systems.

Figure 2: Results for Finance

2030: Financial pressure on governments has become so intense that almost all investment in transport infrastructure has been shifted to the private sector	55.34%	3.9	2.7
2030: Governments are no longer able to contribute to the funding of local transport infrastructure (e.g. main roads and subways), thus user-based financing structures are prevalent	52.14%	3.7	2.4
2030: In emerging countries, there is more capital available to invest in transport infrastructure than in industrialised countries	51.90%	3.7	3.1
2030: International transport infrastructure (e.g. major ports and airports) is controlled by private investment funds, which are strategic drivers of large-scale transport infrastructure projects	61.20%	3.8	3.1
2030: Financing the maintenance of transport infrastructure is more difficult than attracting investments in new infrastructure	65.19%	3.9	2.1

Transportation Infrastructure Tailored to Fit Represents a Competitive Advantage

The evaluated scenarios for "Competitiveness" in T&L in 2030 are shown in Figure 3.

Figure 3: Results for Competitiveness

2030: Transport infrastructure is still a key element of the basic services of an economy, but is no longer a deciding factor in the competition between countries to attract investment	41.44%	3.7	2.8
2030: Digital infrastructure (ICT) has become a stronger driver of economic growth than transport infrastructure	59.66%	3.8	3.4
2030: The success of a logistics cluster (logistics region) depends on the close collaboration of industry, government and academia, in addition to advanced transport infrastructure	77.67%	4.0	4.3

Getting transport infrastructure right remains a competitive advantage as efficient supply chains are a major investment factor. To enhance a competitive advantage, fully integrated infrastructure systems with modern information and communication technology (ICT) present a major enabler for cutting-edge transport developments. Thus, transport infrastructure development can strongly benefit from advancements in digital infrastructure. Moreover, forming clusters based on close collaboration of industry, academia and government will benefit regions by activating new potentials in transportation infrastructure development.

Sustainability Poses the Greatest Challenge

Ensuring the sustainability of transportation infrastructure is probably the most significant challenge to be faced over the next 20 years. The opinion of the experts is shown in Figure 4.

Clearly, transport infrastructure and its networks have a strong effect on the environment. In addition to its ability to stimulate economic growth, transport infrastructure will increasingly be assessed in terms of its environmental compatibility. Increased regulations in the form of emission trading systems or other systems are likely to enhance this compatibility.

Figure 4: Results for Sustainability

2030: A decrease in environmental awareness and regulation has accelerated the realisation of large-scale transport infrastructure projects, boosting economic growth	29.20%	3.8	2.0
2030: Transport infrastructure operators are obliged to participate in emission trading systems to obtain pollution permits	69.06%	3.9	3.6
2030: The environmental costs caused by infrastructure development (including emissions resulting from construction) have become a serious deterrent to investments for which there is otherwise a good economic case	56.19%	3.9	2.6

Environmental costs of transport infrastructure will become an integral part of assessing the full costs of a T&L project. These costs will need to be calculated into the business case of any of these projects.

Innovation Will Be Critical

Flexible planning will be key to logistics service providers, supply chain players, transport infrastructure operators, users and owners since transport infrastructure systems will remain imperfect. Especially in emerging countries, innovative supply methods based on local adaptability and simplicity have to compensate the lack of transport infrastructure.

Governments need to target the implications of the trends in “Supply & Demand” as well. As shown in Figure 5, access to rural transport infrastructure is not a matter of course.

Figure 5: Access to rural transport measured by total population and RAI index (Worldbank 2009)

Country	People without access to rural transport (in mill.)	Rural Access Index
India	301	61
China	23.5	97
South Afric	14.8	21
Brazil	14.2	53
Mexico	9.7	61
USA	8.2	86
Russia	7.4	81
Germany	2.3	89
Saudi Arab	1.1	75
Japan	0.5	99
France	0.2	99
UK	0.2	99

The RAI index estimates the proportion of the rural population that has adequate access to transport systems. Governments need to offer investment incentives to ensure that less investment-attractive rural areas will stay connected to regional conurbations. Governments play an important role in managing supply and demand for transport infrastructure. The surveyed experts believe that road tolls and congestion charges could be a powerful lever to reduce traffic and raise capital to invest in more sustainable modes of transportation.

The financial boundaries clearly impact T&L. Logistics service providers need to assess the availability of capital and the willingness of a government to invest in transport infrastructure when entering a new market.

Governments need to find a balance between investments in new transport infrastructure and ongoing maintenance of existing facilities. It will be essential to incorporate future maintenance needs in all new projects as well. In addition, a shift in focus from upfront costs towards lifetime costs is needed to ensure whole life funding. Rather than a one-size-fits-all approach to finance these activities, public authorities need to find strategies to share risk and responsibility with private investors for individual projects.

In order to stay competitive, logistics service providers should join clusters to actively collaborate with governments, academia and operators of transport infrastructure. Knowledge exchange and management across company borders will be a key success factor over the next 20 years.

In 2030, it is even more essential for governments to maintain, upgrade and expand transport infrastructure in order to ensure and attract foreign direct investments. To achieve this, information and communication technology must be incorporated as the path to be taken towards developing a cutting-edge transportation infrastructure.

In order to ensure eco-friendliness of transport infrastructure by 2030, independent bodies could be established that rate transport solutions in terms of their environmental compatibility. In addition, efforts should be made to reduce demand and optimise capacity.

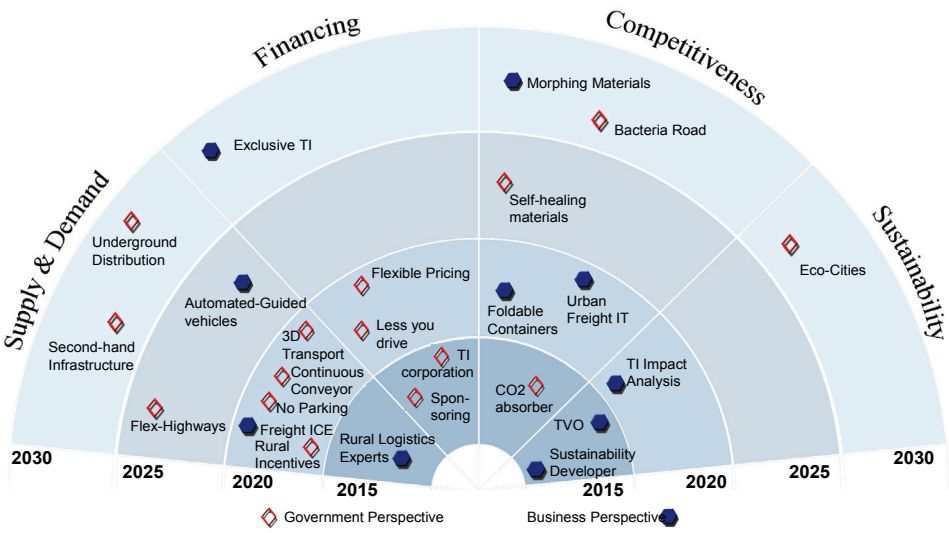
Innovation will be critical in finding these new eco-friendly transport solutions for T&L. More than ever, companies in T&L will need to collaborate to better manage transport emissions in order to cope with the expansion of emission trading systems.

Transport infrastructure developers should be aware of the long-term environmental costs. They will need to assess the entire life cycle of construction, operation and deconstruction to consider harmful environmental effects as well as environmental benefits.

Opportunities for Governments

To close this overview of the Delphi study, we will focus on some promising future opportunities related to transport infrastructure from a governmental perspective over the next 20 years. Figure 6 summarizes these for the four areas identified. The radar depicts the (generic) outcome of several future workshops based on the described scenarios.

Figure 6: Opportunity radar



In Supply & Demand, governments may actively counter the trend of a "rural exodus" by setting up basic transport infrastructure, offering public-private partnerships and implementing other financing mechanisms. In order to reduce congestion in city centres and its side effects, governments may abolish parking spaces at public institutions while ensuring good connections to public transport. Governments might use innovative infrastructure constructions such as sky walks and sky trains or underground distribution systems to lessen the burden on existing transportation infrastructure on the ground. A full automatic continuous conveyor could reduce transport bottlenecks at ports and other hubs by moving containers away from the point of handling to their desired destination quickly. For governments to deal with changing demand, re-usable transport infrastructure comparable to unit assembly systems could be developed.

Governments need to think of ways of how to finance the increasing demand for transport infrastructure. One idea relates to private sponsoring. For example, sponsoring stadiums, such as "Signal Iduna Park" or "Gilette Stadium", could involve financing parts of the necessary transport infrastructure. Tax benefits and other incentives could be used to encourage companies to drive less while individual charges for the use of small parts of infrastructure (e.g., bridges) represent opportunities for reducing demand.

Future CO_2 absorbing materials could be used in new road constructions and could possibly make a big contribution to environmental protection. Self-healing roads through the use of bio-concrete or nanotechnology could reduce maintenance costs. In the same vein, the idea of bacteria-produced roads might be an innovative way for governments to build transport infrastructure in rural areas in the very long-term.

Lastly, governments could use the idea of self-sufficient eco-cities to address the need for a sustainable future infrastructure.

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Envisioning Digital Europe 2030: Scenarios for ICT in Future Governance and Policy Modelling

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Purpose[1]

This foresight exercise was conducted as part of the *CROSSROAD Project – A Participative Roadmap for ICT Research on Electronic Governance and Policy Modelling*, a FP7 Support Action that aimed to provide strategic direction, define a shared vision, and inspire collaborative, interdisciplinary and multi-stakeholder research in the domain. This research set out to help policy makers implement the *Digital Agenda for Europe,* the flagship initiative of the *EU 2020 strategy* launched to increase EU growth and competitiveness in the fast-evolving global landscape and address the grand challenges our world is confronted with today.

[1] The views expressed in this brief are purely those of the author and may not in any circumstances be regarded as stating an official position of the European Commission.

Combining ICT for Governance and Modelling to Assess Policy Impacts

In 2009, the European Commission's Seventh Framework Programme (Work Programme ICT 2009-2010) launched a programme of research on ICT for governance and policy modelling, joining two complementary research fields that have traditionally been separate:

- the governance and participation toolbox, which includes technologies such as mass conversation and collaboration tools; and
- the policy modelling domain, which includes forecasting, agent-based modelling, simulation and visualisation.

These ICT tools for governance and policy modelling aim to improve public decision-making in a complex age, enable policy-making and governance to become more effective and more intelligent, and accelerate the learning path embedded in the overall policy cycle.

In 2010, the European Commission funded the support action: *CROSSROAD – A Participative Roadmap for ICT Research on Electronic Governance and Policy Modelling* (www.crossroad-eu.net) in order to advance the identification of emerging technologies, new governance models and novel application scenarios in the field of governance and policy modelling.

The main goal of the CROSSROAD project was to design the Future Research Roadmap for this domain and to structure a research agenda, which could be fully embraced by the research and practice communities.

Overall, the research roadmap aims to push the boundaries of traditional e-government research to new limits and help resolve the complex societal challenges Europe is facing by applying ICT-enabled innovations and collaborative policy modelling approaches, which include the harnessing of collective intelligence, agent-based modelling, visual analytics and simulation, just to mention a few.

In this context, a foresight exercise was conducted to look at the future of ICT-enabled governance and develop a vision of the role of ICT research in shaping a digital European society in 2030 through four thought-provoking visionary scenarios.

Change Driven by Social Values, Attitudes & Paradigm Shifts

The scenario design developed aimed to provide a structured framework for analysis of current and future challenges related to research on ICT tools for governance and policy modelling techniques. The scenario framework proposed was chosen to stimulate further debate and reflection on possible, radical alternative scenarios. It takes today's world and constructs images of possible future worlds, highlighting ways in which key uncertainties could develop. The aim is to present clues and key impact dimensions, thus increasing the ability to foresee possible development paths for the application of ICT tools for governance and policy modelling techniques. Thus risks can be anticipated and better preparation can be made to take advantage of future opportunities. In turn, this outlines key elements to be taken into consideration for the further roadmapping and impact assessment of future research in this domain.

Four Views on European Information Society

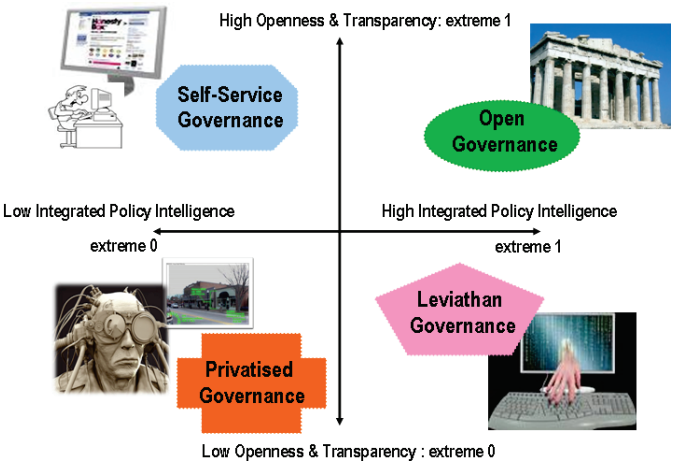
Instead of attempting to forecast possible future ICT-enabled scenarios, four internally consistent – but radical – views were defined of what the future European Information Society might look like in 2030. These give four distinctly different visions of what Europe's governance and policy making system could be and what the implications of each could be for citizens, business and public services.

Following the mapping and analysis of the state of the art in research themes related to ICT for governance, policy modelling and the identification of emerging trends, the main impacts on future research in this area were defined. They were further refined through an analysis of existing scenario exercises and the current shaping of policies and strategies for the development of the European Information Society.

The uncertainties underlying the scenario design were: 1) the nature of the dominant societal value system (more inclusive, open and transparent or exclusive, fractured and restrictive), and 2) what the response (partial or complete, proactive or reactive) could be to the acquisition and integration of policy intelligence techniques in support of data processing, modelling, visualisation and simulation for evidence-based policy making.

Accordingly, the key impact dimensions were classified on two axes: degree of openness and transparency (axis y) and degree of integration in policy intelligence (axis x). The axes represent ways in which social and policy trends could develop.

Based on these dimensions, scenarios were then developed in a narrative manner as descriptions of possible outcomes in selected key areas, representative of the European context, where emerging trends related to the development of ICT tools for governance and policy modelling techniques could have an impact.



The Open Society…

The vertical axis indicates the degree of openness and transparency in a society in terms of democratic and collaborative governance, which could be further enabled by ICTs. The most open and transparent society would be one where even traditional state functions are completely replaced by non-state actors through opening-up and linking public sector information for re-use. Such a society would be characterised by open standards and principles of transparency and accountability in governance and public management. An important aspect of this scenario would be the regulatory and technological solutions and also the socio-cultural attitudes to the basic digital rights underpinning the future Information Society. In fact, the concept of openness is not strictly related to technological solutions but rather to socio-cultural and organisational aspects that can be enabled and supported by technological advancement.

...and the Integration of Knowledge

The horizontal axis shows the degree of integration of data and knowledge and the mode of enabling collaboration between all stakeholders in policy design and decision-making. This involves the possibility – enabled by ICTs – to mash up data and information available from different sources in an 'intelligent way', meaning in a way that is efficient, effective and suitable to generate public value. It also involves the extent to which users, individually or as members of formal and informal social networks, can contribute to the co-design of policies, simulating and visualising the effects of legal and policy decisions, and engage in real-time monitoring and prior assessment of possible expected impacts at local, regional, national and pan-European levels. This horizontal axis is also associated with the capacity and willingness of policy actors to share power and change decision-making mechanisms in order to facilitate the redefinition of basic democratic freedoms in a collaborative fashion. This could go to the extreme of

redesigning the traditional mission of the state and the role played by governance stakeholders. Again, ICTs are not the driving force; rather change is driven by changes in social values, attitudes and new paradigm shifts in terms of information management, knowledge sharing and the allocation of resources.

Scenarios for Digital Europe 2030

In the ***Open Governance*** Scenario, users will enjoy unprecedented access to information and knowledge. By shifting cognitive capacities to machines, humans will be freed from the work of memorising and processing data and information and will be able to focus on critical thinking and developing new analytical skills. This will enhance collective intelligence (both human and ICT-enabled). Humans will be able to use policy modelling techniques to help solve global challenges. Possibilities for the provision of personalised and real-time public services will be opened up. The online engagement of citizens and various governance stakeholders will increase. Citizens, businesses and researchers will have direct access to data they need, and this will create new opportunities for people to interact with and influence governance and policy-making processes and help to make progress in solving societal problems. Governance processes and policy-making mechanisms will be based on intelligent, ICT-enabled simulation and visualisation systems, which will be able to find meaning in confusion and solve novel problems independently of human-acquired knowledge. New, open ways of producing and sharing knowledge will radically change traditional governance and decision-making. This will herald an era of open innovation, with unimagined opportunities for research and technological development. Public, private and third sector institutions will start to listen more carefully to their stakeholders, and a sort of 'molecular democracy' will arise.

The ***Leviathan Governance*** Scenario assumes that an ‘enlightened oligarchy’ will emerge that uses high-tech tools and systems to collect and manage public information and services. Judgement and decision-making will be based on analytical processing of factual information from the many by the few for the benefit of all. Full-scale automatic simulations and policy intelligence tools will facilitate decision-making and the oligarchs will simply approve the recommendations of these tools for the best policy option for the majority of citizens. ‘Real-time governance’ will be possible where the government/citizen relationship is under total control. Public service delivery will be personalised without people having to ask, thus saving a great deal of time. Citizens will trust the government and will be willing to delegate their right of initiative. They will be persuaded to be happy with this situation, as no human-caused problems will exist; emotions and thoughts will be controlled and directed towards the public good. Citizens’ choices will be restricted by predefined and pre-calculated algorithms that optimise people’s performance. However, information overload or potential failure of information systems to respond to critical, unforeseen situations would result in chaos, with humans and devices not knowing how to respond.

In the ***Privatised Governance*** Scenario, society will be shaped by decisions taken by corporate business representatives. Discussion on social issues and about the role and behaviour of citizens will be muted, as people will be pawns whose needs and desires will be managed by large corporations. Interactive and participatory governance mechanisms will be sidelined, along with democracy as we know it today. Simulations based on data gathered by sensors and collected from continuously monitoring and analysing networks, businesses, customers and the environment will produce global information that will nonetheless be fragmented and owned by corporations. Systems will be threatened by frequent attacks from independent groups and dissident communities. The media will be owned by the large corporations and will generally support them. Misinformation and jamming campaigns will be launched, making it necessary to verify all information and data. In this scenario, there will be opportunities for high innovation and development due to the pressure of competition on a free market. However, such opportunities will be useful only for the limited number of users able to afford them. Risks will arise due to private interests and fragmentation of the public good, leading to a ‘fragmented society’ where social welfare services will not be guaranteed to all, thus exacerbating possible social tensions and conflicts.

The ***Self-service Governance*** Scenario envisages a society where citizens will be empowered to play the role of policy makers. In small expert communities, citizens will devise policies according to the do-it-yourself principle; they will choose from a menu of public services those they need and consent to. This ICT-enabled, self-organised society will be able to address emerging problems faster than traditional government could. Its creative, contextual solutions could prove to be more robust and resilient in a crisis. Nevertheless, the diversity of opinions between discrete communities may result in the deepening of existing divides and a lack of social cohesion. Insularity will afflict minorities most severely, as they lack local social networks and may run into communication problems due to language and cultural differences. However, thanks to efficient translation tools, the dissipative communities may, in the end, create a vibrant cross-cultural and multi-language society. The difference between success and failure will be marked by the distinction between creative group thinking and ‘crowd stupidity’. The process of the gradual disappearance of institutions and lack of trust in government will result in the need for new trust providers. Reputation management, for content and people, will play a significant role in service provision. As the majority of citizens will not be interested in participating in governance due to the lack

of engagement culture, new Caesars may emerge who unify disparate groups but damage the subtle equilibrium between self-serving and collaborative cultures.

A Radically Different World Due to ICT Disruptions

In all the scenarios developed, the world in 2030 is expected to be radically different from today's due to the unprecedented growth and speed of ICT uptake in several fields and the related impact ICT tools that enable governance and policy modelling techniques may have. The influences and drivers of innovation and renewal in the public sector, combined with increased financial pressure on states, will result not only in change, but will also affect the pace at which the state adapts to the new environment, to its new roles and to increased engagement with stakeholders and users.

Whichever scenario dominates in the future, conventional wisdom and familiar governance models will be challenged in the coming years as ICT-based disruptions impinge on democratic, consultative and policy-making processes. There is already evidence that the scope and scale of the transformations to come will have a major impact on society.

Since 2005, there has been a phenomenal growth in mass on-line collaborative applications, which has captured the imagination and creative potential of millions of participants – particularly the younger generations. In addition to new forms of leisure pursuits, community-building activities have also entered the political arena. Hence, these tools herald the transition to a different form of dynamically participative governance models.

Current Governance Models Not Appropriate

While such scenarios are readily imaginable, it is recognised that we currently do not have appropriate governance models, process flows or analytical tools with which to properly understand, interpret, visualise and harness the forces that could be unleashed. Present governance processes provide laws and regulations, interpret and define societal norms and deliver societal support services. Their legitimacy is derived through democratic processes combined with a requirement for transparency and accountability.

In a world that is increasingly using non-physical communication and borderless interaction, the traditional roles and responsibilities of public administrations will be subject to considerable change, and classical boundaries between citizens and their governments will become increasingly blurred. The balance of power between governments, societal actors and the population will have to adapt to these challenging new possibilities.

The scenarios developed as part of CROSSROAD served as an input to be compared with the integrated analysis of the state of the art in the domain of ICT for governance and policy modelling. Based on this comparison, a gap analysis was conducted to identify an exhaustive list of specific gaps where on-going research activities will not meet the long-term needs outlined by the future scenarios.

Through a participatory foresight process it was possible to bring together not only experts and interested parties from academia and research, industry and government, but also to involve directly policy-makers and other interested stakeholders. This exercise resulted in a substantial contribution to shaping the roadmapping of future research in the domain, thus proving to be useful and needed.

New Tools to Fully Exploit Mass Collaboration

Altogether, and due to the increasing demand for openness, transparency and collaboration that address broad governance and policy-making challenges, the scenarios identify the need for developing and applying ICT tools and applications that fully exploit the potential of mass collaboration and the open and participatory paradigm underpinning future technological developments and policy directions in Europe.

Research and innovation investment in this domain could create value for the EU community and avoid fragmentation of research efforts. It will require the development of a joint strategic research agenda on ICT for governance and policy modelling to support the building of an open, innovative and inclusive Digital Europe 2030. Innovation, sustainability, economic recovery and growth will in fact depend more and more on the ability of policy makers to envision clearly and effectively both the root causes and the possible solutions to complex, globalised issues.

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Food Security by 2050: Insights from the Agrimonde Project

EFP Brief No. 196

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Organizer: CIRAD, INRA

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Purpose

The brief describes the methodology and conclusions of a foresight project called Agrimonde. Between 2006 and 2008, this project gathered a panel of French experts who built two contrasting scenarios of the world's food and agricultural systems by 2050: Agrimonde GO, a business-as-usual scenario used as a reference point, and Agrimonde 1, a rupture scenario exploring a world that has been able to implement sustainable food production and consumption.

Food Security Issues Back at the Forefront

The future of global agricultural and food systems is today at the heart of numerous intertwining debates. They stem from the increasingly widespread certainty that the continuation of current trends in food consumption and production is unsustainable and that radical changes in behaviour, policies and technologies are necessary (MA 2005, World Bank 2008, IAASTD 2009). Three trends now appear inevitable: 1) the (still) fast growth of the world's population, 2) climate change, and 3) the increasing scarcity and rising prices of fossil fuels. In view of these trends, several studies have warned of a possible stagnation of yields in various crops (IAASTD 2009), and the Millennium Ecosystem Assessment (MA) has highlighted the ***deterioration of ecosystems*** and the consequent threats to the multiple services that they render to humanity (MA 2005). Besides structural trends, the threat of ***food riots***, re-occurring as a result of the current price volatility and the possible impacts of competition between food and biofuel production, have brought food security issues to the forefront.

Undernourishment figures confirm the seriousness of the situation. Indeed, after declining at the end of the 1970s, the number of undernourished people started to rise again in the mid-1990s and has now reached approximately 1 billion (FAO 2010).

The issue being raised again is that of a possible structural tension between the potential growth of food production and the increase in the demand for agricultural products, driven by economic and demographic growth, changing diets and the growing need for alternative sources of energy.

The Agrimonde Project

Between 2006 and 2008, responding to an initiative of CIRAD and INRA, the two main French agricultural research institutions, a panel of French experts developed a project called Agrimonde with the goal to build and analyse contrasting scenarios of the world's food and agricultural systems by 2050. The project's objectives were threefold: 1) to anticipate the key issues research will have to address; 2) to initiate a process of debates and appropriation of the topics on a national scale; 3) to promote the participation of French experts in international debates on food security issues.

Qualitative Storylines and Quantitative Modelling Used in an Interactive Way

Drivers for the evolution of food and agriculture are extremely diverse and numerous. To cope with this complexity, we based scenario building on complementary quantitative modelling and qualitative analyses. Storylines about the main drivers of change guided us in making sets of quantitative assumptions. These assumptions were used to simulate resource-use balances of food biomass at global and regional levels, which in turn enriched the content of each storyline through efforts to enhance coherence. This iterative process eventually enabled us to develop comprehensive quantitative and qualitative scenarios.

Quantification was performed using the quantitative tool ***Agribiom***, thanks to which all agricultural food productions, consumptions and trade can be evaluated using one single measuring unit, the kilocalorie. Calories are distinguished according to their origin: plant, animal (grazing and non-grazing) and aquatic. Agribiom comprises data covering four decades (1961-2003), enabling us to analyse past trends in the whole range of plant and animal productions and utilizations worldwide.

Quantitative assumptions on future biomass resources and uses were made at the regional level (Asia (ASIA), the Former Soviet Union (FSU), Latin America (LAM), Middle East/ North Africa (MENA), OECD, Sub-Saharan Africa (SSA)). The coherence of each set of quantitative assumptions was checked by assessing the balances between food biomass resources and their uses. There might be deficits in some regions, but resources should cover uses at global level.

Assumptions on ***regional biomass*** use in 2050 combines assumptions on ***human population*** and their diets. As for resources, assumptions were made at regional level concerning mainly: 1) land use, 2) cultivated land productivity measured in calorie per hectare, and 3) conversion of plant calories into animal calories.

To establish the values that these variables could take in 2050, we analysed 1) past trends, 2) the scientific literature dealing with each variable's determinants, and 3) scenarios built in the various studies dealing with food and agriculture. Only the conversion of plant into animal calories was simulated. The magnitude of the increase in animal food consumption is a clue to the planets' future capacity to feed its population since husbandry accounts for a substantial share of the use of plant calories. It was therefore important to precisely grasp ***calorie conversion***. Thus, unlike other scenario-building studies based on economic models, Agrimonde uses a simple quantitative model processing physical, not economic, data. It does not simulate the functioning of the main commodity markets. This shortcoming, however, is partly offset since Agribiom avoids the "black box" feature of complex modelling with a multitude of parameters and causality relationships.

The Agrimonde Scenarios

We chose to build two scenarios: a ***business-as-usual scenario called Agrimonde GO (AGO)***, inspired from the MA Global Orchestration scenario, and a ***rupture scenario called Agrimonde 1 (AG1)***. This scenario explores a world in 2050 that has been able to implement sustainable development through a drastic reduction of both undernourishment and excessive food intake, and a change of the technological paradigm towards ecological intensification. In keeping with the definition proposed by Conway (1998) or Griffon (2006), ecological intensification was defined as the diffusion of practices and technologies enabling agriculture to meet growing needs, to be a driving force of economic development and to preserve natural resources.

Two general principles were applied to the construction of the scenarios so as to facilitate their comparison. Firstly, in order to assess the capacity of each region to satisfy its own food needs in 2050, ***interregional trade*** was considered only as a way of clearing regional surpluses in some regions and of filling deficits in others. Secondly, we wanted each region to experience the same ***demographic pressure*** in both scenarios and to analyse the effects of demographic trends without them being masked by large migratory flows. Consequently, we chose for both scenarios the United Nations (UN) median projections of ***population growth*** (around 9 billion people worldwide in 2050 with a "normal" level of international migration).

For AGO and except for the demographic assumptions mentioned above, we used the quantitative assumptions made in the framework applied by the MA. A normative choice, based on an understanding of what a sustainable diet might be, prevailed in the elaboration of assumptions on food consumption in AG1. In AGO, economic growth boosts consumption in all regions whereas in AG1, the income-food consumption nexus is not the most determining one due to concerns for health, equity and the environment. Food availability in 2050 is assumed to equal 3,000 kcal/cap/day (500 of which of animal and aquatic origins) in all regions, which corresponds to the global average in 2000. An average availability of 3,000 kcal is also the figure that FAO considers sufficient to maintain the proportion of undernourished people at a relatively low level. This assumption nevertheless contrasts sharply with past trends, especially in Sub-Saharan Africa where food consumption is supposed to increase by 30% over 50 years and in the OECD countries where it is supposed to decrease by 25%.

AG1's assumptions pertaining to land areas were made on the basis of physical factors of soil availability and quality and compared with sustainability criteria (in particular the preservation of forest areas). Finally, the assumptions on yields were formulated by considering past trends and technological change that would make it possible to increase yield while preserving the ecosystems. Among factors taken into consideration, the anticipated impacts of climate change on land availability and yields were considered major determinants of the future production potentials. As a result, at the global level between 2000 and 2050, cultivated land increases much faster in AG1 with 12 million hectares of new cultivated land per year (taken for the most part on current pasture areas) against 7 million in AGO, and 4 million in the last four decades of the 20th century. In AGO, yields are the driving factor; they increase by 1.14% per year over 50 years, against 0.14% in AG1, and 2% per year between 1961 and 2000.

Feeding the Global Population in 2050 a Matter of Access Not Food Shortage

Five main lessons can be drawn from the Agrimonde's global-level scenario analysis (see Paillard et al. 2011 for further details, in particular at regional level).

Firstly, the global food production levels assumed in each scenario for 2050 satisfy the assumed levels of global food consumption. The ***planet's natural resources are sufficient to properly feed the global population in 2050***, which is approximately the year when the maximum global population is anticipated. Thus, just like today, the main challenge in terms of food security will not be a lack of production but will remain a problem of ***access to food*** by the poorest populations.

Secondly, the scenarios underline the crucial role of diets in the realisation of resource-use balances. On the one hand, in AGO, per capita total food availability increases by 20% between 2000 and 2050 and the share of animal products increases from 16 to 23%. On the other hand, in AG1, these indicators remain stable at global level. As a result, while the global need in plant calories (including plant food, feed, seeds, loss etc.) increases by 90% in AGO, it only increases by 35% in AG1. The ***convergence of diets and of consumption habits*** (growing consumption outside the home and of processed food, generating growing waste) towards the Western model would then have serious consequences not only from a health viewpoint (obesity and related diseases) but also for the preservation of ecosystems.

Thirdly, in both scenarios, the volume of net trade in food between regions necessary to meet regional food needs is much higher in 2050 than that observed in 2000. Three regions show structural shortages in both scenarios. Two of them, ASIA and MENA face a shortage in natural resources (water and land). In the third, SSA, the increase in food production is lower than population growth and the corresponding increase in food consumption. Thus ***trade regulations appear essential*** in order to 1) prevent net exporting countries from taking advantage of the structural food dependence that some regions face, 2) avoid competition that would be unsustainable for small local producers, and 3) guarantee that trade does not lead to an increase in the impacts of agriculture on the environment.

Fourthly, in AG1, yield gains, while fast in regions such as LAM or FSU, are very moderate at global level. Thus, even under the assumption that yields will increase relatively slowly, the planet can properly feed nine billion people in 2050. Consequently, ecological intensification, through the scaling up of ***local agro-ecology experiments***, appears to be an alternative option to the classical model of agricultural intensification, as recently pointed out by Olivier de Schutter, the UN Special Rapporteur on the Right to Food (de Schutter 2011).

As he emphasized, the main benefits of agro-ecology lie in the fact that it preserves natural resources and is accessible to smallholders (low input and capital intensity). This brings us to our ***fifth*** conclusion: the contribution of trade to the food security of regions with food shortages will only be possible if ***access to food*** in those regions is drastically enhanced through the development of local opportunities for wealth creation. And because in the most food insecure countries, these opportunities are mostly to be found in agriculture, investments in this sector in developing countries is the key to end undernourishment.

Agrimonde: a Landmark Study Provoking Controversies

Agrimonde has become a landmark foresight study (mostly among French experts and stakeholders). The AG1 and AGO scenarios are references, whether adopted or rejected, that contribute to structuring the debate on food security and more generally on the future of food and agricultural systems. This can be stressed through some of the main controversies provoked by the scenarios, which concern their sustainability and plausibility.

Tackling Environmental Issues

Environmental sustainability is not a feature of the AGO storyline since in this scenario economic growth is given priority over the preservation of the environment. Nevertheless, AG1 and AGO can be considered as two different strategies to meet the challenge of feeding a growing population in a sustainable way. On the one hand, AGO bets on substantial yield gains that would make it possible to spare land areas – reserves, corridors, forests, etc. –

which then can be devoted to the preservation of ecosystems. On the other hand, AG1 chooses to expand cultivated areas and to use environment-friendly technologies to cultivate them at the accepted cost of lower yield gains. The conversion of land into cultivated areas accelerates compared to past trends, particularly in regions with a large unexploited cultivation potential, such as SSA, LAM and FSU. Even though forests are spared, accelerated land conversion is not without impact on biodiversity and carbon storage. However, the sustainability assessment of AG1 cannot end here. For instance, it would be meaningless to measure its carbon footprint by simply multiplying converted land areas by the quantity of carbon that is currently emitted when pastures are converted into cultivated land. Ecological intensification actually strives toward a higher carbon storage capacity through innovations in farming systems and lower emissions through a reduction in nitrogen fertilizer use.

In AG1, ecological and productive functions of ecosystems are combined on the same territory (agroforestry is a good example of such a combination), which tends to blur the traditional frontier between productive areas and preserved nature areas. Thus, technological choices appear strongly linked to our choices of spatial organisation and complementary to the performance criteria that are applied to farming systems. In AG1, these criteria have to be designed to measure not only their food production performance but also their ability to maintain ecosystem services, which is not central to what is expected of agriculture in AGO.

Legacy of the Growth Paradigm

The plausibility of the Agrimonde scenarios and the feasibility of the transitions that they propose provide another interesting area of debate. AGO is a plausible scenario if trade liberalisation and technological progress are sufficient drivers of economic development. Moreover, it requires that we will be able to further increase yields through radical innovations, such as drought-resistant GM crops. The scale of the challenge is huge if we consider the very high level of yield already attained in regions such as ASIA and the OECD as well as the current health of many ecosystems and the consequences, over next decades, of climate change and fossil fuel rarefaction. AG1 rests heavily on the availability of arable land. Even though existing data tends to show large amounts of uncultivated arable land, more reliable data on land use, soil fertility and possible future impacts of climate change and urbanisation are needed to check the plausibility of land use assumptions in AG1. Moreover, the existence of large unexploited arable land areas does not necessarily imply that they will be available for food production. For instance, in regions where land tenure is customary, land conversion would have dramatic impacts on pastoralists whose food security depends heavily on their having access to rangeland. The competition between food and biofuel production is also likely to affect the amount of land that will be devoted to food production.

Diet Change in Rich Countries?

The radical shift in diets is certainly the most challenging feature of AG1. This scenario assumes a 25% drop in food consumption in OECD over 50 years, mainly through a decrease in animal product consumption. Likewise, it assumes that emerging countries will manage to rapidly curb the current trend towards diets higher in fat and meat. These very strong assumptions do not challenge the interest of this scenario since foresighting is not forecasting, and exploring ruptures in trends is one of the main purposes of scenario building. Besides, health and environmental concerns are prompting an increasing number of rich countries' consumers to modify their diets and limit food waste. It is therefore plausible, and in any case interesting, to consider the implications of a progression of such behavioural changes in rich countries. The question calls for a radically different answer when considering developing countries in which a significant share of people do not have access to sufficient food and lack proteins. The assumption that in coming decades, consumers will become concerned about the ecological footprint of their consumption behaviour does not seem plausible. However, nutrition transition in emerging countries is far more rapid than it was in Northern countries. It is therefore probable that the populations' awareness of the harmful effects of excessive calorie and fat intakes will also spread faster.

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Citizen Visions on Science, Technology and Innovation

EFP Brief No. 204

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Type: EU-level single issue foresight exercise
Organizer: FP7 CIVISTI Project Coordinator: Danish Board of Technology, Lars Kluver lk@tekno.dk
Duration: Sep08-Feb11 **Budget:** N/A **Time Horizon:** 2025 **Date of Brief:** Sep 2011

Purpose

This activity was conducted as part of the EU FP7 CIVISTI project (Citizen Visions on Science, Technology and Innovation) funded through FP7 under the Social Sciences and Humanities theme. The project aimed to develop and pilot a cost-effective mechanism for involving citizens in the formulation of European science, technology and research policy. A number of new and emerging issues for European S&T were identified, leading to the development of a set of recommendations for future European framework programmes.

Citizen Involvement in the Policy Process

The development of scientific and research policy at EU level already incorporates a system of extensive consultation with the member states. However, such consultation is generally limited to key stakeholders, such as industry representatives and the scientific community, and is rarely extended to the general public.

The CIVISTI project is based on the idea that the process of defining relevant research agendas could benefit in many respects from consultation with ordinary citizens. With the right facilitating methods, the concerns and aspirations of ordinary citizens can be developed as supplementary input to the existing consultation process. Such an approach will deepen the process of European democracy by supporting inclusiveness and increased transparency.

Most forward-looking activities traditionally source their input from those involved in technological development and research disciplines (the supply side). CIVISTI is unique in taking as its starting point the ultimate beneficiaries of any technological development – the general public (the demand side).

First Europe-wide Citizen Consultation on Science & Technology

The CIVISTI methodology is based on three key elements:

- A first citizen consultation where ordinary citizens are asked to develop their visions of desirable futures.
- An expert-stakeholder workshop where scientific experts review the visions put forward by the citizens and develop them into policy recommendations.
- A second citizen consultation where the recommendations are presented to the citizens for endorsement and prioritisation.

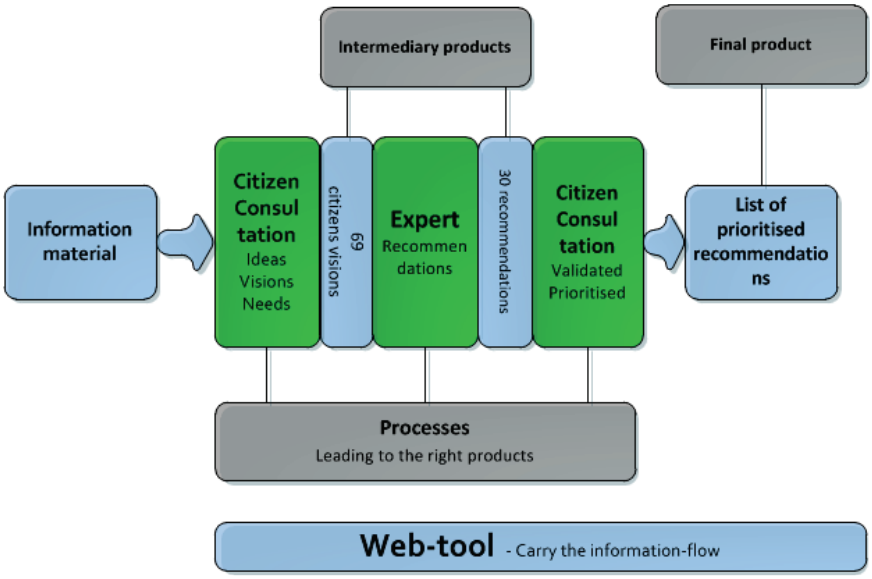
Inviting Citizens

The process got underway with a consultation session in each of the seven CIVISTI partner countries where ordinary citizens were asked to formulate visions of desirable futures based on their concerns and aspirations. Seven citizen panels each consisting of approximately 25 citizens were established, with participants carefully selected to ensure a broad representation of gender,

age, educational level and occupation. The seven workshops were all held within a month's time.

For inspiration and common knowledge-building on future visions and EC science policy, the project team prepared appropriate guidance material and distributed it to the participating individuals beforehand.

Fig.: Diagram of the CIVISTI methodology



Each consultation session took the form of a two-day structured workshop led by a facilitator. The participants were encouraged to articulate and develop approximately 25 visions, which were then documented according to a predefined format. Each workshop concluded with a voting session with the objective of identifying the nine or ten most important visions prepared by the group. This resulted in a total of 69 visions for the seven participating countries.

Expert-Stakeholder Workshop

In the second phase of the process, a small group of experts and stakeholders were brought together to process the citizens' visions and transform them into research agendas and policy options for European research. The framework for extracting new science and technology policy options from citizen visions was inspired by Kingdon's *streams model* of policy agenda setting, which is a widely applied approach in policy analysis.

On the first day of the workshop, the experts were divided into six groups of three, with each group being facilitated by a member of the CIVISTI team. The visions from all participating countries were pooled and distributed for analysis among the six teams. Each team was requested to discuss six related topics according to their field of expertise, with each topic incorporating between one and three visions. The experts endeavoured to transform the visions into concrete recommendations, taking care to maintain a clear link between the original vision and the recommendation. This process resulted in the generation of more than 100 recommendations.

On the second day of the workshop, the experts selected the 30 top recommendations on the basis of novelty, importance and timeliness in an open-space process. The experts refined the recommendations and sought to formulate them in a manner that could be understood by both ordinary citizens and policymakers.

Second Citizen Consultation

In the third and final phase of the consultation process, the citizen panels convened once again, and the participants were asked to validate and prioritise the research agendas and policy options prepared by the experts. The participants were requested to evaluate the recommendations according to the following criteria:

- ***Faithfulness***: the degree to which the recommendation reflects the idea of the original vision.
- ***Effectiveness***: the extent to which the recommendation would help to achieve the desired vision.
- ***Desirability***: the extent to which the recommendation represented a desirable action.

Science & Technology Topics at the Crossroads of Everyday Life

Challenges

Despite its success, the CIVISTI project encountered a number of challenges, which are highlighted to point the way to a more streamlined approach in future exercises.

Engagement of citizens: despite efforts to keep citizens engaged between the first and second consultations, the project experienced a considerable dropout rate. This was probably due to the length of time that elapsed between the two sessions, arising from the fact that the methodology was still under development and constituted a major component of the project. Reducing the time lag between the first and second citizen consultations should overcome this problem.

Drafting of recommendations: great care must be taken during the review exercise, where the experts transform the citizens' visions into policy recommendations, to ensure that such recommendations are faithful to the original vision. During the second consultation session, these recommendations are referred back to the citizens, who expect to find a clear link between the two.

Consolidated ranking: there was extensive discussion on how to combine the seven country results into a single ranked list of recommendations. Should each participating country be allocated an even number of votes, or should there be a weighting in proportion to the country population? In the case of CIVISTI, it was found that this was not an issue and the final results were very similar using both methods.

Citizen Visions

The first consultation exercise resulted in a total of 69 visions, characterised by their breadth and interdisciplinarity. The visions spanned a broad range of topics, covering scientific, technical and social subjects, and addressing both present as well as future perspectives.

Several of the visions addressed similar topics, and the following analysis revealed that they related to a total of 37 distinct topics. However, the range of topics is not as broad as that of FP7, with certain areas being notably absent, such as nuclear power, nanotechnology, and production technologies.

As might be expected, many of the recommendations were oriented towards matters that citizens encounter in their everyday life or are based on their personal experiences. Most of the topics have a strong social focus as opposed to a natural science or technological one.

The following themes appear to be uppermost in the minds of citizens:

- Health care and medical services
- Education and learning
- ICT, automation and artificial intelligence
- Legislation, quality of life and life style
- Employment and new modes of work
- Energy

Towards a More Society-oriented Research Agenda

The top ten recommendations emerging from the CIVISTI project are detailed below. A number of these recommendations are already the subject of research in FP7 and little additional action is called for in their regard. This is in itself a meaningful result indicating citizen support for the work currently in progress under the framework programme. Other recommendations, however, are not being addressed to the desired extent and appropriate remarks are made for possible action.

The recommendations are discussed in the order of their final ranking by the citizen panels:

1. Promote technical and social innovations that can enhance people's access to and use of public transportation.

Most aspects of public transport are already well addressed in FP7 with specific mention in the *Transport* work programme, and numerous relevant projects have been funded through the framework programme.

However, the CIVISTI results are a strong indication that the progress achieved so far, although noteworthy, still falls short of what is desired by the public. It is therefore proposed to submit this as a topic for *Mobilisation and Mutual Learning Action Plans* for future *Science in Society* (SIS) work programmes.

2. Foresight and research to explore sustainable options of decentralised energy production systems and the resolution of energy related conflicts.

This topic is already the focus of considerable attention and extensive research by the EU, and it is believed that no additional action is called for in this area. Citizens emphasise the long-term perspective of this initiative.

3. Go and re-appropriate the countryside!

The CIVISTI consultations highlighted a public desire to establish attractive contemporary life in the countryside. It is proposed that this theme should be investigated and developed further through an activity funded through the *Socio-economic Sciences and Humanities* (SSH) work programme.

4. Tools for disabled people.

This recommendation is already addressed to some extent both by thematic work programmes and especially by the *Ambient Assisted Living* joint programme. However, it may be useful to promote greater interaction between research organisations, carers and civil society organisations working with people with special needs in an action along the lines of the *Mobilisation and Mutual Learning Action Plans* as seen in recent SIS work programmes.

5. Optimisation of urban space: towards dense European eco-cities.

The *Environment* work programme does include an action line dedicated to urban development. However, very little research has been funded in this area.

The CIVISTI results express a strong desire by citizens for concerted action through long-term research and pilot projects with the objective of creating a blueprint for European eco-cities with sustainable waste management, transportation, urban space use and energy usage. Such action should be based on significant input from the public.

6. Social innovations for aging societies are needed.

Research should be undertaken to identify issues and possible solutions relating to the sudden transition from full-time employment to retirement. It is proposed to

submit this topic for possible inclusion in a future SSH work programme.

7. Increase direct democracy through e-voting.

Citizens expressed a keen desire to participate more regularly in national and possibly supranational decision-making. Traditional referenda are very expensive and time-consuming, and are rarely contemplated. Technology for e-voting (direct recording electronic voting) is already in existence, but there exist issues of security, audit and transparency. Moreover, the cost of holding a referendum using e-voting is still too high to allow regular use. Further research is needed to improve security and bring down costs. The topic should be put forward for possible inclusion in a future *Information and Communication Technology* work programme.

8. Develop effective urban infrastructures supporting a multigenerational lifestyle.

This recommendation revolves around the use of communication and mobile technologies to support multigenerational families through urban design and infrastructural development that provides a friendly environment for large families and their changing needs during familial life cycles. It is proposed to investigate this theme further in an activity funded through the SSH work programme.

9. Humanistic research to explore what dignity during the dying process means to contemporary Europeans.

It is believed that this subject has not previously been specifically addressed in the framework programme. It may be proposed as a topic for possible inclusion in a future SSH work programme.

10. Select or develop plans and techniques for areas with extreme climate conditions.

This topic has already been addressed to some extent through the projects funded under the FP7 *Knowledge Based Bio-Economy* (KBBE) work programme. However, activity in this area is rather limited and it is proposed to submit this recommendation to be considered for inclusion in a future *Food, Agriculture and Fisheries, and Biotechnology* (FAFB) work programme.

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Towards Transformative Innovation Priorities

EFP Brief No. 211

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Purpose

This brief synthesises the findings of forward-looking activities that were recently carried out in different European countries with a focus on research and innovation. In order to structure the activities' outcomes, a framework is used that distinguishes different types of outcomes. The findings of the activities are then presented along this framework. The last section suggests some conclusions for European-level, challenge-driven research and innovation priority setting. The study was conducted for the expert group Global Europe 2030-2050 http://ec.europa.eu/research/social-sciences/fwl-experts-groups_en.html and financed by the European Commission's Social Science & Humanities Programme.

National Innovation Priorities Addressed

The countries in focus were France, UK, Germany, Spain, Poland, Finland, Ireland, Luxemburg, the Netherlands and the region of Flanders. All nine activities adopted forward-looking methods for a structured assessment of possible pathways for research and innovation. All activities were based on intense involvement of experts and stakeholders with diverse backgrounds. Some adopted very large-scale participation and reached out to broad publics (FORSK2015, NL Horizon Scan); others were more confined to core actors with specific expertise (UK TIF, T&I Flanders, BMBF Foresight). Moreover, some of the activities aimed at generating possible pathways of change within a certain time horizon or even pursued fully fledged country scenarios, as in the case of Poland and Ireland. Others were more interested in scanning signals pointing towards relevant changes (Foresight.fi, NL Horizon Scan), and again others sought to collect and assess a wide range of proposals for research and innovation (R&I) topics (FORSK2015, FNR, ClésTech).

While some of the activities focused on assessing technological trends (ENCYT2020, T&I Flanders, ClésTech) others adopted a very broad perspective on up-coming socio-economic change and its consequences for research and innovation (France 2025, Poland2020). Other activities put particular emphasis on linking established realms of research and innovation, on the one hand, and areas of need and problems in new future-oriented ways (BMBF-Foresight, NL Horizon Scan).

With this rich diversity of approaches, all selected activities have one ultimate goal in common: defining a research and innovation agenda that best addresses future needs. Most of the activities used a set of criteria for assessing RTI topics composed of global challenges, on the one hand, and national objectives, on the other. Thus, the synthesis may well provide valuable insights on the challenges ahead when orienting research and innovation towards the grand societal challenges of our times, as envisaged in the European Innovation Union Initiative.

Categorising Future Research & Innovation Priorities

In the synthesis the categories will be used as follows:

Research and innovation topics: Specific topics for research and innovation assessed as highly future relevant and therefore to be prioritised. Due to the nature of the activities, these topics usually stem from engineering and natural science realms. Example: Metamaterials (UK TIF).

Application domains: Domains and sectors where significant applications of the technology and innovation areas are expected. Example: Transport (ENCYT, UK TIF).

Socio-economic change signals: Changes in society and economy assessed as highly relevant for priority setting in research and technology innovation (RTI). Example: New forms of ownership (Foresight.fi, UK TIF)

"Grand Challenges": Major challenges for society expected to drive the research and innovation agenda in the future. Example: Need for preservation of ecosystem services (FORSK2015, FNR)

Crosscutting priority areas: Proposed RTI focus areas linking several elements out of the four previous aspects. Example: Manufacturing on demand (UK), Production-Consumption2.0 (Germany)

Some activities contribute in depth to one of the categories; others address two or more aspects as illustrated in Figure 1.

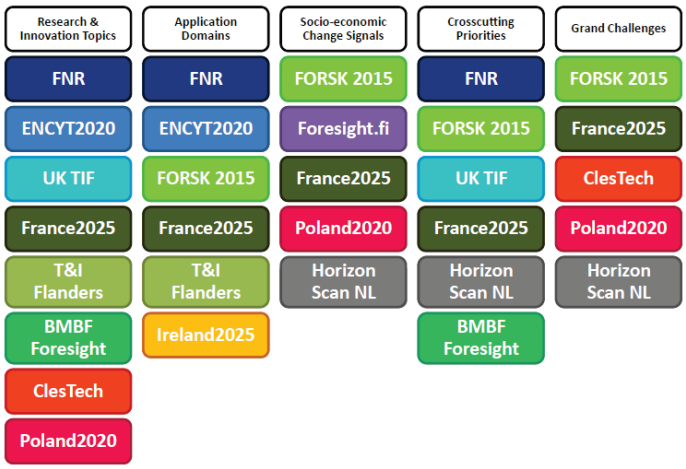

Figure 1: Main contribution of the studies

Converging Topics

Despite national specificities and differences among the countries, a certain convergence of R&I priorities can be observed. Topics related to energy transition as well as sustainable patterns of production and consumption are high on the agenda of several countries followed by health related topics and information and communication technologies.

Signals of Socio-economic Change

A number of the activities emphasise socio-economic change as a key element of the innovation arenas. In particular, several activities point out the need to explore new forms of identity-forming, cultural diversification and community building to understand successful innovation pathways.

The Foresight.fi blog specifically considers changes in socio-economic patterns as a core part of research and innovation futures. Issues such as changing attitudes towards product ownership, identity formation, self-expression, changing innovation patterns, new concepts of work, new types of jobs, new work and communication attitudes, open data, open science, new growth models, information owner-ship/control are discussed at some length and seen as relevant drivers not only for society overall but also for the direction of technological innovation. Another study that considers socio-economic innovation in depth is the NL Horizon scan. Some of the proposed priority topics explicitly address socio-cultural research, focusing for example on the socio-cultural meaning of an aging population. Another cluster is dedicated to new forms of work and education. Two other topics deal with global political and economic changes. The UK TIF study deals in depth with intellectual property rights as an area of innovation in its own right.

Furthermore, the following areas of socio-economic change are mentioned as relevant for the research and innovation fields in at least three activities:

- Values, lifestyles, behaviours, determinants of choices, in particular of coming generations
- Social fabric (age, culture)
- Patterns of consumption/use
- Value creation patterns, business models
- Conception of humanness
- Economic patterns, growth models
- Work/life patterns
- Modes of governance
- Public sector, transparency, open data
- Science-society interaction, citizen participation
- Modes of communication and trust building
- Leadership challenges

Application Domains

The domains where the innovations are expected to be applied are similar in all activities. Across activities, there is a striking emphasis on food and agriculture, both in terms of security and safety and as a key aspect of environmental sustainability and culture. The other two top innovation target areas are energy and transport followed by health, housing, communication, education, public administration and security.

Some national differences can be clearly identified. France, for instance, is putting strong emphasis on agriculture whereas Luxembourg is focusing on multimedia and service innovation. Germany is innovating along traditional production paradigms whereas the UK is pushing innovative manufacturing technologies in combination with new service and business concepts. Finland is especially concerned with the future of the countryside.

"Grand Challenges"

Most of the activities did not explicitly attempt to define the grand challenges driving research and innovation activities but rather adopted them from well-known documents such as the Millennium goals. In one case (Ireland), competitiveness of national industry was used as the only relevant criterion, but also several other national activities chose technology and innovation areas with a strong emphasis on securing advantages over competing economies.

However, most activities saw the need to address global challenges as an important rationale for RTI priority setting and adopted a mix of selection criteria combining competitiveness and challenge-oriented criteria.

The following societal challenges are explicitly mentioned as drivers for RTI priority setting:

- Energy (securing energy supply and decarbonising energy production through new sources and efficient use)
- Counteracting climate change
- Preserving biodiversity
- Food safety and security
- Preserving ecosystems services/securing a clean environment
- Adapting to climate change
- Securing water supply
- Combating chronic and infectious diseases
- Handling global conflicts
- Understanding and dealing with changes in social fabric, in particular demographic change but also diversity
- Ensuring well-being and quality of life
- Ensuring resource security

Towards Socio-technical Breakthrough

None of the activities highlights one particular technology area as likely to yield radical breakthrough innovations in the near or mid-term future. However, most activities aim towards breakthrough transformations in key innovation arenas through alignment of innovations from technological and socio-economic realms in order to achieve change in addressing societal challenges. By definition, such ***transformative priorities*** require research across engineering, natural and social sciences as well as the humanities, as they target aligned social and technological breakthrough innovation rather than just isolated technological change.

The synthesis offered here focuses on the most striking convergences within the national foresight activities. Accordingly, the transformative priority arenas outlined below are far from covering all relevant topics for research and innovation identified by the activities.

	Key approach	Related national R&I priorities	Social innovation aspects
Energy transition	Developing competitive, energy efficient and sustainable energy systems that can satisfy future energy demands and environmental requirements	**Crosscutting**: Accelerating the development of new energy sources; the energy transition; energy systems of the future; energy mix) **Specific:** Energy generation, storage, distribution (and respective technologies); understanding and modelling human behaviour; service innovation	
Bio-resource management	Sustainable management of bio-resources for food, health, energy and materials	**Crosscutting:** Bio-resource-based production; Production-Consumption2.0; sustainable resource management **Specific:** Agricultural technologies; industrial biotechnology; understanding and modelling human behaviour	
Sustainable patterns of production and consumption	Transformative innovation towards sustainable patterns of production and consumption	**Crosscutting:** ProductionConsumption2.0; manufacturing on demand; local cycles **Specific:** Production technologies and concepts; complexity and systems thinking; understanding and modelling human behaviour; service innovation; green housing; new forms of collaboration; hybrid (product/service) value creation	Values, lifestyles, behaviours; determinants of choices, in particular of coming generations; patterns of consumption/use; value creation patterns; business models; economic patterns; growth models; work/life patterns; science-society interaction; citizen participation
Human-technology continuum	Exploring new high-quality modes of human-technology interaction	**Crosscutting:** Robotics and interconnectivity; human enhancement; human-technology cooperation, Internet revolution **Specific:** Lab-on-a-chip/bio-electronics; performance enhancers; brain modelling; brain-computer interface; omics; intelligent sensor networks and ubiquitous computing; multi-sensory input; service and swarm robotics; searching and decision-making; secure communication; trust; surveillance; semantic web; remote/virtual services; service robotics; assistive systems; cognitive prostheses	Changing values, lifestyles, behaviours; social fabric (age, culture); conception of humanness; work/life patterns; modes of communication and trust building
Infrastructure transition	Pathways for sustainable infrastructure transition (transport, energy, housing and water)	**Crosscutting:** Sustainable transport and infrastructures; smart infrastructure; infrastructures for the future **Specific:** Transport technologies; smart grid; service innovation; human behaviour; next generation networks	Values, lifestyles, behaviours; determinants of choices, in particular of coming generations; work/life patterns
Living spaces	Sustainable patterns of rural and urban living spaces	**Crosscutting:** Better lifespaces – space for life and growth (DK); Two related transitions: Creating and utilizing space (NL); Sustainable living spaces (DE); Countryside and local cycles (FI); Cite2020 (F) **Specific:** Sustainable construction materials; green/smart housing; service innovation; human behaviour; agricultural technologies	Values, lifestyles, behaviours; social fabric (age, culture); patterns of consumption/use; work/life patterns; science-society interaction; citizen participation; modes of communication and trust building

Conclusions for the Innovation Union

The transformative priorities emerging from the national forward-looking activities outlined in the previous section directly link with the "grand societal challenges" addressed in the Lund declaration and the Innovation Union initiative. Moreover, they are perfectly in line with the Innovation Partnerships proposed by the Innovation Union Flagship, both in terms of set-up and content. In particular, the areas Smart Cities and Smart Mobility as well as Agricultural Sustainability outlined by the Commission Communication fit well into the framework presented in this paper. But also the challenge-driven approach, the strong role of social innovation and the need to go beyond the "technology focus of the existing instruments" fit with the Innovation Union approach.

Transition Arenas Must Not Be Isolated

Several of the societal challenges are closely interlinked. It is obvious that the evolution of living spaces is closely tied to the underlying infrastructures and energy sources, which again co-evolve with the patterns of production and consumption. Therefore, the transition arenas cannot be easily separated. Optimising one aspect without taking into account the other is bound to fail, as several activities point out using the example of potential conflicts of biodiversity and bio-resource use.

Cultural Diversity Matters

Although several activities converge around certain socio-technical breakthrough arenas, the meaning is still different in each cultural context. This is obvious in the case of the living spaces of the future. Even though some countries have proposed almost identical priorities, the main concerns behind these propositions differ: The Fins are very much concerned with life in the countryside as a key element of their culture; the Dutch in turn expect to free space by changes in agricultural use and think of new possibilities for making good use of scarce space; the French focus is on the future of agriculture and food quality whereas the Germans, with their recent experience of shrinking cities in Eastern Germany, are considering flexible spaces to adapt to changing life-styles. Similar observations hold for all other transition arenas. Accordingly, when acting at the European level, "normalising" national diversity into one-size-fits-all approaches is bound to fail. The rich diversity needs to be kept as a particular strength.

Defining and Implementing Transformative Priorities Requires Participatory Processes

Transformative breakthrough priorities, as suggested here, are not a purely a matter of science and technology but involve substantial social and cultural innovation. Accordingly, they cannot be addressed through research alone but require aligned social and technological experimentation. This again cannot be enforced by top-down priority setting in the realm of science and technology. Participatory processes involving not only researchers and engineers but also European citizens are needed to define the adequate designs for these experimental spaces. The activities investigated here give some indications how this could be done, also at the European level. In particular, the Netherlands Horizon Scan and the Danish Forsk2025 seem to offer feasible routes for orienting research and innovation in society and technology towards shared goals by a creative and participatory linking of problems and solutions.

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Creative Foresight Space (CFS) for Enhanced Work Milieux

EFP Brief No. 226

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Purpose

This brief presents the concept of Creative Foresight Space (CFS), which is an alternative workspace, as well as a foresight methods-based processing platform for a new kind of proactive and innovative working culture. CFS is a concept to stimulate at the same time both creativity and futures thinking. It combines physical, digital, virtual and peer-to-peer collaborative approaches, to result in innovative and social futuring in organisations. It is designed especially to meet the challenges posed by the transition from the information society into the meanings society. CFS also provides a diverse platform for special futures workshops - called Futures Cliniques. Expected results from CFS consist of enhanced work milieus, augmented work motivation, as well as from strengthened futures thinking and foresight competence.

Linking Innovation to Foresight in Corporations and Organizations

Innovations are born where there is enough encouraging space for creativity. Companies and organisations striving for innovation are increasingly interested in creating workplaces and workspaces that promote interaction, creativity and innovation. Companies and organisations have an immense unused potential to develop creative and innovative work environments. Such development can be linked to the attraction of regions or towns.

As the operational environment of companies and organisations has changed, foresight has gained more ground in their operations. In order to bring systematic foresight and innovation processes into a company, the whole organisation needs to be committed to a new way of thinking. This, in turn, requires a new culture of managing as a part of a whole new working culture.

Creative Foresight Space (CFS) will provide a new type of work milieu as integrated into ordinary offices. CFS links innovation processes (creative thinking) to foresight processes (futures thinking).

The project on Creative Foresight Space was initiated to find out the possibilities of developing better work environments. This was sought for by supporting the processes of organisational change through a Creative Foresight Space that encourages creativity and futures thinking. In addition to developing the concept of creative foresight space, the project included a wider foresight process that concentrated on the knowledge and expertise needed in the future.

Enhancing Creative Work Milieux for Future Thinking and Well-being

The theoretical objective of the study was to develop a concept of an innovative and experimental working space to stimulate at the same time creativity, futures thinking and wellbeing at work.

The concrete aims of the study were to design visually stimulating **Creative Foresight Space (CFS)** 1) to host participatory foresight sessions, especially Futures

Cliniques, 2) to provide a space for self-organised futures exploration, 3) to demonstrate and apply several methods developed in futures research for futures sense-making and innovative problem solving for companies, public institutions, regions and citizens. CFS and Futures Cliniques were designed as a structured process, employing user-friendly multisensory instruments for open futures learning.

Part of the study was to probe possible futures for societal development and for the future of work. This was conducted through literature surveys, interviews and participatory foresight sessions held in two regional CFS pilots. The ultimate purpose of CFS was to help decision-makers by opening up vistas and even unexpected prospects for future developments at a longer and broader perspective than standard strategy.

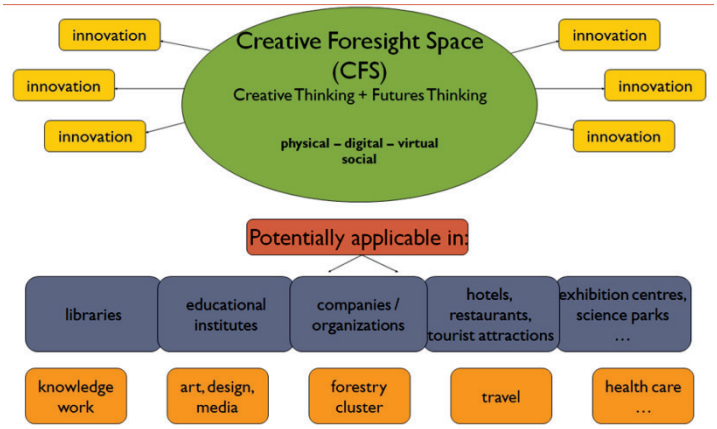

Figure 1. The Concept of Creative Foresight Space

Futures Wheel, Table, and Window

Creative Foresight Space (CFS) is a methodological umbrella concept, developed at Finland Futures Research Centre (FFRC) within the project. It manifests itself as a futures gallery or social futures learning hub, to enhance working milieus in all kind of organisations. It also acts as a platform for participatory, co-creative foresight sessions. Such sessions were structured as special Futures Cliniques.

The methods demonstrated and applied in all Futures Cliniques included for example the Futures Wheel, which is an easily applicable and discussion-oriented tool, and the Futures Table. In particular, the Futures Window was used, which is a visual presentation of weak signals, stimulating the futures work to follow watching it (Heinonen & Hiltunen 2012).

On average, at least five different foresight methods are always being demonstrated and used within a Futures Clinique. The Futures Research Methodology CD Version 3.0 (Glenn & Gordon 2009) produced by the Millennium Project was also frequently employed. In addition, material from the iKnow project (Ravetz et al. 2011) was used and further elaborated. Besides foresight methods, also several innovation techniques were being applied in Futures Cliniques, e.g. the method of de Bono's (1985) Six Thinking Hats. The participants were not required to be familiar with any of the methods beforehand. Instead the idea was to enable futures learning - both content-wise and methods-wise.

The visual design and mood of the Creative Foresight Space is a method in itself, aiming at multi-sensory futures exploration. In some of the sessions, emphasis was laid on visualisation and visual material from cartoons to pieces of art were experimentally used to nourish the participants' imagination (Heinonen & Kurki 2011).

Two concrete cases of CFS were installed for a certain period of time (ca. six months) for experimenting. During the experiments, all the results were carefully identified and documented. One of the cases was CFS set up in Helsinki City Library in 2010 (in Finland). The other case was implemented inside a technology Centre Innopark in Hämeenlinna region (in Finland).

The concept of CFS can be implemented in two separate modes: the Stimulus version or the Slow version. The Stimulus version aims to excite and explode imagination and through such stimulation enhance creativity. The Slow version, on the other hand, enhances creativity through elements soothing the visitor and letting time and space for new ideas or understanding to emerge. This kind of futures learning (Heinonen, Kurki & Ruotsalainen 2012) can be achieved through slow motion digital walls, or by providing niches for silence and solitary futures exploration.

Shift Toward Meaning Society

The most important socio-economic trend identified during the project was the **shift from the information society towards the meanings society**.

Applying this shift to work, the central findings were the need for new organization models, radical mixing of different industries and branches, as well as utilizing prosumerism (producers + consumers) in a new work paradigm. Adding to these a set of new competences and skills were identified. The diamond of seven competences that are critical for future work life in 2020 was presented.

The future of work in ubiquitous interaction

The future of work and the future economy will be shaped especially by changes in two intermingling areas: **the technologies used and people's ways of life**.

The guiding technology for the future will, quite unsurprisingly, be the Internet with its different applications and services. The Net will affect our culture deeply. The values and norms of **web 2.0** will spread to the entire society – **and the workplace**. Digital natives will take participation, bottom-up approaches, collaboration and sharing for granted. They are intrinsically motivated

rather than extrinsically influenced. Adding to this, people strive more and more for a life that is personally and individually meaningful. The source of **meaningful experiences** can be anything, be it consumption, work, arts, or social relationships.

The Internet and other key technologies and services (e.g. cloud computing, mobile devices, application services) together with the strengthening ethos of self-expression are leading away from the information society to a new societal form, the meanings society. This transition will have a significant impact on how we work and on the organizations in which we work.

Despite automation work will not disappear. People are simply doing what gadgets are not capable of – taking care of creative, non-routine and un-linear tasks. Nevertheless, by 2050, work can transform in such a deep way that one can declare the end of work as we know it. We might see a return to the roots of work, to the time before the institution of paid work.

Work *per se* is an act of creativity, which aims at satisfying our material and immaterial needs. People enjoy working, because it manifests their best qualities: creating, solving problems, using ones skills and crafts, developing one self. Working creates the experience of autonomy as well as binds people to each other through the division of labour. Work is an act of individualism as it is that of collectivism.

Instead of the institution of paid work under an employee, in the future self-organizing peer-to-peer production and prosumerism could form the basic framework for work institution. In the future, the ideal worker may not be a diligent toiler with narrow expertise, but an enthusiastic and ingenious amateur (Heinonen & Ruotsalainen 2012). Workers know well their field of expertise, but are curious and interested in a myriad of things. Engineers cherish the ideal of the Renaissance Man. Of the general work competences especially time competence, systems competence and meanings competence are needed.

Meaning Competence as a New Skill

Especially **meanings competence** can be of most crucial importance in the future. Production in the creative economy is in essence cultural meanings. Communication is carried out through meanings. Production aims more and more at products and services which aid in identity production and constructing a personally meaningful way of life. This is not solely a concern of the creative class, but all industries have to take into account this change in society and consumer demand.

Meanings competence is the ability to create and interpret meanings, construct and communicate social reality. Workers need meanings competence not only as tool, but also as a skill to construct one's work as comprehensible, fulfilling and meaningful. Jobs will be less and less clearly defined, and workers must learn to "define" their jobs for themselves. Creating meanings competence is a social process, which calls for interaction competence: culture is by definition social, shared. Creativity, stories and innovations can only be created in socially livable environments, in which the interaction between individuals is fluid. Socially lively work means also taking consumers along in the production process: it is the best way to ensure that the products and services will be deeply meaningful. Essentially, meanings competence is not only a matter of work life, but people will increasingly strive at creating their life meaningful and purposeful.

Danger of Work Becoming too Big

The most important trend identified considering working life was not only the mixing together of different industries but different spheres, values and procedures: consumers becoming producers (and producers consumer-like), work becoming leisure-like (and vice versa).

This development has several benefits, as it helps making work more meaningful and products more demand-matching. However, it contains serious threats: instead of work becoming more meaningful and fulfilling, it can attain too big a role in our lives. Furthermore, these issues are linked with the emerging theme of the changes between public and private spheres.

Perhaps not by 2020, but most probably by 2050 technology has melted to become an inseparable part of our environment, but also of ourselves. Our thinking, communication, work and leisure are intermediated, supported and enhanced by technology. One of the most prominent effects of technologies is the dramatic fertilization of communication. Vivid communication promotes openness, which on its part promotes innovation. We are increasingly living a life of ubiquitousness and transparency. It is a matter of further investigation what are the pros and cons of this development.

Testing New Techniques, Products and Processes

Examples of the main topics that were dealt with in Futures Cliniques are:

- Future Concepts of Urban Housing and Sustainable Multi-Locality
- Radical Innovations on Combating Climate Change
- The Future of Library
- The Future of Technology Centres
- The Intertwining Futures of Work and the Internet
- The Utilization of 3D Worlds
- Emerging Digital Culture
- Meaning and Time Competence as Future Work Skills

Clients for recent Futures Cliniques conducted by Finland Futures Research Centre include for example the Finnish Ministry of the Environment, the Finnish Innovation Fund, Technology Centre Innopark and Helsinki

City Library. For each Futures Clinique the participants were selected to represent different industries, branches and fields. The heterogeneity of the participants and co-creative methods used resulted in various progressive and future oriented ideas. For example, the Futures Cliniques considering the futures of libraries helped in redesigning of the activities of Helsinki city library “Kohtaamispaikka” (Meeting Point).

The participating case organisations profited from the project in the form of new ideas for future development. In addition to the core concept (CFS), it was possible to test some of the tentative ideas, as well as the new techniques, products, services and processes of the participating organisations in the workshops. The participants also received all the material created in the project and in the Futures Cliniques conducted within the CFS.

The results of the project were also presented in the media, which both disseminated information and made the project more influential on local and even regional level, thus giving the participating organisations a means for marketing. Concrete input for regular work was provided by the ideas and innovation germs picked up from CFS, together with adoption of a more holistic and longer-term looking ahead.

Democracy and Participation to Profit from Creative Public Spaces

The project implicated the untapped possibilities of collaborative, co-creative and peer-to-peer foresight activities. Participatory foresight or planning methods could be used considerably more in policy and decision making processes. In government, each Ministry could have its own Creative Foresight Space. Large companies and organisations could have their own Creative Foresight Space, while smaller enterprises could share a common CFS, located e.g. inside a technology park, science hub or conference centre.

Another central issue is the planning and designing of public spaces. The concept of CFS could be implemented not only in corporations, but in public spaces and public enterprises too. This would not only improve work-related wellbeing but benefit democracy and participation. For citizens, libraries and educational institutes would be ideal places for futures learning through Creative Foresight Spaces.

Ubiquitous digital technologies and Internet-platformed solutions have a huge potential to provide for creative processes as well as participatory policy planning and democratic decision making. The potential of Internet-based technologies and services should be further examined especially in conducting virtual foresight workshops, cross-fertilised with face-to-face Futures Cliniques.

The project on Creative Foresight Space with the introduction of this hybrid concept for futures learning, and with its documentation of the results from two experimental cases is the first step. The second step is to disseminate the experiences of these cases to make a concrete call for further action. The concept of Creative Foresight Space and of Futures Cliniques could be revisited for involving policy-makers more directly in the foresight processes. These tools can be utilised to enable decision-makers, experts/researchers, planners, and citizens to collaborate − crowdsourcing the futures, "learning" the futures.

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