FUTURE-ORIENTED TECHNOLOGY ANALYSIS IN SECURITY AND SUSTAINABILITY: IMPACTS AND IMPLICATIONS ON DECISION-MAKING

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Summary

The paper addresses how future-oriented technology analysis (encompassing mainly foresight, forecasting and technology assessment approaches) can address societal issues and challenges and have impacts to private and/or public sector decision-making and actions, in particular in relation to sustainability and security. Whereas the paper reports some findings on the future of sustainability and security, even more important, it aims at providing evidence how FTA projects, in particular foresight, have been applied and what have been their impacts especially on policy-making. Towards this end, the paper examines selected foresight cases around the world. The paper explores how foresight activities in sustainability and security have had impact to policy-making as well as how policy sphere has influenced on conducting foresight and in more general FTA activities.

Keywords

Evaluation; Foresight; Future-oriented technology analysis; Sustainability; Security

The views expressed in this paper are those of the authors and cannot be taken as indicating the views of the European Commission or of its services, or of the Chinese Academy of Science.

1 Introduction

Future-oriented technology analysis (FTA) (encompassing mainly foresight, forecasting and technology assessment approaches) (Technology…, 2004)) can address societal issues and challenges and have impacts on private and/or public sector decision-making and actions. We discuss FTA in security and sustainability, which are both cross-cutting concepts. While the authors consider diverse approaches valuable in the realm of FTA, for the purposes of this paper, the empirical analysis focuses mainly on foresight in connection with policy-making; though some implications are addressed also in view of other FTA approaches (technology assessment and forecasting) and application contexts (private sector and non-governmental organisations).

Whereas the paper reports some findings on the future of sustainability and security, even more important, it aims at providing evidence of how FTA, namely foresight, methods have been applied and what have been the impacts of such projects. Doing so, we expect to identify findings also possibly relevant for the development of the wider realm of FTA.

Since the Brundlandt Commission (1987), many alternative definitions of sustainability have been proposed and diverse interpretations of the concept made. Many of these are based upon the 'three-pillar' or 'triple bottom line' concept. Whereas the Brundtland Commission presented a two-pillar model reflecting environment and development concerns, the three-pillar model separates development issues into social and economic factors, emphasising that material gains are not sufficient measures or preservers of human well-being. For instance, some major sustainability challenges address climate change, global equity and competiveness. For the purposes of this article, the triple bottom line can be considered an interpretation of sustainability that places equal importance on environmental, social and economic considerations in decision-making, thus their analysis in an integrated manner.

Security refers to the condition of being protected against danger or loss that originate from outside such as war, disaster, civil unrest, vandalism, or sabotage. Herein, security means that something not only is secure or safe but that it has been secured. Security is typically related to critical infrastructure, a term used by governments to describe material assets that are essential for the functioning of a society and economy (such as electricity generation and distribution, telecommunication, transportation systems, public health, financial services, and security services (both police and military).

At political and policy level, security has been gaining more and more importance especially after the severe terrorist attacks of the 11th September 2001. Today, security is understood as a cross-cutting issue that entails a number of challenges. The cross-cutting dimension of the security field includes recurring concepts such as risk, threat, vulnerability, defence, counter measure, etc. Society faces a number of challenges that have an impact on security, to name a few there is terrorism, organised crime, regional instability, natural disasters. All these issues might call for a variety of both non-technological and technological actions of preventive or counter measures. Research and innovation (R&I) plays an important role in addressing and anticipating these threats. Such activities can contribute to identify, prevent, deter, and protect society against unlawful or malicious acts that might undermine the security of society.

Sustainability and security issues are closely intertwined. It is crucial to understand the linkages that require responses to global threats. These global threats that undermine the security of citizens are not only related with terrorism and crime, but might come from scarcity of raw materials, high commodity prices and macroeconomic and financial instability. One of the recent policy debates has concentrated around the issue of possible shortfalls in supplies of foodstuff due to increased prices. This might become a global threat in the future and it is linked with issues related to climate change (e.g. floods, natural disasters, conflicts)

and structural factors (i.e. increased demand). Furthermore, climate change and the security of energy supply demand for more innovation, diversification, and a more proactive and coherent energy security diplomacy.

Both sustainability and security related technologies are only one part of an effective strategy and response to address the challenges and threats and must be applied in combination with organizational processes and human intervention. New technology will provide changes in how activities are organized and how humans react to uncertain situations. Technological research and development could be further strengthened and integrated when appropriate with research on political, social and human sciences. Basically, there is an increased need for analysis and assessment of challenges. For example, there is a need of analysis related to the security/ development connection that includes the core of the external policies, energy security and climate change. In order to develop an effective security policy and strategy, more coherent and comprehensive information is needed.

FTA activities can be seen as crucial functions to prepare for the future; not only to identify the promising technological pathways, but also to engage relevant stakeholders and create common visions into action (Smits & Kuhlmann, 2004; Könnölä et al., 2007a). Furthermore, FTA processes can also become a pertinent design phase for the creation of new value networks that are based on the novel combinations of technologies, organisational partnerships and institutional arrangements. Interestingly, these dimensions match largely with approaches addressed when the challenges of sustainability and security are dealt with.

In the following, Section 2 elaborates the conceptual framework for the analysis of FTA projects. In Section 3, the selected projects are examined and analysed within the framework. Section 4 is for discussion.

2 Characteristics of FTA projects

FTA is an umbrella concept that covers a wide range of different types of future-oriented and participatory processes. In view of understanding the impacts of projects it is worth first characterising different kinds of projects with different kinds of likely impacts in the innovation and policy system. The design of FTA activities addressing sustainability and security challenges can benefit from the structured approaches that help to identify the expectations concerning the management of the FTA process and final outcomes. Within these lines Könnölä et al. (forthcoming) have developed a framework for the purposes of strategic management of a foresight portfolio in a contract research organisation. We apply and elaborate this framework for the purposes to characterise foresight projects conducted in relation with sustainability and security issues.

The key design dimensions in the framework consist of:

- outcomes,
- chosen future perspectives,
- management approach and
- stakeholder engagement.

In each of the four dimensions it is possible to conceptualise archetypal dichotomies that support further the characterisation of a FTA project. Furthermore, for the classification purposes, we consider outcomes and future perspectives both referring to the outcome-related aspects of the project, for instance responding to a question on what and what kind of outcomes are achieved. The management approach and stakeholder engagement refer,

instead, to the process-related aspects of the project, for instance responding to a question on how the outcomes were achieved and by whom.

2.1 Informative vs. instrumental & informative outcomes

FTA outcomes consist of outputs, results and impacts of the exercise. Outputs refer to the products and services, tangibles and intangibles. Results in turn refer to advantage or (disadvantage) that the beneficiaries obtain soon after the end of their participation to the FTA; and impacts refer to consequences affecting beneficiaries during and after the project. For the purposes of the paper we consider instrumental and informative outcomes.

- ***Informative outcomes*** refer to the use of FTA process and dedicated methods to improve the awareness and understanding of present and future challenges of the innovation system and its parts. Thus, the informative outcomes do not refer to the expectations that FTA activity would necessarily lead to specific actions.
- ***Instrumental* & informative *outcomes*** refer not only to informative outcomes but also to the use of foresight to support the specific foreseen decision-making situation, for example related to resource allocation or the formation of strategic partnerships/joint actions.

In view of security and sustainability challenges, there is a need to provide outcomes to support targeted decision making situations. As well it is necessary to collect and codify information that allow a better understanding of the future drivers and challenges, develop visions, defining the setting of priorities and have more accurate forecasts on the time-horizons of S&T developments.

2.2 Consensual vs. diverse future perspectives

Future perspectives can be addressed to define the approach how and with what methods the project develops understanding of the future. FTA activities often focus on the production of consensual future perspectives that refer to the creation of common understanding on priorities, relevant collaborative networks and future actions. These outcomes can be addressed in view of consensual or diverse future perspectives (Könnölä et al., 2007b):

- ***Consensual future perspectives*** refer to the creation of common understanding on priorities, relevant collaborative networks and future actions.
- ***Diverse future perspectives*** refer to understanding diverse ideas, opinions and perspectives in priority-setting, identifying and fostering alternative and competing coalitions and value networks as well as exploring alternative futures and generating rivalling visions.

Addressing both consensual and diverse future perspectives are crucial dimensions when dealing with sustainability and security. In both fields, in particular the development of alternative scenarios help address uncertainties and diverse interconnections between many drivers. On the other hand, it is crucial to be able to develop also consensual visions and recommendations into action for policy and in more general decision-making.

2.3 Fixed vs. autonomous management

The FTA process can be taken up with different kinds of management approaches, which is often driven by the diverse expectations laid on the project. The creation of new, especially shared, knowledge is challenging, in particular, when the people participating in the FTA process have heterogeneous backgrounds, which occurs when various interest groups

(industry, academia, government, NGOs, etc.) and different geographical areas (countries, regions, etc.) are engaging in the FTA process. This means that special attention must be paid to the organisation of the process and to the appropriate use of formal tools and procedures. Furthermore, those in charge of the FTA process are likely to benefit from the sharp definition of their role and approach in the management of the FTA process. This makes it easier to design the process in a coherent way and to communicate the responsibilities of different stakeholders. Here, two extreme approaches can be identified in view of the classification purposes (Salo et al., 2004).

- **Fixed management** can be characterised as centralised approach in which co-ordinators fix the scope and methods of the exercise at the outset and control the process, which is often the case for example in Delphi exercises (Helmer, 1983).
- **Autonomous management**, in turn, refers to the process intermediated by the co-ordinators, who facilitate autonomous and evolving participant-led continuum of meetings and other activities, which maybe the case for example in expert panel work.

Addressing security and sustainability issues require typically many types of participants as well as different kinds of methods to adapt to the interests and expectations of the participants but can also ensure the relevant outcomes useful for further application in decision-making. Thus, both dimensions may play important role in the design and management of FTA in security and sustainability.

2.4 Extensive vs. Exclusive stakeholder engagement

One way to conceptualise stakeholder engagement is to define extensive and exclusive stakeholder engagement (Barré, 2002) and the continuum of different possible combined approaches between them, namely from confined exclusive engagement to extensive but exclusive engagement towards to extensive and open engagement of stakeholders.

- ***Extensive stakeholder engagement*** refers to the approach in which the actual number of participants is high, the stakeholder participation is encouraged and open for all the interested stakeholders and many kinds of stakeholders are invited to participate in the process.
- ***Exclusive stakeholder engagement*** which means that stakeholder participation is not extensive and thus not open for all the stakeholders interested.

Extensive stakeholder engagement in a FTA process in which also experts are involved, allow stakeholders to become better aware of signals of change and threats and consequently to put in place preparedness mechanisms to act on time. Anticipation of intelligence (or knowledge) is a contribution to improve the knowledge base for the designing of policies. In the security and sustainability fields, stakeholders have the possibility to develop scenarios on which basis diverse policy options could be outlined. Other benefits that could be achieved through the Foresight process include creation of linkages amongst participants, development of a shared understanding on the various issues at stake, and on future challenges. The opportunity for exclusive participation in FTA may also be highly important in security and sustainability fields as this mode allows confidentiality and trust among the participants. Hence, it is likely that in the FTA designs both exclusive and extensive elements are present.

3 Empirical findings on FTA in Security and Sustainability

3.1 Introduction

Security and sustainability issues have been addressed by the FTA community already several decades. However, recently, society and respectively also the FTA community have shown growing interest in these issues. In particular, sustainability issues have become typical issues along the shift in science and technology policy to address also societal issues. However, until today, the references on FTA studies on security have not been as numerous as could be expected. For instance, the European Foresight Monitoring Network (EFMN) addressed in one of its Foresight Briefs[1] the Foresight studies conducted in the period between 2000 and 2007. 36 studies (out of 160) were identified having a future-oriented dimension and addressing some security components. These studies were conducted mainly at national level. For instance, FTA could be used more widely to better understand the potential of the market demand of the security market. Good practice examples exist in the literature on FTA on security as the EFMN Brief outlines especially in the areas of civil security and IT security.,

Also some policy-makers have seen the value of FTA in addressing these issues (ESRAB, 2006). For instance, the European Commission Framework Programme 7 has identified Security research as one of its strategic elements where FTA activities are advocated to deal with security as a cross-cutting and problem oriented issue.

While the authors consider diverse approaches valuable in the realm of FTA, for the purposes of this paper, the empirical part focuses on foresight and policy. The authors of the paper performed a quick scan on foresight projects that address security and/or sustainability issues. The suitability of the projects selected by each author was discussed and the list of projects for further analysis was made rather randomly. The attempt was not to make a global scan of the conducted foresight projects in the field, but rather to analyse some projects considered relevant and/or distinctive to provide some empirical findings for further analysis. The projects are described shortly in Table 1.

The conceptual dichotomies of the FTA dimensions defined in Section 2 provide a practical structure for the analysis assuming, of course, that FTA project consists of identifiable elements for the classification. In practice, FTA activities often consist of some elements of the both sides of these dichotomies, and altogether they form the combination of a case specific process design. This approach is used in the subsequent sections to characterise a number of FTA projects. The positioning of individual projects in the framework clarifies the methodological decisions and the rationales of stakeholder engagement. Once the projects are positioned in the framework they provide overview of the whole portfolio of FTA projects analysed that supports building the more holistic view of the activities.

[1] The full list of Foresight studies is included in the EFMN Foresight Brief n. 134 'Future Challenge for Europe: Providing Security and Safety to Citizens' that could be found at: http://www.efmn.eu/efmn/searches/briefs-search.html

Table 1: Selected foresight projects in Security and/or Sustainability.

Project	Outcomes	Future Perspectives	Management	Stakeholder Engagement
Nordic ICT Foresight[2]	*Informative* Evaluations of key ICT applications, Nordic scenario set in context of ICT development, scenario-based visionary roadmaps. Building views of the Nordic potentials in ICT development among key actors. Action proposals and policy recommendations	*Diverse* Alternative scenarios. Also identification of ICT applications with development potentials in Nordic region; future-oriented elaboration of factors affecting the Nordic business and development environment in ICT.	*Fixed* Structured discussion and the generation of new ideas in the workshops *Autonomous* Creative brainstorming and ideation in the different scenario and roadmapping workshops	*Exclusive* Intensive stakeholder engagement in core group *Extensive* Co-operative idea and concept creation among stakeholders from different Nordic Nordic organisations and firms; networking
VTT Water Research Roadmap 2006[3]	*Informative* Create common understanding on future challenges and VTT expertise *Instrumental* Support the formation of different treams of R&D actions within VTT.	*Diverse* Inclusion of alternative views on priority-setting. The identification of key action areas for VTT water research and their priority-setting	*Fixed* Structured questionnaire; Defined agenda for workshops and structured priority-setting *Autonomous* Flexible use of methods in working groups	*Exclusive* VTT expert engagement in steering group and workshops to enable intensive communication *Extensive* networking among VTT experts on water related R&D through questionnaires, co-writing
Nordic H2 Energy Foresight[4]	*Informative* Awareness raising and deepening the overall understanding of the entire value chain (hydrogen production, storage, distribution, stationary hydrogen uses and hydrogen uses in transport). An action plan for the Nordic key actors – without a direct link to any decision process	*Consensual* Shared understandings were searched for in order to be able to give action recommendations for the Nordic key actors. Still, a variety of views and opinions were considered and debated during the process.	*Fixed* The overall design of the process was determined already when planning the project. The model and modelling techniques in use guided the data gathering of the system analysis part. *Autonomous* There was still a significant degree of freedom to adapt to the perceived needs during the process and the development of roadmaps and scenarios	*Extensive* The participation was open for research institutes, industry, associations and public organisations of the five Nordic countries.

[2] http://www.vtt.fi/inf/pdf/publications/2007/P653.pdf
[3] Unpublished
[4] Nordic H2 Energy Foresight for the Nordic Council, http://www.h2foresight.info

Project	Outcomes	Future Perspectives	Management	Stakeholder Engagement
EU: IRRIIS scenario work[5]	*Informative* Identification of emerging safety and security issues in an EU project to ensure the safety of critical infrastructures.	*Consensual* A project level consensus on the future developments. Still, different scenarios were considered.	*Fixed* A fixed procedure and methods selected in the beginning of the project *Autonomous* Autonomous scenario work among the stakeholders. The experience of stakeholders "overwrote" the methodological rigidity in some points.	*Exclusive* The work was carried out among the project partners. *Extensive* The results were tested against available expertise outside the project consortium
UK DCDC Global Strategic Trends Programme	*Informative* Identification of cross-dimensional analysis of the future context of Defence in the next 30 years. *Instrumental* The document is a source for the development of the UK Defence policy.	*Consensual* This process aims to provide new evidence and thinking on strategic trends on specific risks highlighting significant defence and security implications. The findings consist in probability based outcomes.	*Fixed* The procedure was fixed at the beginning of the process. It applies trend analysis with a time-horizon of 30 years. *Autonomous* Expert group work.	*Exclusive* Process was mainly small expert group work. *Extensive* Ideas were exposed in conferences and a survey was launched to opinion-formers leaders in business, government, media, NGOs and academia. The outcomes were reviewed by external experts. The findings were tested against the views of an international and largely non-Western peer group.

[5] The EU Integrated Project IRRIIS - Integrated Risk Reduction of Information-based Infrastructure Systems, http://www.irriis.org/?lang=en&nav=218 ; http://www.irriis.org/File.aspx?lang=2&oiid=8661&pid=572

Project	Outcomes	Future Perspectives	Management	Stakeholder Engagement
Foresight Canada[6]	*Informative* Identification of emerging and and frontier technology domains addressing subjects such as future fuels, bio-health innovation, geo-strategic systems, animal health and infectious disease. *Instrumental* The outputs were used to contribute to a joint security technology initiative of Canada as well as strategic S&T investments in the Defence R&D Canada Centre for Security Science.	*Consensual* The outputs drove discussions of national security challenges to provide input into capabilities needed to meet these challenges.	*Fixed* Strategic environmental scan based on experts' view was used assess probability and impacts of projected threats. *Autonomous* The overall process was based on workshops. Creative workshop discussions.	*Extensive* The process involved a network of security stakeholders. These were coming from different government departments, private companies, and research organisations. *Exclusive* Only invited participants.
FISTERA: Foresight on Information Society Technologies in the European Research Area:[7]	*Informative* Identification and SWOT analysis of current socio-techno-economic trends, drivers and challenges; key characteristics of IST research in Europe including human resources aspects; futures challenges, applications and priorities for information society technologies (ISTs) in the EU. *Instrumental* Outputs were used to prepare the FP7 ICT programme.	*Consensual* FISTERA highlighted priority application areas where R&D investments should be intensified in the future, motivated both by S&T developments and by socio-economic needs.	*Fixed* Scenario workshops, on-line Delphi study, on-line forum, national seminars ("FISTERA road show"), supported by desk research). *Flexibility* Results of each phase of the project were widely disseminated and feedback on these results was used in the next phases, also to adapt the methodological approach.	*Extensive* There was an extensive engagement of stakeholders. More than 500 experts including policy makers, business actors and researchers from all EU Member States responded to the on-line Delphi study. In addition, a total of more than 600 stakeholders in a various EU Member States were addressed in a series of national seminars, and a number of scenario workshops were held, each involving in average 25 participants.

[6] Office of the National Science Advisor (ONSA)

[7] FISTERA: Foresight on Information Society Technologies in the European Research Area (2002-2005). A FP5 IST Thematic Network coordinated by JRC-IPTS and managed in collaboration with DG Information Society . *http://fistera.jrc.ec.europa.eu/*

Project	Outcomes	Future Perspectives	Management	Stakeholder Engagement
Future Impact of ICTs on Environmental Sustainability[8]	*Informative* Explore how ICTs will influence future environmental sustainability (time horizon: 2020) and develop policy recommendations. Results were discussed with both DG Information Society and DG Transport and Energy of the European Commission.	*Diverse* Description of a large degree of uncertainty of impact of ICTs on the environment. The scenarios developed during the exercise accommodated a diverse range of views and suggested a number of possibilities.	*Fixed* The methodology was fixed at the beginning of the project. It consisted of data gathering and combination of qualitative scenarios and quantitative modelling.	*Exclusive* The exercise was mainly conducted by the research partners. The scenario building step involved around fifteen external experts and stakeholders. At various steps of the projects, experts were consulted to validate the results and methodological aspects. Policy recommendations were validated thought interviews of about twenty experts in ICT or environmental policy
The 8th Japanese technology foresight program	*Informative/* Understanding future S&T challenges *Instrumental* The 8th Japanese technology foresight program aims to provide necessary information for making the 3rd S&T basic plan of Japan.	*Consensual* The 8th Japanese technology foresight program consists of consensual Delphi survey, scenario, bibliometrics and needs analyses	*Fixed* The methodology for the 8th Japanese technology foresight program is fixed at the beginning of the exercise,, including: Delphi, Scenario, bibliometrics, and social and economic needs analysis. *Autonomous* There was still a significant degree of freedom to adapt to the perceived needs during the process and the development of scenarios and social and economic needs.	*Extensive* There was an extensive engagement of diversified stakeholders. About 2239 experts participated in Delphi survey. Also, many experts of social sciences participated in scenarios analysis and needs analysis.

[8] Future Impacts of ICTs on Environmental Sustainability, Project commissioned by JRC-IPTS, to a consortium of research organisations, http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=1208;

Project	Outcomes	Future Perspectives	Management	Stakeholder Engagement
Innovation 25 in Japan	*Informative* *the final report of "innovation 25" has set out 5 scenarios for future Japan, and find out the prior S&T topics to achieve the social goals.* *Instrumental* *"Innovation 25"aims to make long-term strategy for Japan.*	*Consensual* *"innovation 25"has set 5 scenarios of Japan society in 2025,and it includes "Long Health Society", "Safe and Secure Society", "Society with Multiple Career Path", "Japan contributing to Global Issues" and "Japan Opening to the World".*	*Fixed* The methodology was fixed at the beginning. The Cabinet Office established the Innovation 25 Strategy Council and the Innovation 25 Special Mission, and six fields were discussed by workshops independently. *Autonomous* There is freedom in discussion for social scenarios in each field, and the priority setting of science and technology based on technology foresight.	*Extensive* There was an extensive engagement of diversified stakeholders from government, academia and industry.
National Technology Roadmap in Korea	*Informative* Learning about the technology pathways and needs. National Technology Roadmap in Korea aims to make long term strategy plan.	*Consensual* National Technology Roadmap (NTRM) in Korea has set up five complementary visions, two of which are related to sustainability and security directly, including the "Advancing the E2 (Environment and Energy) Frontier" and the "Improving National Safety and Prestige".	*Fixed* The major activities in establishing NTRM have been guided by the NTRM Head Council. The Executive Committee was also set up with 5 sub- committees that are the core body in developing NTRM. In addition, TRM teams (in total 74 teams) were set up to draw TRMs for key technologies in the second stage. *Autonomous* Each TRM team consists of around 10 technology experts from industries, academic circles and research circles.	*Extensive* A total of 751 committee members have participated in drawing NTRM.
The Revision 3rd Korean technology foresight	*Informative* S&T developments *Instrumental* The "Revision of 3rd Korean TF" aims to strength the linkage between the foresight and policy making, namely to provide necessary information for making the 2nd Korea S&T Framework plan.	*Consensual* The "Revision of 3rd Korean TF" has analyzed the impacts of 19 megatrends & issues, and identified 182 future strategic technologies.	*Fixed* The methodology was fixed at the beginning.	*Extensive* There are broad engagement of diversified stakeholders from government, academia and industry.

Project	Outcomes	Future Perspectives	Management	Stakeholder Engagement
National Technology Foresight in China	*Informative* Understanding future S&T developments and needs. NTFC aims to provide also necessary information for making five-year plan of science & technology development.	*Consensual* NTFC has identified lots of key technologies in 9 research fields based on the Delphi survey.	*Fixed* The methodology was fixed at the beginning.	*Extensive* Very diversified stakeholders from government, academia and industry have participated in NTFC.
Technology Foresight towards 2020 in China	*Informative* TF2020 aims to provide necessary information for making long term strategy for science and technology development in China, and for influencing the allocation of S&T resources in CAS.	*Consensual* TF2020 has set up 6 pictures of China development in 2020, and identified 734 key technologies in 8 research fields based on the Delphi survey.	*Fixed* The methodology was fixed at the beginning.	*Extensive* Diversified stakeholders from government, academia and industry are very active in the process of TF2020.

FTA projects can be further classified according to the FTA design and management dimensions. When a foresight project is linked to specific decision-making situations, the outcomes are likely to both informative and instrumental. Alternatively, when a foresight project does not have the strong linkage to decision-making but improves the general awareness and understanding of the system, it can be characterised as informative. The future perspectives of the outcomes can be further characterised either as consensual or diverse. When the dimensions of outcomes (informative vs. instrumental&informative) and future perspectives (consensual vs. diverse) correspond the horizontal and vertical lines, the FTA projects (described in Table 1) can be positioned in four different quadrants (consensual and informative; consensual and instrumental&informative; diverse and informative and diverse and instrumental&informative) (Figure 1).

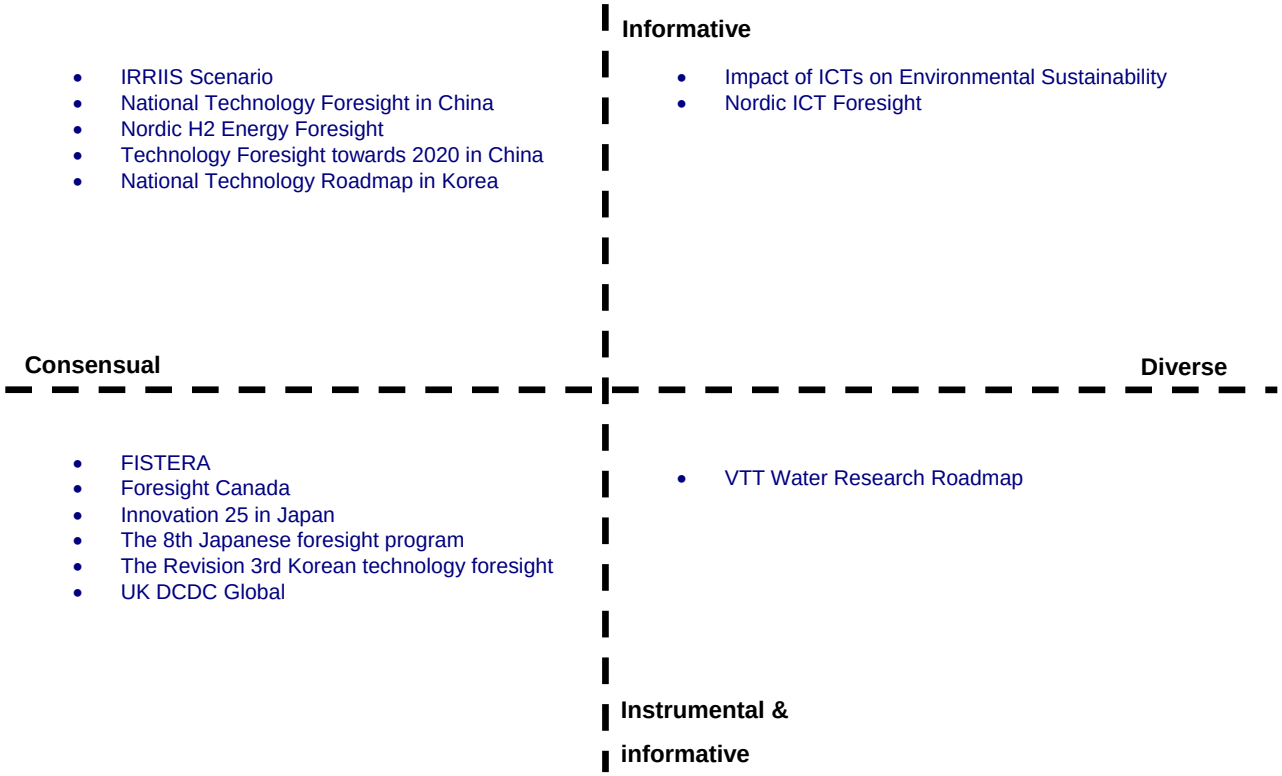

Figure 1 FTA projects positioned in view of the dimensions of outcomes (informative vs. instrumental&informative) and future perspectives (consensual vs diverse).

In parallel, the projects can also be positioned in view of process oriented dimensions. When the process management (autonomous and fixed) and stakeholder engagement (extensive and exclusive) dimensions are considered to correspond to the horizontal and vertical axes, they produce together a coordinate system (see Figure 2). Here, the horizontal axis represents the qualitative continuum from fixed to autonomous management, and the vertical axis the continuum from extensive to exclusive stakeholder engagement.

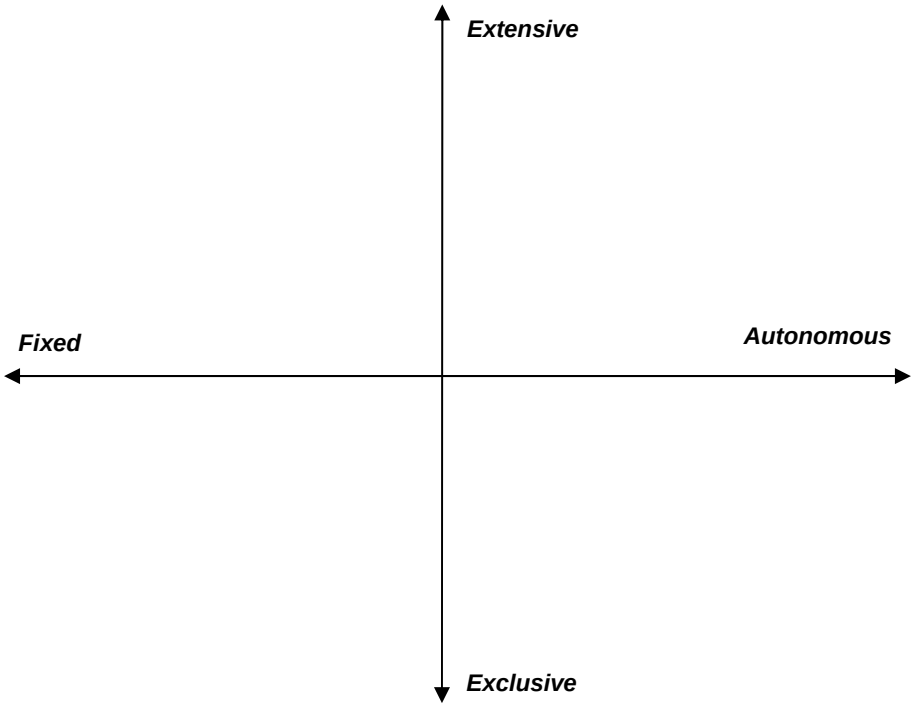

Figure 2 Process management (from fixed to autonomous) and stakeholder engagement (from exclusive to extensive) dimensions in a coordinate system.

Further on, if this coordinate system is positioned to each quadrant of Figure 1, the FTA projects can be positioned in the coordinates to provide detailed information on the nature of the outcomes and process of each project (Figure 3). Hence, once the project is in one of the four quadrants (according to consensual vs. diverse and informative vs. instrumental&informative) the exact position of the project can be defined in the coordinates (from fixed to autonomous and from exclusive to extensive).

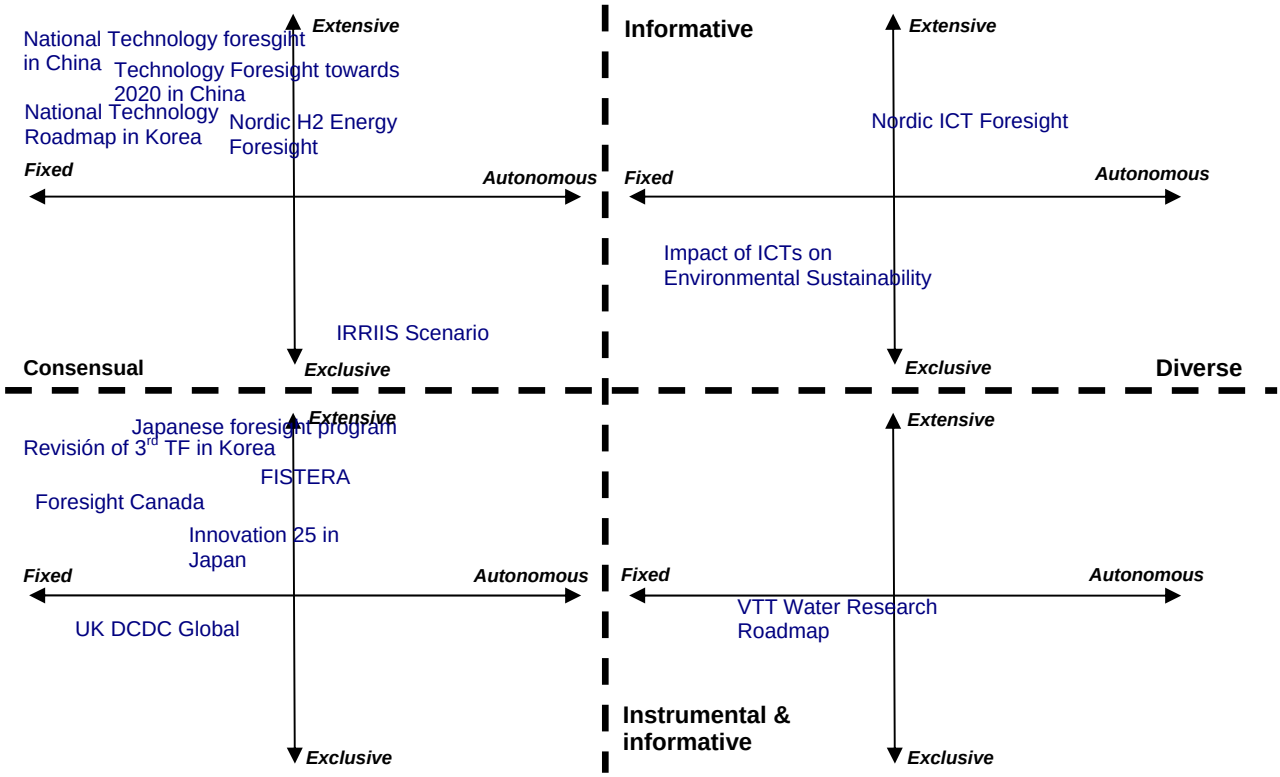

Figure 3 FTA projects positioned in view of the dimensions of outcomes (informative vs. instrumental&informative), future perspectives (consensual vs. diverse) and in the coordinate system of stakeholder engagement (extensive and exclusive) and management (autonomous and fixed).

Projects positioned in the quadrants and the coordinate systems provide bases for further analysis of their characteristics and methodological choices. Subsequently, we discuss the projects in each quadrant: their positioning in the coordinate systems and the impacts and implications to sustainability and security related policy- and decision-making.

3.2 Consensual and informative

Consensual, informative processes create common understanding on priorities, relevant collaborative networks and/or future actions. They are expected to improve the understanding of present and future challenges of the innovation system and its parts. However, specific short-term actions are not necessarily expected after the projects. This setting relieves the participants partly from claiming value and from the pressures of policy-making and lobbying and hence may enable also otherwise adversary parties to learn together and search for common ground for long-term agendas. Among the foresight projects examined, we identified to following projects:

- IRRIIS Scenario
- Nordic H2 Energy Foresight
- National Technology Foresight in China

- Technology Foresight towards 2020 in China
- National Technology Roadmap in Korea

IRRIIS Scenario work was part of the European integrated project that provided improved understanding of the developments in the security field. The IRRIIS scenario process was on the future developments in energy and communication technology and their interactions. It was expected that the project results would describe the future scenarios in detail, including diverse uncertainties in such scenarios. This challenge was dealt with in the brainstorming workshops, intensive e-mail communication, commenting and co-writing. The consensual scenario work was considered extremely challenging due to high uncertainties related to the issue. The results were communicated to the Commission, but direct impacts to policy making have not been recorded.

In the Nordic H2 Energy Foresight the major challenge was to create shared understandings on future hydrogen-based energy systems between different stakeholder groups representing five different countries. Much of the efforts were directed towards the creation of a common language and understanding between technical experts, modelling people and foresight experts and the various groups of stakeholders (industry, research institutes, public organisations and associations) in the five Nordic countries. The project applied the combination of interactive workshops, modelling, analytic back-office work and a small-scale Delphi-type enquiry.

For FTA activities on emerging issues that are not yet proven to be of high policy importance it may be difficult to engage policy-makers in the process. In the Nordic H2 Energy Foresight, specific efforts were made to engage policy-makers but with limited immediate success. This may be partly due to the initial positioning of the projects as informative rather than instrumental, thus not considered as policy-making processes (Könnölä et al, 2007b). At best, indirect and diffuse policy links during and after such projects may be influential in the long run, however. The project produced a number of reports as outputs, which are further summarised also to policy-makers and wider public to create awareness of this new emerging field. The project seemed to have limited direct influence on decision-making. The impacts of the project are considered rather to be the wiser awareness raising and networking within the Nordic innovation system and beyond.

Consensual and informative FTA processes in Asian countries such as Japan[9], China[10] and Korea, seem have important role both in enhancing national systems as well as in the international communication. National Technology Foresight in China and Technology Foresight towards 2020 in China as well as National Technology Roadmap in Korea were all strongly informative processes that were initiated to capture experts' views on future S&T challenges. Hence, the processes served policy-making by providing relevant background information, but they were not as such meant to engage policy-makers in the process. In practice, the technology foresight in Korea and China has borrowed lots of experiences from technology foresight (forecasting) exercises in Japan. The results of technology foresight in Asia countries have improved the understanding of major challenges that have great impact on the development of Asian countries, especially the issues concerning the sustainability and security.

3.3 Consensual and instrumental

[9] Japan is the pioneer of technology forecasting and foresight, and has completed 8 times technology foresight activities since 1970.

[10] FTA exercises in China in broad sense can be traced to "The 12 Years Science Development Planning" made in 1956, when over one thousand top scientists participated in the work ranging from technology selection, priority setting, subject arrangement, resource distribution, by using a method similar to a Delphi survey.

Consensual and instrumental processes create common understanding on priorities, networks and/or future actions as well as support the specific foreseen decision-making situation. Among decision-makers this is likely to lead to interests in the results. However, policy interests may also enter in the foresight process and create rigidities and difficulties to provide new and fresh perspectives for change. This may be supported by ensuring extensive stakeholder participation through the diversity and high number of participants. The foresight projects examine in this quadrant consist of:

- FISTERA
- Foresight Canada
- Innovation 25 in Japan
- The 8th Japanese foresight program
- The Revision 3rd Korean technology foresight
- UK DCDC Global

FISTERA: Foresight on Information Society Technologies in the European Research Area (2002-2005) was an FP5 IST Thematic Network coordinated by JRC-IPTS and managed in collaboration with DG Information Society. Main results of the project consisted of: Identification and SWOT analysis of current Information Society socio-techno-economic trends, drivers and challenges; key characteristics of IST research in Europe including human resources aspects; futures challenges, applications and priorities for ISTs in the EU. In addition, FISTERA developed a novel approach to describe and present complex technological trajectories in information and communication technologies (ICTs) centred on ICT-based functionality (i.e. centred on what they can bring to the users). FISTERA highlighted priority application areas where R&D investments should be intensified in the future, motivated both by S&T developments and by socio-economic needs. Its final results were presented at the project conference held in June 2005. In addition to direct interaction with policy and decision makers, FISTERA produced several reports and books (Compano et al., 2006). The identifiable clients of the exercise included DG Information Society of the European Commission; ISTAG, the Advisory Group to the EU Information Society Technologies RTD programme (IST); Directors of ICT Research in the EU Member States; and Commission Officials,. FISTERA did influence directions for R&D in ISTs in Europe. Its contribution was, however, difficult to trace in published official documents of the European Commission that often do not explicitly refer to sources of ideas. FISTERA had an impact at both the EU and Member States level. Its results also fed and generated a number of debates on the future of ISTs in Europe. In terms of indirect impact, the FISTERA technology trajectory concept was used by industry and academia as a "thinking tool". The FISTERA methodology inspired several national foresight exercises, and a review of FISTERA by NISTEP underlined the relevance of FISTERA's approach to formulate national science and technology policies also in Japan.

The Foresight exercise conducted in Canada through a series of collaborative projects aimed at emerging and frontier technology domains that could be important to national policy development process for the next ten years. The projects included several partners, mostly from inside the federal government. The approach adopted was based on the creation of a network of security stakeholders and future S&T thinkers to reflect upon key issue and challenges related to societal, technological trends and major discontinuities. Other issues dealt were on risks related to borders, infrastructure, and public security and safety in 2015.

The process was organised as a series of workshops. Participants received strategic environmental scan prepared by an international group of S&T specialists on security and intelligence, on future technologies and on foreign affairs specialists. One of the conclusions from the process was that the complexity of the security environment is likely to continue to increase with advances in S&T, as many of these issues raise concerns on ethics and privacy. The outputs were used to drive the interdepartmental discussions of challenges to Public Safety and Emergency Preparedness Canada (PSEPC), the capabilities needed to meet the challenges, and how S&T Foresight and strategic S&T investments in the new Centre for Security Science could help to acquire those capabilities. The process assisted the new Public Security Technical Programme (PSTP) of the Canadian office of the National Science Advisor (ONSA). ONSA had been asked to provide advice on a futures-oriented Public Security Science and Technology agenda that could be aligned with the US Department of Homeland Security as part of the Security and Prosperity Partnership of North America. The initiative provided focus to the capabilities and skill areas that a new Defence Research & Development Canada (DRDC) Centre for Security Science might need to meet the anticipated national security..

The outcomes of consensual and instrumental technology foresight activities in Asia countries such as Japan, Korea and China have played increasingly important role in the policymaking process for science & technology and innovation. For example, The 8th Japanese technology foresight program consists of 13 fields, 130 areas and 858 topics, among which the fields such as “agriculture, forestry, fisheries, and foods”, “energy and resources” and “environment” are directly related to sustainability and security. Japan has completed “Innovation 25” on the basis of the 8th technology foresight program, with a series of social scenario discussions concerning 6 fields such as “the era of lifelong health”, “safe and sustainable cities”, and “solving of global environmental problems and coexistence with the world”11. Both the 8th Japanese technology foresight program and the “Innovation 25” is more consensual and instrumental than informative. The 8th technology foresight has provided important support for making the 3rd basic plan for science and technology of Japan. China is planning to make the 12th five years plan for science and technology development by using the knowledge generated from roadmap activity. The “Revision of 3rd Korean TF” is more consensual and instrumental than informative. Besides, National Technology Roadmap (NTRM) in Korea with five visions is more consensual and instrumental than informative. Two visions are related to sustainability and security closely, namely: the “Advancing the E2 (Environment and Energy) Frontier” and the “Improving National Safety and Prestige”.

In the UK, the Development, Concept and Doctrine Centre (DCDC) a Directorate General of the Ministry of Defence (MOD) conducted a foresight process that produced as a key output a report the DCDC Global Strategic Trends Programme 2007-2036. The report presents an understanding of the changes that are likely to take place during the next 30 years by considering major trend-based outcomes in 5 dimensions: resource, social, political, S&T, and military. The trend-analysis is supported by a wide external consultation of experts in order to make the information included in the report both comprehensive and independent. In any case the method applied for the report offers an indication of confidence based on the available evidence and assessment of risk. The report outlines significant defence and security implications associated to the identified strategic trends. In preparation of the report, the information provided is based on robust judgements across various alternative futures, which concentrate on the challenges of the most likely future themes and developments. The study assesses that human activity will be dominated and affected by three so called pervasive 'ring road issues': climate change, globalisation, and global inequality.

[11] http://www.nistep.go.jp/achiev/sum/eng/rep101e/pdf/rep101se.pdf.

In order to provide a coherent framework and to achieve a systematic understanding of possible human responses to these and other drivers of change, the trend-based outcomes were synthesised within 4 global 'Key Themes': Population and Resources, Identity and Interest, Governance and Order, Knowledge and Innovation. The work is the product of analysis by the DCDC therefore it could be labelled as exclusive in terms of stakeholder engagement. However, it has aspects of extensive engagement of stakeholders as outcomes are tested against the views of international panel of peer experts through exposure of results in conferences and by commissioning a survey that is consulting leaders in governments, business NGOs and the academic sector. The DCDC Strategic Trends is a fixed and continuous process. It is updated on a regular basis as new evidence and thinking emerge. This initiative is designed to result improved quality of defence policy. It is one of the source documents for the development of the UK Defence Policy. The outcomes of DCDC Strategic Trends are target to defence decision-makers but it could also have wider impacts in society and be used to stimulate a wider discussion among stakeholders.

3.4 Diverse perspectives and informative

Informative processes with diverse future perspectives take into account diverse ideas, opinions and perspectives in priority-setting, identifying and fostering alternative and competing coalitions and value networks as well as exploring alternative futures and generating rivalling visions. This relieves participants on the intensive search for consensus and direct support for decision-making, which provides opportunities for creative thinking and the inclusion of diverse and alternative view-points that can challenge incumbent and path-dependent approaches hindering – especially radical – changes in the innovation system. Among the projects examined two projects could be identified in this quadrant:

- Impact of ICTs on Environmental Sustainability
- Nordic ICT Foresight

The European project "Future Impact of ICTs on Environmental Sustainability" aimed to explore (qualitatively) and to assess (quantitatively) the ways in which ICTs would influence future environmental sustainability (time horizon: 2020). Scenarios were means to accommodate uncertainty and formed the basis for the construction of the evaluative simulation model. Two workshops were held specifically in order to contribute to build the scenarios and the model. The exercise was mainly conducted by the research partners. The scenario building step involved around fifteen external experts and stakeholders. At various steps of the projects, experts were consulted to validate the results and methodological aspects. Policy recommendations were validated thought interviews of about twenty experts in ICT or environmental policy. Main outputs consisted of (Erdmann et al., 2004):

- Quantification of future impact of ICTs using a set of indicators of environmental sustainability
- Demonstration of the importance to select and implement adopt the "right policies" that can reduce negative environmental impact and increase positive impact of ICTs
- A set of policy recommendations concerning each of the identified indicators and cross-cutting issues.

The scenarios developed during the exercise accommodated a diverse range of views and suggested a number of possibilities. This diversity made possible to quantitatively describe possible impacts that will be influenced by future policy. The findings of the exercise showed

that a large degree of uncertainty existed on impact of ICTs on the environment, and that "rebound effects" could lead to opposite impacts to that desired (e.g. if transportation becomes cheaper and faster thanks to ICTS, this would create more traffic and more energy consumption). Outputs were discussed with both DG Information Society and DG Transport and Energy of the European Commission.

The Nordic ICT Foresight was designed using the similar modular process structure as in the Nordic H2 Energy Foresight. However, the project laid particular emphasises on incorporating diverse perspectives in the vision, scenario-working and roadmapping. The major challenge in the process was to facilitate communication among stakeholders from various knowledge fields. ICT (information and communication technologies) is a broad theme. This creates also difficulties in forming common understanding about the visions of the project and highlighted ICT applications. The scenario-working was considered difficult, partly due to the fact that some stakeholders changed along the way. The project was also rather complex consisting of, for instance; desktop analysis, SWOT matrices, facilitated visionary brainstorming, clustering and scenario evaluations, visionary socio-technical roadmapping and formation of action proposals according to the previous project phases. This exercise was designed to provide a relevant platform to discuss in a structured way the future of ICT in Nordic countries. Hence, it was not planned to have direct impacts to decision-making. However, the participants from different sectors of the society benefited from the exercise. It helped them position in the system, network with other stakeholders and in general enhanced their innovation capabilities.

The foresight projects identified in Asia seemed to be all consensual, hence this would suggest that foresight exercises with open-ended diverse visions of the future are not common in these countries. However, the diversity of viewpoints in Asian countries may come from the richness of activities. Foresight activities in Asian countries are conducted in different levels, such as national level, regional level, sector level and firm's level. In national level, it is encouraged to attract different stakeholders to join in the foresight exercises so as to have better understanding about diverse perspectives and to provide more information about future for decision-making. In regional level, it is encouraged to make full use of regional comparative advantages in shaping the future. In sector level, it is encouraged to build different scenarios by taking different possibilities of related technology development. In firm's level, it is encouraged to take global market and innovation resources into consideration in setting up firm's future vision.

3.5 Diverse perspectives and instrumental

Instrumental processes with diverse future perspectives generate diverse ideas, opinions and perspectives, which support the specific foreseen decision-making situation or for the formation of strategic partnerships/joint actions.

The only identified project in this quadrant was an internal foresight project in VTT Technical Research Centre of Finland. The key foci of the VTT Water Research Roadmap were the creative combination of wide-ranging water related issues at VTT as well as the generation of new R&D initiatives. Questionnaires and mind-mapping and brainstorming workshops were used to engage VTT experts in roadmapping and the formulation of innovation ideas. During the project, it appeared that there were diverse opinions on VTT technology expertise and future market opportunities in water research. This called for mapping these differences and identifying diverse project plans instead of producing consensus statements on common future priorities. The roadmaps were finally constructed through co-writing with different intensities of participant engagement. The report was further used in the decision making of the identified project plans as well as the general development of water related research at VTT. The instrumental approach

and still integration of diverse perspectives was largely possible, because the project was organised internally, which meant that also competitive and delicate issue could be addressed already during the process.

3.6 Conclusions

The cases that are illustrated in this paper show that, depending on their design and management, the foresight projects provide different types of outcomes. Most of the projects described have important informative functions in sense that they improve the understanding of issues and of their future implications and challenges. This is almost a natural function or characteristic of any Foresight exercise that stems from the process itself, but this does not necessarily lead to immediate actions. Foresight with instrumental outcomes is likely to be designed in order to support the decision-making process and lead to development of actions and therefore also its usefulness and effectiveness for supporting policy-making is more evident. The positioning of the projects in the framework helped characterise the projects and the related expectations on them. Here, we make the following remarks:

- Almost all the analysed projects have outcomes that can be characterised as consensual. This is not surprising as the important FTA objectives are the priority-setting and common vision-building. However, the lack of projects with outcomes with emphasis on diverse future perspectives may lead to limited exploration of alternative future pathways which can be considered as strengths of many FTA methods and approaches.
- It may often be appropriate to design a FTA process as informative when the new field is emerging or the issues consist of high uncertainties. This allows addressing diverse perspectives and scenarios as well as common vision-building. However, positioning a project as informative and communicating this to stakeholders may create difficulties to attract stakeholders who wish to be close to decision making.
- Tracing the impacts of FTA is often very difficult. In many cases, decision-makers (both policy and business) do not refer to the sources used when decisions are made.
- Projects with the focus on instrumental outcomes have often important informative impacts, including indirect or unexpected impacts. FTA projects influence on all participants in the process as well as their networks. Furthermore, the outputs are often “re-used” by actors not considered in the design phase. This systemic nature of the FTA may have several ramifications, for instance, rationales for co-financing exercises.

4 Discussion

This paper has tried to emphasise that Foresight can address societal issues and challenges such as security and sustainable development. For sure one of the advantages of implementing Foresight projects in these areas is to stimulate long-term thinking, develop linkages, and build shared R&D awareness and capacity to be better prepared to advance R&I policies in view of new challenges.

FTA studies can stimulate long-term thinking in this area, develop linkages, and build shared R&D awareness and capacity to be better prepared to advance R&I policy in view of new challenges. FTA has the potential to discover not only novel threats and technological opportunities but also emerging security related ethical, cultural and organisational challenges. It can facilitate public debate and foster shared understanding among stakeholders. FTA can contribute to provide the most promising approach to deal with security as an evolving concept.

It can identify areas where there is the need to develop (technological) capabilities, but FTA can also recognise areas to strengthen (Europe's) industrial competitiveness and areas where centres of excellence can be created on security.

In the past years, a lot of work has been done in the FTA community to try justifying the relevance of Foresight for policy makers by coming up with different characterisation and typology of different Foresight studies. This work is extremely important to position Foresight as one of the supporting tools for policy decision making. It is also important because policy making formulation is more and more based on evidence base at all policy levels. However, the impact of Foresight on policy-making remains not an easy task to demonstrate and depends from many variables such as the design and management of an exercise, the involvement of the relevant stakeholders that are then able to take up and communicate the messages that can be transformed into actions.

As outlined above, FTA can play a role in understanding the evolving security and sustainability challenges. At European Union level the attention is shifting as it is clear that there is the need to address causes of threats and risks and diverse perspectives of sustainable development. In security field, policy is focusing more on the security of people, which may require a different approach on how policy should be designed and implemented. As both the security and sustainability fields are quite dynamic and complex, their future strategic contexts demand to consider the potential of possible major discontinuities and shocks (e.g. a mega-seismic disaster or the unintended outcomes of technological developments). In the field of security it is extremely important to avoid underestimation of the scale and nature of long-term changes. This it is not an easy task as it means that fundamentally (even irreversible) different drivers of change respect to the known ones should be identified. It is especially in these types of context that the implementation of FTA has the opportunity to highlight its benefits and potentials since the understanding of changes, mitigation and avoidance of risks play an essential role.

In order to increase the policy relevance of FTA activities, one future avenue might be to enhance the international FTA collaboration. For instance, in Asia, the five major research institutes in the field of science and technology policy from China, Japan and Korea have establish a mechanism for knowledge exchange by holding tri-lateral workshop annually, which has effectively promoted the exchange of both technology foresight exercises and related policy studies addressing also sustainability and security issues in three countries, and further attract more attentions from decision-makers. Besides, the international/national conference on technology foresight has played important role in attracting diversified stakeholders to participate in the foresight exercises. For example, three leading research institutes in the fields of technology foresight in China jointly hold a series of national conferences on technology foresight, which promote the knowledge transfer concerning technology foresight and result in many new exercises in regional levels such as Guangdong, Tianjin and Yunnan, etc, finally draw more attention from decision-makers. Now, FTA activities, namely foresight, in China, Japan and Korea have been regarded as important tool for making science and technology as well as innovation policy, both in national level and regional level.

Fundamentally, FTA activities can build capacities and capabilities to understand and act upon the challenges of sustainable development and security assurance. Here, the important role for FTA remains to be its ability to create a forum or common platform for different kinds of stakeholders to discuss present conditions and future challenges. Furthermore, the systematic application of FTA methods is likely to play an important role also in the future.

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