Paper title: Grand challenges – a new framework for foresight evaluation?

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1. Introduction

A new mission seems to emerge for the EU research and innovation policy. The focus that is increasingly gaining importance at the EU level refers to dealing with the so-called 'global' or 'grand' challenges. These comprise challenges in in relation to environmental pollution, energy shortages, food and water shortages, implications from an ageing society, migration and so on. The EU as well as individual Member States are orienting their policies towards effectively tackling these challenges with increased emphasis on an integrated approach in research and innovation.

The nature of grand challenges presents special features highlighting the need for a multi-actor, multi-disciplinary and multi-level approach in tackling them. Foresight has a specific role to play in this regard as it can facilitate such approaches in analysis and policy-making. Foresight can produce high quality and relevant anticipatory intelligence for policy – making promoting multi-disciplinarity and creativity. At the same time, it can facilitate collaboration and alliance building among multiple-actors and it can enlarge the pool of stakeholders involved through active public engagement.

Within this framework, it is worthwhile to examine the role of foresight in accommodating the special needs in dealing with grand challenges. Even more, it is meaningful to examine whether special conditions or factors can be set for foresight exercises to be successful in contributing to dealing with grand challenges and in turn to build an evaluation framework based on these conditions.

This is the aim of the present paper. In turn, the research questions addressed are
- What are the main factors associated with the nature of grand challenges that should attract attention in designing and implementing foresight with the purpose of dealing with grand challenges?
- Accordingly, what should be the special features of a foresight programme in dealing with grand challenges?
- Can an evaluation framework be designed for assessing actual or potential contribution of foresight programmes in dealing with grand societal challenges?

Following the above research questions, section 2 specifies the special features of grand challenges when put forward as policy for policy intervention. Before answering how foresight can meet these special needs the main roles and functions of foresight are briefly introduced in section 3. Section 4 then examines the relevance of possible

foresight impacts with the necessary elements in dealing with grand challenges while section 5 focuses on building a foresight evaluation framework corresponding to the special needs in dealing with grand challenges. This is mainly based on establishing the relevance of foresight roles and functions and consequent impacts to grand challenges and by translating the special needs of grand challenges into evaluation criteria based on the internal and external factors influencing the course and success of foresight exercises. The last section (6) summarises the main conclusions and indicates further areas of research.

The paper is submitted for the EU-SPRI conference, Manchester 20-22 September 2012 under theme 4:
"Policy-shaping processes: role of public debates and participative democracy, developments in support tools and processes such as evaluation and foresight, evolving views on implementation structures (and in particular funding agencies)"
It will discuss evolutions in foresight design and assessment in order to put foresight in the service of the latest high-level EU policy aim, that of dealing with grand challenges.

2. The special nature of 'grand challenges'

The main focus of the latest EU policy in research and innovation, as expressed by the Europe 2020 Strategy[1] and its Innovation Union[2] Flagship Initiative, is on effectively dealing with the so called 'major societal challenges' or 'global challenges'. These refer to challenges such as environment and climate change, over-exploitation of natural resources, energy and water scarcity, and implications from an ageing population.

These challenges present special features and requirements when put forward as rationales for policy intervention. First of all, their nature is complex and difficult to describe while also highly inter-related (Boden et al. (2010). In this regard they require a multi-disciplinary approach in finding possible solutions engaging different knowledge bases and combining both 'hard' and social sciences and humanities (Cagnin, et. al. 2011). Multi-disciplinary research needs to be facilitated. However, existing programmes supporting research at European level face several limitations in achieving the necessary flexibility, scale, creativity and cross-disciplinary research needed to tackle grand challenges, (Annerberg, 2010) although this may be true to different degrees across the different research themes.

Secondly, the global nature of grand challenges is also characteristic. It is increasingly acknowledged that today's challenges cannot be addressed by governments, corporations, NGOs, universities and intergovernmental bodies acting alone (Millennium Project, 2007). This affects the type of actors needed to embark on taking action in dealing with them. International actors and the ability and willingness to delegate power at the international level are crucial in this regard.

At the same time, the coordination of efforts at all levels of governance, i.e. international, the national and regional, is of equal importance to deal with challenges that cross national borders. Under this framework joint programming initiatives among Member States have been gaining importance. As the Europe 2020 Strategy notes, a partnership

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[1] COM(2010) 2020, Brussels, 3.3.2010
[2] COM(2010) 546 final, Brussels, 6.10.2010

approach is needed that should extend to EU committees, to national parliaments and national, local and regional authorities, including also social partners and civil society. (CEC, 2010)

Following this approach several new policy coordination initiatives have been designed alongside older ones at European level. These include for example the Joint Programming Initiatives (JPIs)[3], the Knowledge and Innovation Communities (KICs),[4] or the broader concept of The European Innovation Partnerships (EIPs) introduced in the Innovation Union Flagship Initiative (CEC, 2010). These new initiatives are called to tackle the short-comings of older tools in attracting and engaging stakeholders like businesses (Annerberg, 2010), and in coordinating national and local research and innovation policies towards joint goals (Idea Consult, 2010).

At the same time, grand challenges are also seen as opportunities for development calling for an integrated approach to research and innovation for their exploitation (European Commission, 2010). This implies certain factors that have to be accommodated to enable innovation generation. Innovation generation is dependent on collaboration and networking (Archibugi, D., Lundvall, B., (edit), 2001), knowledge diffusion across boundaries of cognitive objects, disciplines and backgrounds (Fischer (2005) and complementary competences within alliances based on mutual interests and benefits.

A third major feature of grand challenges is that they cannot be tackled with technological solutions alone. Dealing with the specific grand challenges requires broader changes in human perceptions and behaviour, norms and values of societies as well as social innovations promoting non-technological solutions. (Cagnin, et. al. 2011) In fact, the nature of grand challenges call for the concept of 'transformative and responsible innovation' to radically change the currently unsustainable practices and to aim beyond profit and economic competitiveness to safeguard social and environmental goals (Depledge, et. al., 2010).

Overall, grand challenges stress the importance of multi-disciplinary research, a multi-actor approach in examining current state of affairs and exploring possible solutions, multi-level governance and policy coordination across geographical boundaries and the numerous affected policy areas, as well as an environment enabling research and innovation generation and exploitation both in science and technology and society.

3. Key foresight roles and functions

The special needs of grand challenges point to certain conditions that have to be in place to facilitate dealing with them. Can these factors be enabled by foresight practices, outputs and impacts? This is the main question underlying the present paper. However, before answering how foresight can meet the special needs identified above and how such a contribution can be assed it is important to briefly introduce the main roles, functions and impacts of foresight exercises and discuss their relevance to meeting the needs of grand challenges.

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[3] http://ec.europa.eu/research/era/areas/programming/joint_programming_en.htm
[4] http://eit.europa.eu/kics1/knowledge-and-innovation-communities/overview.html

Several scholars have written about the roles and functions attributed to foresight depending on its rationale or the envisaged impacts on policy making or the issues and stakeholders addressed. A consensus seems to emerge on three major functions that are usually cited, i.e. the functions of 'informing policy', 'facilitating policy implementation' and 'embedding participation in policy-making'.

According to Da Costa, et. al. (2008) 'informing policy' refers to the supply of anticipatory intelligence including also visions for change and possible options, and transmitting them to policy-makers in order to improve the knowledge base for policy conceptualisation and design. Central to the first function of foresight is the improvement of the knowledge base for thinking about and designing policy as well as the provision of a wide range of new ideas stemming from a creative process activating a diverse range of sources.

The 'informing policy' foresight function directly relates to the first rationale as identified by Georghiou, et. al. (2008), i.e. 'directing or prioritising investment in science, technology and innovation'. Apart from the first rationale this function also encompasses the other rationales in Georghiou, et. al. (2008) typology that relate to information and knowledge, i.e. 'providing anticipatory intelligence to system actors' and 'increasing understanding about the future' under the third rationale, and 'informing policy and public debates' under the fifth rationale. Warnke and Heimeriks (2006) refer to this function as one of the main modes of policy support.

'Informing policy' is not limited to providing anticipatory intelligence but can also extend to support policy making with specific forms, like 'agenda setting'. 'Agenda setting' is thus more a process or mode of policy support that can result from the 'informing policy' foresight function, rather than a distinct function itself as advocated in Warnke and Heimekis (2006).

The 'informing' function of foresight also relates with the first key objective underpinning most national foresight exercises as reported by Loveridge, et al. (2001), i.e. to inform national science, technology and innovation policy planning by providing guidelines that can be used for priority setting.

The second key foresight objective is to encourage long-term strategic thinking amongst a wide range of actors (Loveridge, et. al. 2001). This objective can refer to the second major foresight function, i.e. 'facilitating policy implementation'. Central to the second function is developing shared visions and building commitment across diverse interest groups. The second function reflects the value of the foresight process itself in creating linkages, interfaces, knowledge flows and networks across diverse groups of people or organisations and thus improving the implementation of policies. (Da Costa, et. al. 2008)

This function relates to the rationale of 'building new networks and linkages around a common vision' as presented by Georghiou, et. al. (2008). It also addresses elements from other rationales especially those related to collective learning enabled through networking, i.e. 'changing mindsets about the future' and 'building future visions' (from the third rationale) and 'enabling informed buy-in to decision-making processes' from the fifth rationale.

'Facilitating policy implementation' is also associated with the mode of policy support, 'foresight as systemic innovation policy instrument'. As Warnke and Heimeriks (2006) note, by establishing linkages between actors and providing platforms for joint learning,

foresight helps to improve the ability of the system to react to changes and thereby to initiate and keep up innovation processes. In a similar vain, this function links with the third key objective of most national foresight exercises (Loveridge, et al. 2001). This objective involves encouraging the development of better innovation systems, by improving co-operation and strengthening relationships and partnerships through the development of networks between business, science and government officials.

The third function is 'embedding participation in policy-making' by facilitating the participation of civil society in the policy-making process. This function regards the value of foresight in improving governance by supporting inclusiveness and thus increasing transparency and legitimacy. The third foresight function is closely related to the second as the involvement of a diversity of stakeholders in intelligence gathering and vision building also improves the legitimacy of the policy-making process. (Da Costa, et. al. 2008)

The third function directly relates to the forth major rationale of Georghiou, et. al. (2008) i.e. 'bringing new actors into the strategic debate' the anticipated outcomes being broadened participation and democratic renewal (Georghiou and Keenan, 2006). As Barré (in Tübke, et. al. 2001) notes, democracy in a knowledge society is rooted in the existence and quality of the interactive processes linking a wide variety of actors. The so-called 'social process' model of foresight can contribute to bringing these processes closer to decision-making procedures albeit with certain risks and limitations in practice.

The foresight function 'embedding participation in policy-making' can also associate to Warnke and Heimeriks' (2006) second mode of policy support, 'foresight orienting innovation towards societal needs'. As they note the forum for exchange can serve discussions between demand and supply perspectives and in this way foresight can orient innovation towards societal needs and future users' demands. In this regard, it also relates to the key objective of Loveridge, et. al. (2001), 'development of better innovation systems'.

Da Costa, et. al. (2008) separate another foresight function related to 'reconfiguring the policy system'. They argue that foresight exercises can challenge the departmentalised or 'compartmentalised' government structures with the cross-cutting, multi-dimensional issues addressed and the consequent need to overcome fragmentation in structures, sources and perspectives. Thus, foresight may contribute to reconfiguring the policy system by supporting reflexivity and learning within complex governance systems to adapt to changing context and challenges. Notwithstanding the importance of such a role, it is more suited conceptually to consider it as a wider foresight aim and consequent impact primarily linked to the 'facilitating' but also 'embedding' function rather than as a separate function in itself.

Summarising, the three main foresight functions can be renamed and described as follows to reflect their correspondence with the different rationales, objectives and modes of policy support.
- Function 1: 'Informing and directing policy planning' through extended / improved knowledge and improved capacities in strategic thinking;
- Function 2: 'Facilitating decision-making and policy implementation' through platforms for interaction / joint learning and strengthened ties, alignment and mobilisation of actors around shared visions;

- Function 3: 'Embedding more stakeholders' views in policy-making' through increased & more diverse base of actors involved in decision-making.

These three functions are not excluding each other. Yet, each one is differentiated from the others by specific features that are of more crucial importance to them than the other functions. The first function primarily aims at supplying anticipatory intelligence in directing policy. This may indeed be an aim of the two other functions as well. The differentiating feature here is that the primary focus is the production and provision of anticipatory knowledge itself. The emphasis is not on the networks and coalitions built in producing and implementing it (which is the focus of the second function) nor on bringing new and diverse actors in the debates in improving inclusiveness, transparency and legitimacy (which is the focus of the third function).

The emphasis of the second function in on the networks, strategic partnerships and coalitions built around shared future visions and the consequent collective learning taking place within them. Facilitating networking also helps embed more stakeholders' view in policy – making, thus making the second and third functions look similar. However, it is the diversity of the actors engaged as well as the primary focus in improving governance by supporting inclusiveness, transparency and legitimacy that differentiates the third function from the second. In reality foresight programmes usually serve more than one functions at the same time but to different extents.

**Table 1: Main foresight functions with associated rationales, and objectives**

Function	Rationale	Key objectives
Informing and directing policy planning through extended / improved knowledge and improved capacities in strategic thinking.	- Informing funding & investment priorities - Eliciting research and innovation agendas - Reorienting science and innovation systems - Benchmarking national science and innovation systems - Raising the profile of science and innovation to attract investments - Providing anticipatory intelligence to system actors - Increasing understanding about the future - Informing policy and public debates	Extending breadth of knowledge about future, supplying strategic anticipatory intelligence, building capacity and framing knowledge into policy-support.
Facilitating decision-making and policy implementation through platforms for interaction / joint learning and strengthened ties, alignment and mobilisation of actors around shared visions.	- Building networks / coalitions around shared problems - Building trust among actors unused to working together - Aiding collaboration across administrative / epistemic boundaries - Highlighting inter-disciplinary opportunities - Changing mindsets about the future - Building future visions to help system actors chose develop. paths - Enabling informed buy-in to decision-making processes	Collective knowledge creation and learning, aligning and mobilising actors around shared visions, strengthening inter-actors' relations, and nurturing a foresight culture.

Embedding more stakeholders' views in policy-making through increased & more diverse base of actors involved in decision-making.	• Increasing number / involvement of system actors • Extending range of types of actors in decision-making	Bringing new actors in strategic debate, providing social forums for strategic reflection, debate and action and improving governance by supporting inclusiveness, transparency and legitimacy.

Da Costa et. al. (2008) also cite a symbolic function for foresight underlined by the wish of policy-makers to signal to the public a rationally-based decision-making process that leads to legitimate and publicly - accepted results. However, a symbolic use of foresight can be a characteristic of any foresight functions, rather than a function in itself. Another type of separation of foresight functions is according to their 'formality'. While those described above (cf. Table 1) can be considered as 'formal' or 'primary' functions, there are also 'informal' or 'secondary' functions happening in parallel. 'Secondary' functions can be for example associated to learning, skills development, development of a foresight culture, identification of blockages to success, or shifting the stakeholders' mind to think a different way either in terms of evolutions (disruption scenarios, bio-economy, knowledge-based economy) or in terms of practical things about the policy-processes that have to be put in place. Such 'secondary' functions may be appearing within any 'primary' foresight function.

Instead of being isolated the foresight functions should be linked to each other. For instance the third function of 'embedding more stakeholders' views in policy-making' should be linked with the other two functions to reflect the importance of engaging a wider set of stakeholders in any foresight exercise. On the other hand, 'informing and directing policy' is strongly linked with the other functions as this can be a major aim of any foresight exercise. Overall, the three functions are interrelated because of the above inter-linkages as well as because in reality foresight programmes have elements of all foresight functions although to different extents.

Figure 1: Inter-relations of the main foreight functions
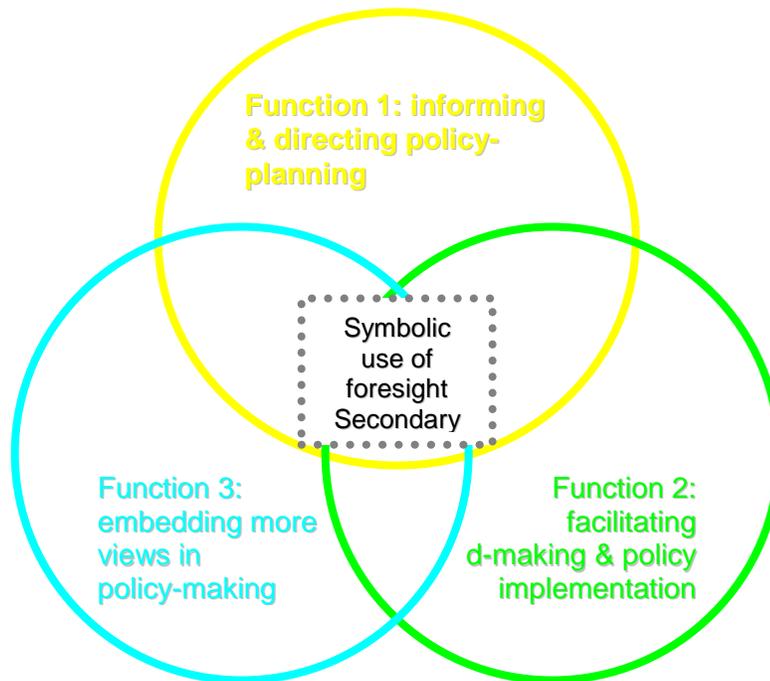
4. Relevance of foresight impacts to grand challenges

The three major foresight functions presented above lead to certain types of impacts a shown in the following table (Amanatidou, 2012). As in reality the functions are intersecting each other, some overlap and complementarity also exists in impacts across the different functions.

Table 2: Foresight impacts classified per foresight function

Function: Informing and directing policy planning through extended / improved knowledge and improved capacities in strategic thinking.	
Improved knowledge base about future: • Better understanding of strengths, weaknesses, opportunities, threats and dynamics of change • Assessment of existing strategies and policies • Increased awareness of risks - effective contingency planning • Detection and analysis of weak signals Framing knowledge into policy support: • Disclosure of hidden agendas and obstacles	• Agenda setting • (Funding / investment) priority setting • Better informed strategies and policies Capacity building: • Increased experience in using foresight tools • Use of foresight within organisations / other settings • Strategic thinking / vision building capabilities

Function: Facilitating decision-making and policy implementation through platforms for interaction / joint learning and strengthened ties, alignment and mobilisation of actors around shared visions.	
Collective learning and knowledge creation: • Knowledge flows across diverse groups • Breaking of boundaries (geographical, institutional, or disciplinary) • Development of shared visions **Foresight culture development:** • Stimulation and inspiration to apply foresight • Strategic thinking capabilities • Capacity to engage in foresight • Increased involvement in foresight activ. • Thinking out of the box • Challenge of mindsets **Improved decision/policy-making:** • Better management of pressures and challenges	• Enabling buy-in to decision-making processes • Disclosure of conflicts / self-reflecting among actors • Alignment and commitment to shared visions **Improved system actors and inter-actor relations:** • Trust building between system actors • Improved communication and collaboration • Links / networks across diverse groups • Empowerment of (new) actors • New networks and strengthened communities • Enhanced reputation and image **Improved policy systems:** • Reconfiguration of policy systems / bodies • Overcome of path dependency and lock-ins • Improved coherence of policies
Function: Embedding more stakeholders' views in policy-making through increased & more diverse base of actors involved in decision-making.	
Strengthened role of society 4. Intensification of public debate 5. Deepening of dialogue with society 6. Building of policies on societal debates 7. Orientation of innov. to societal needs 8. Development of societal actors' identities	Improved governance 9. More transparent, open, participatory, legitimate processes to governance 10. Broadened participation – democratic renewal

Source: Amanatidou, 2012

The contribution of foresight in dealing with grand challenges can be examined through the foresight impacts based on the outputs as well as processes. Based on the envisaged impacts some correspondence can be identified with the special needs in dealing with grand challenges as presented in the following table. The first function primarily aims at supplying anticipatory intelligence in directing policy. This function relates to the knowledge component of the needs of grand challenges and specifically the need for a multi-disciplinary approach in providing anticipatory intelligence in identifying emerging challenges and in finding solutions. It is the impacts related to the 'improved knowledge about the future' that are more relevant in this regard.

The emphasis of the second function is on the networks and coalitions built around shared future visions and the consequent collective learning taking place within them. This directly relates to the networking and alignment element in dealing with grand challenges and promoting innovation. Specifically, it is the need for a multi-actor approach in examining current state of affairs and exploring possible solutions that is mainly addressed here alongside the importance of creating diverse networks in generating innovation. The need for policy coordination across multiple levels of governance (regional, national, international) and policy areas can also be addressed by the specific foresight function as it also aims at improved policy systems and configurations.

The third function relates to the diversity of actors engaged as well as improved governance by supporting openness, transparency, legitimacy and increased public participation. This reflects the importance of social changes and innovation needed in dealing with grand challenges calling for more inclusive processes in governance.

Table 3: Relevance of foresight impacts to the special needs of grand challenges

Foresight functions	Impact types	Grand challenges needs
Informing and directing policy planning through extended / improved knowledge and improved capacities in strategic thinking.	Improved knowledge base about future Framing knowledge into policy support Capacity building	Multi-disciplinary approach in research and exploring possible solutions
Facilitating decision-making and policy implementation through platforms for interaction / joint learning and strengthened ties, alignment and mobilisation of actors around shared visions.	Collective learning and knowledge creation Foresight culture development Improved decision/policy-making Improved system actors and inter-actor relations Improved policy systems	Multi-actor approach; Multi-level governance; Policy coordination; Research and innovation generation & exploitation
Embedding more stakeholders' views in policy-making through increased & more diverse base of actors involved in decision-making.	Strengthened role of society in public policy-making: Improved governance with open and transparent procedures	Social changes and innovations More participatory governance

In turn the specific grand challenges' needs can be translated to specific factors and principles that foresight exercises should enable and abide by in contributing to dealing with grand challenges. These will then form the main principles that a foresight evaluation framework can be based on as discussed in the following section.

5. Building a foresight evaluation framework corresponding to the special needs in dealing with grand challenges

Several scholars have argued that in conceptualising and evaluating foresight, it is better to examine it as a system (Saritas, 2004; Amanatidou and Guy, 2008). Foresight has to be seen as a system comprised of a number of basic elements, namely 'actors', 'processes', 'inputs and outputs', and 'objectives'. These elements form the 'foresight internal factors' influencing the course of foresight exercises. In turn, the foresight system's interaction with the wider environment has to be studied in order to identify the 'external' factors affecting the success of the whole process. These comprise factors such as the 'institutional context', 'structures and state of innovation systems, 'socio-cultural', and 'governance' features (Amanatidou and Guy, 2008).

It is the specific qualifications of these factors as well as their inter-relations that develop in a foresight exercise that influence its course and success in impact delivery.[5] In building a foresight evaluation framework to examine the contribution of foresight in

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[5] For an example of how these factors influence the success of foresight exercises see Amanatidou, 2012.

dealing with grand challenges it is important to examine the relevance of the special needs of grand challenges to the foresight internal and external factors. This is done in the following figure and explained below.

Figure 2: Relevance of grand challenges' needs to foresight factors

| Foresight internal factors | Grand challenges needs | Foresight external factors |
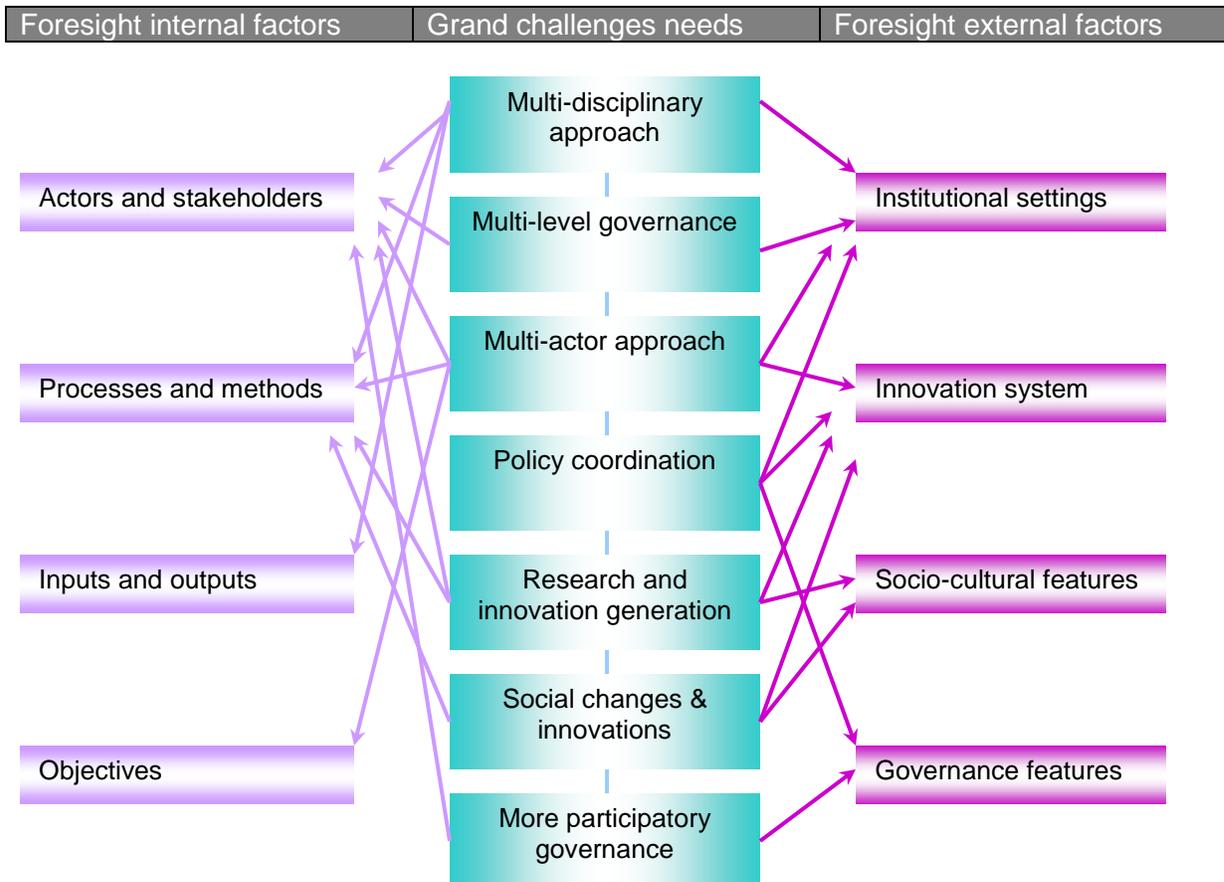
From the foresight internal factors it is evident that the 'actors' and 'processes / methods' relate to most of the needs implied in dealing with grand challenges. In terms of the external factors, the institutional settings and structure and state of innovation systems are the elements that seem to influence more the degree to which grand challenges can be dealt with through foresight exercises.

While foresight can determine its internal factors it can hardly control the external factors, although foresight exercises do affect the wider environment in which they occur. Thus, while the internal factors can be turned into criteria for evaluating foresight, the external factors can only be used to explain possible success or failure of foresight exercises. Below follows a discussion on how the needs of grand challenges translate into foresight internal and external factors.

The multi-disciplinary approach in research and examining possible solutions has to be reflected in who is involved in the foresight exercise (actors and stakeholders) and how, i.e. the processes and methods applied have to enable multi-disciplinarity in using

relevant inputs and producing outputs covering multiple perspectives. The relevant literature suggests that apart from the 'usual' suspects (either supply or demand side organisations) the involvement of social scientists into the stakeholder mapping phase of foresight might be useful in ensuring diversity and a complete examination of all possible alternatives. (Warnke and Heimeriks, 2006). Overall, the actors and stakeholders initiating and called to participate in a foresight exercise have to reflect the inclusiveness and diversity demanded by grand challenges also in terms of multi-level governance, different policy areas as well as types of stakeholders including societal actors to facilitate more participatory governance.

Adding to these principles political will and high-level commitment is also crucial (Saritas, 2004; Georghiou, 2001) as is the degree of interest and the adsorptive capacities of the 'clients' in the foresight exercise and its results (Havas, et. al. 2007) The collective mindset and capacity of the thinkers to be engaged in the foresight process are equally critical and have important impacts on the relevance, quality and speed of the exercise (Cassingena-Harper, J., Pace, G., (2007)

Foresight effects also depend upon wide participation, and deep interactions (Georghiou, 2001). Processes and methods are important to promote active engagement and systematic interactions. Available literature stress that methods have to take account of the problems dealt with, be adapted to the questions that need to be asked and be matched to the objectives of the programme. (Loveridge, et. al., 2001). At the same time, it is key to ensure that genuine consultation is practiced, feedback is sought and acted upon, and that processes are not restricted to a top-down, one-way flow of information or a token soliciting of opinions on decisions already taken. (Clar, et. al. 2008)

Matching the need of grand challenges, the literature also highlights that in relation to inputs and outputs, the primary concern of foresight should be a diversification of expectations and visions. Visions and expectations need to be as rich on the side of society as on technology. (Warnke and Heimeriks 2006) Scholars mark the importance of creativity and inter-disciplinarity in terms of integration of different perspectives, sectors, disciplines as well as their relationships with the society. (Saritas, 2004) The quality of the futures do matter but in contrast to traditional forecasting techniques, the most important aspect for quality is not their validity, but their creativity and the extent by which they transcend existing beliefs and innovation patterns. (Van Der Meulen, et. al., 2003) The selection of the appropriate foresight process and tools are critical in the solution context and creative thinking plays a key role in aligning process and tools with the current and envisaged context. (Cassingena-Harper, J., Pace, G., (2007)

At the same time the multi-actor approach implies different and possibly diverse objectives. In this regard it is important for the objectives to be clearly set and communicated from the outset (Loveridge, et. al. 2001). Some common ground needs to be identified in case of multiple objectives. Experience has shown that prior engagement of all stakeholders in agreeing on the programme aims and methods is a good way to avoid insuperable problems due to diverse interests and expectations (Cassingena Harper and Georghiou, 2005). Overall, the questions to answer have to be clearly defined; the policies and strategies that will be informed have to be agreed with the relevant stakeholders; and ambitions have to be realistic. (Office of Science and Innovation, 2005)

The diversity of actors involved and the degree to which methods are combined drawing on expertise, creativity and interactions affect the potential for innovation generation inside the foresight exercise. Innovation generation is also affected by the external environment with the state of innovation system and the wider socio-cultural environment promoting creativity and innovation. (Rooney, D., et.al, 2003)

The external factors affecting foresight exercises are equally important. Barré and Salo (2002) believe that the main reason why foresight projects have failed is due to inaccurate analyses of the socio-political context in which they were undertaken rather than due to methodological problems although this may play a role, too. They stress the importance of recognising the sensitiveness of the design of foresight to different cultures, to different rationales of decision-making scenes. Havas, et. al. (2007) agree that the actual effectiveness of foresight depends to a significant extent on its neat embedding in the innovation system and innovation policy context ('contextualisation') and they highlight the importance of four important dimensions of this contextualisation: governance culture, policy attention, socio-economic dynamics, and resource availability.

The institutional settings in national contexts as well as at the international level determine the type of actors to be involved as well as the degree to which they will be able to collaborate and coordinate with each other depending on existing fragmentation (Arnold, et. al., 2005). This is relevant for grand challenges in ensuring a multi-disciplinary and multi-actor approach as well as multi-level coordination across different policy areas.

The structure and state of the innovation system, on the other hand, determine innovation performance at the national or international levels as well as the degree to which different policies are inter-linked and can thus be coordinated.

At the same time the socio-cultural features towards change can determine the degree to which the social changes needed by grand challenges are feasible. Elements of the socio-cultural environment that may affect the course of foresight exercises and feasibility of social change is public trust in national and international institutions, or existing traditions in relation to public engagement (Barré in Tübke, et. al. 2001) as well as a culture promoting innovation and creativity (Rooney, D., et.al, 2003.

Existing governance features and the extent to which wider public engagement is or can be promoted is another factor that affects the inclusiveness needed in dealing with grand challenges. The policy making culture is also characterised by the role of organised interests and the public awareness or level of social debate about the issue at stake. Domination of decision making by a particular group or a coalition of groups restricts the openness for adoption of knowledge, and, policy options. High levels of public awareness and public involvement in technology policy might present a counterbalance to organised interests and enhance the role of technology assessment. (Ladikas and Decker, 2004) These elements are especially relevant in the energy field for example where the unsustainability of current solutions demands changes in social behaviour and consequently breaking of specific path dependences and vested interests.

The style of public debate about the issues at stake can also affect the course and effectiveness of activities in the technology assessment and related fields. A highly controversial style of public debate on technology with well organised interest groups

and intransigent positions and stakes may prove to be a less favourable environment than a more open and disinterested style of debate, or vice versa. However, this may vary not only from country to country, but also from issue to issue within a country. (Klüver, et. al. 2000).

Given that grand challenges are of global nature, the above factors have to be examined both at the national as well as the international levels, i.e. depending on the international institutions that are relevant to be involved. Based on the above, the following principles can be set for the foresight internal factors which can act as evaluation criteria for foresight exercises. At the same time the qualifications that the external factors should have are specified in enabling contribution to the special needs of grand challenges

Table 4: Foresight principles in contributing to dealing with grand challenges

| Foresight internal factors / principles	Foresight external factors
Actors: 1. Relevance of types of actors to the nature of grand challenge (international, national, ability to take action); 2. Degree of high-level political support/commitment at national / international levels; 3. Fragmentation of participating institutions at the national / international levels.	Institutional context 1. Inter-institutional configurational relations; fragmentation among institutions in policy system at national / international levels.
Processes & Methods 1. Accordance/ relevance to problems, objectives and special features of grand challenge; 2. Degree methods draw on experience/expertise/creativity/interactions; 3. Transparency, openness and inclusiveness of processes.	Structures / state of innovation system 1. Type / state of innovation system and performance at national / international levels; 2. Promotion of new ideas and experiments on political agendas at national / international levels.
Inputs & Outputs 1. Scientific rigor, reliability, multi-disciplinarity, creativity richness of perspectives;	Socio-cultural context 1. Tradition (type and extent) of public engagement in relevant processes at national / international levels; 2. Degree of public trust in national / international institutions; 3. Culture encouraging creativity/innovation;
Objectives & Background 1. Clear, non-divergent objectives; clear communication of objectives;	Governance 1. Degree governance promotes public participation at national / international levels; 2. Public awareness on issues examined and style of debate; role of 'vested interests';

These principles can then form the evaluation criteria against which foresight exercises can be assessed in contributing to dealing with grand challenges. It has to be noted however that the external factors cannot be determined by foresight a priori but nevertheless can be influenced during and after a foresight exercise occurs.

As a result an evaluation framework can be built focusing on how internal and external factors translate to reflect special needs and conditions in dealing with grand challenges. The evaluation approach is set by the following assumptions:

- The possible foresight contributions / impacts to dealing with grand challenges presuppose certain foresight rationales and functions;
- The special needs of grand challenges translate into special foresight internal and external factors;
- These factors can be turned into specific principles against which foresight exercises can be assessed.

Starting from the relevant foresight rationales and aims we proceed to functions, which can lead to relevant impacts, provided that the right factors are in place corresponding to the special needs of grand challenges. Thus, rationales, functions, impacts and needs are combined in a cycle underlined by the specific internal and external conditions or foresight principles for dealing with grand challenges. An illustration is attempted in the following figure.

Figure 3: A foresight evaluation framework in dealing with grand challenges
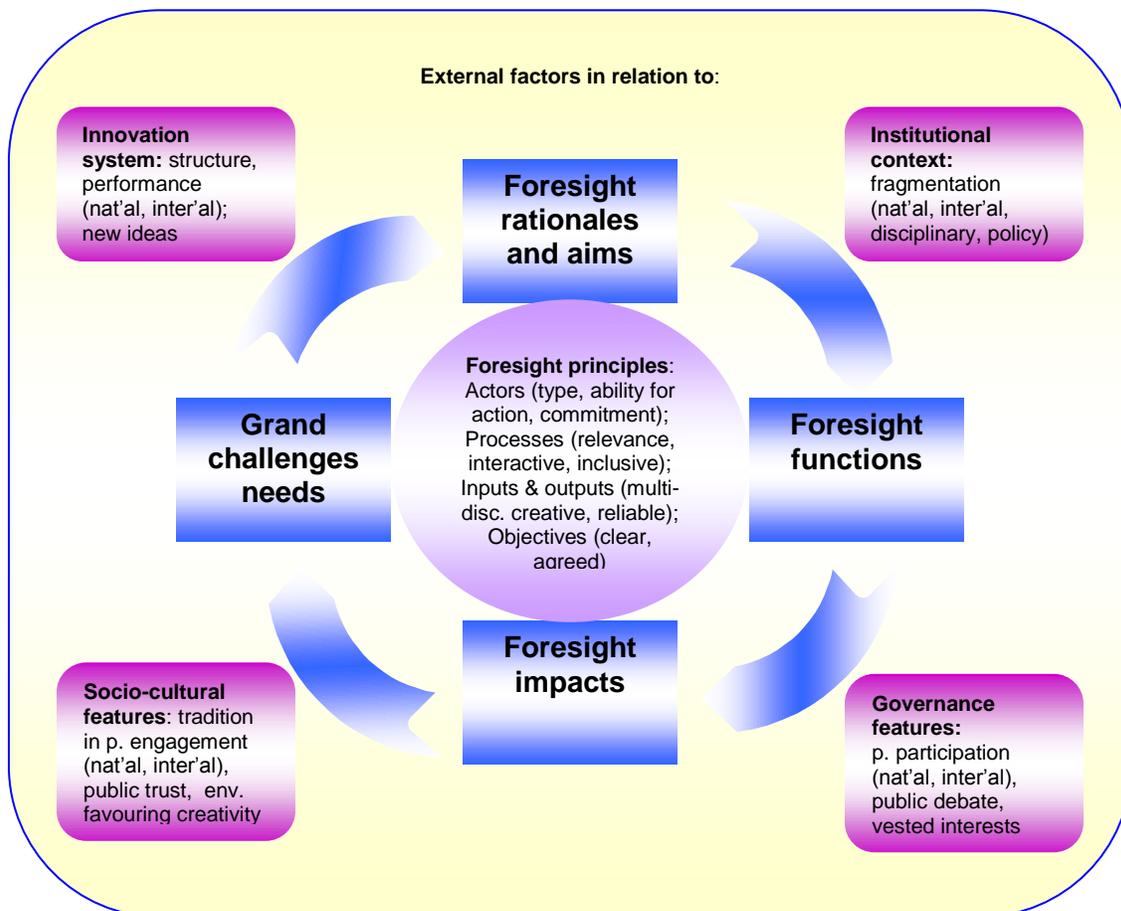
Apart from the evaluation criteria it is important to define the evaluation issues that underline the evaluation approach. Certain attempts have been made to set up evaluation criteria for foresight evaluation. Georghiou and Keenan (2006) point to three types of evaluation issues: accountability, with questions such as whether the activity was efficiently conducted and proper use made of public funds; justification, with questions such as whether the effects of foresight justify its continuation and extension; and learning, asking how foresight can be done better in particular circumstances.

The authors also point out that evaluation issues should also be adjusted to the role of the specific foresight exercise. If foresight is aimed at correcting an inherent tendency to have excessively short-term horizons and a difficulty in forming new networks around technologically and socially innovative activities, then it may be best evaluated in terms of its ability to change values and behaviour in these directions. This seems particularly relevant to the need for social change in dealing with grand challenges. Thus, the evaluation issue of 'behavioural additionality' becomes important when evaluating foresight in terms of dealing with grand challenges as it acknowledges the importance of behavioural and social change. This makes imperative the exploration of the interactions of foresight outputs with the strategic behaviour of participating actors and the understanding of the other influences upon strategic decision-making.

In addition another type of additionality also seems relevant for foresight evaluation in dealing with grand challenges. This is the 'cognitive capacity additionality'. 'Cognitive capacity additionality' reflects any change in the different dimensions of the cognitive capacity of an agent caused by policy action. It is linked with the notions of output additionality (depending on physical devices and knowledge that may be outputs of the activity itself) as well as behavioural additionality in the sense that changes in behaviour of organisations are intrinsically linked with the modification of their knowledge base and the cognitive capacity generated by a (state-supported) activity. Furthermore, it is worth noting that as it is difficult to define all dimensions of and changes in cognitive capacity it is difficult to put this concept into practice. Some important dimensions could concern the absorptive capacity of an agent, its ability to master the codes used to articulate the existing and emerging knowledge, or its capacity to interact with its environment. (Georghiou, et. al. (eds.), 2002)

Both the notions of 'behavioural' and 'cognitive capacity' additionality are relevant for foresight evaluation. The former can address any changes in the behaviour of agents caused by foresight performance either during or after the programme ends, thus enabling examination of anticipated impacts that may appear in the long-run. The latter directly links with the value of knowledge in terms of the social configurations responsible for producing and using it and also in terms of the multi-disciplinarity needed for dealing with grand challenges.

6. Conclusions

Grand challenges emphasise the importance of multi-disciplinary research and multi-actor approach in responding, engaging a wide range of stakeholders, multi-level governance as well as policy coordination and coherence across the numerous affected policy areas. They point to implications stressing the importance of actors' alignment, alongside active public engagement. Additionally, the integrated approach to research

and innovation advocated in the latest EU strategic orientation in dealing with grand challenges, gives priority in fostering innovation generation and exploitation.

Available literature suggests that foresight can indeed address and cover the special needs of dealing grand societal challenges. Grand challenges place specific requirements on foresight exercises in terms of actors (to achieve multi-actor engagement), processes and methods enabling interactions (to achieve networking and alignment), inputs and outputs (to enable identification of challenges and achieve multi-disciplinarity and innovativeness in finding solutions). At the same time, addressing grand challenges is affected by the external environment and specifically the 'institutional context' both at international and national/regional levels, 'structures and state of innovation systems, as well as 'socio-cultural', and 'governance' factors.

Given the relevance of foresight functions (and consequent impacts) to the special needs of grand challenges, a special evaluation framework can be designed to assess the contribution of foresight in dealing with grand challenges. This can be done by establishing the relevance of foresight roles and functions and consequent impacts to grand challenges and by translating the special requirements in addressing grand challenges into specific evaluation criteria based on the internal and external factors influencing foresight exercises.

From the evaluation issues usually applied in foresight evaluation, behavioural and cognitive capacity additionality seem to be particularly relevant in dealing with grand challenges. The former underlines the importance of behavioural and social change much needed in dealing with grand challenges, while the latter puts emphasis on the development of cognitive capacities and the value of knowledge.

While a first attempt has been made to define a foresight evaluation framework corresponding to dealing with grand challenges, it is important to further examine the special features of grand challenges. The complexity and inter-relatedness of the challenges needs to be understood and thoroughly investigated. A detailed examination of the special features of each challenge also needs to inform the evaluation framework as suggested in the present paper.

Given the multiple functions and impacts that foresight can have, further research would also be wise in relation to the role that foresight can have in the EU and national initiatives oriented towards dealing with grand challenges. It is mainly the informing function of foresight that is being addressed in these instruments rather than its role in mobilising actors or in enhancing capabilities. (Cagnin, et. al. 2012)

Last but not least, dealing with grand challenges needs a cross-national response. However, multi-level governance practices, instruments and actors are the exception rather than the rule. It would be interesting to define what needs to be accomplished at the local / national level and at the cross-national / international levels and examine how foresight can contribute to identifying appropriate actors and set suitable mechanisms and structures. Evaluating the 'structuring' role of foresight would be a difficult but worthwhile challenge.

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