



Future scenarios to inspire innovation



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ABSTRACT

In recent years, accelerated by the economic and financial crisis, complex global issues have moved to the forefront of policy-making. These grand challenges require policy-makers to address a variety of interrelated issues, which are built upon yet uncoordinated and dispersed bodies of knowledge. Due to the social dynamics of innovation, new socio-technical subsystems are emerging, however there is lack of exploitation of novel ideas and sustainable solutions to address these grand challenges. In this paper we argue that issues of how knowledge is represented can have a part in this lack of exploitation. For example, when drivers of change are not only multiple but also mutable, it is not sensible to extrapolate the future from data and relationships of the past. This paper investigates ways in which futures thinking can be used as a tool for inspiring actions and structures that address the grand challenges. By analyzing several scenario cases, elements of good practices and principles on how to strengthen innovation systems through future scenarios are identified. This is needed because innovation itself needs to be oriented along more sustainable pathways enabling transformations of socio-technical systems.

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1. Introduction

In the context of this paper, future scenarios can be seen as narratives set in the future to explore how the society would change if certain trends were to strengthen or diminish, or various events were to occur. Future scenarios substantially differ from predictions, i.e., extrapolations or trends, substituting the criterion of plausibility for probability [1]. Scenarios are not equivalent to images of the future, but they consist of images of the future. Images of the future are snapshots of future states, whereas scenarios consist of a logical sequence of images of the future [2].

1.1. Developing and using future scenarios

Scenario analysis is practiced across many domains and is not restricted to specialized futurists or scenario specialists [3]. Developing and using scenarios can contribute at various levels of society by generating appropriate inputs for planning and decision-making and by facilitating dialogues between various stakeholders [4]. The value of the scenario exercise depends on the ways in which the resulting insights are implemented in on-going and forthcoming actions. However, the explicit and direct uses of scenarios in predefined decision-making contexts are just part of a broader social process [5]. Also important indirect and diffuse links exist between developing and using scenarios and orienting innovation systems and research priorities [6].

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Developing and using future scenarios can:

- contribute to society's strategic intelligence by stimulating future-oriented thinking and by widening the perspectives and knowledge base of researchers, policy-makers and business decision-makers.
- be useful in creating a common language and understanding between the various interest groups.
- create and support a systemized negotiation process among key stakeholders (social actors).
- be helpful in engaging decision-makers in specific issues, legitimating a chosen course of action, and supporting fruitful debates among stakeholders.

Although the use of scenarios has gained much adherence, its subjective and heuristic nature leaves many academics and decision-makers uncomfortable [7]. How do we know whether we have credible and salient scenarios? And how does developing and using scenarios lead to the expected direct and indirect inputs for orienting innovation systems? These concerns are legitimate and the use of scenarios would gain in academic standing if more research were conducted on their comparative performance and underlying theoretical premises [7]. While the scenario literature makes explicit the methodological differences and similarities of various approaches, it tends to pay little attention to the underlying epistemological assumptions [8]. For example, scenarios that imaginatively represent plausible futures will meet resistance if they are used as predictions.

1.2. Grand challenges

The aim of this paper is to initiate a discussion on how scenario analysis can help to better cope with the grand challenges and to disclose some principles by which scenario processes can inspire innovation. Today's grand challenges – from climate change to unemployment and poverty – go beyond economic and social policies [9]. Grand challenges are usually interrelated and operating at a global scale [10]. Often it is not clear what the real causes are and different policy options are competing, causing shifts in problem perception and priority setting. One result of the above described complexity is a type of uncertainty about the future, an uncertainty whose distinctive feature is disagreement among experts and stakeholders about the long-term consequences of present-day innovations [11]. In addition, uncertainty increases as policy targets move progressively further from the present and it is uncomfortable: fear of the unknown generates resistance to change [12]. But also efforts to control, manage, and engineer the future produce increased uncertainties [13]. For instance, developments in science and technology have a strong potential to influence social change. There are, however, many reasons why the practical use of scientific knowledge and technology varies widely between countries. Societies differ, just as economies, and governments deal with international scientific developments in different ways through the policies they pursue [14]. This analysis indicates that policy and systems of innovation are shaped by social, cultural and political power as well as by technological rationalism and such indeterminism makes systemic approaches to innovation policy far from linear or predictable.

The recent economic crisis reminds us of the importance of mobilizing science, technology and innovation not solely for generating economic benefits, but also for anticipating and responding to the grand challenges [15]. At a strategic level, the European Union took up this challenge via the Innovation Union Flagship Initiative as part of the Europe 2020 strategy launched in 2010. This initiative is an example of a strategic approach integrating research and innovation instruments and actors to tackle the “innovation emergency” related to the grand challenges the European Union is facing [16], p1. Futures thinking is an essential element of developing such a strategy. For example, Hamel and Prahalad [17] emphasize that strategy should draw up consistent visions of the future. In addition, several scholars state that scenarios constitute a major tool for considering the future in strategic planning [18–23].

The traditional concepts and models of innovation are not always adequate to embrace the complexity for addressing the grand challenges [10,15]. Grand challenges require that policy-makers address a variety of interrelated issues, which are built upon as yet uncoordinated and dispersed bodies of knowledge. It has been well documented that the innovation process is interactive including a multitude of short-term and long-term feedback loops between the different stages of the innovation process [15,24]. Looking at the grand challenges, innovations are not only contributing to the solutions. Innovations in the past have been also part of the current unsustainable trends. Therefore innovation research needs increasingly be oriented towards the challenges presented by environmental complexity and socio-economic turbulence [25].

In order to investigate how scenario analysis can help better cope with the grand challenges and inspire innovation, we analyze several scenario exercises to better understand the role future scenarios can play as a tool for orienting innovation systems. The remaining sections of this paper are organized as follows: [Section 2](#) sets out the methodology of how we use reflexive inquiry to analyze the scenario case studies. [Section 3](#) describes how we conceptualize inspiring issues and paradigms from different scientific disciplines such as business and innovation research, futures studies, sociology and policy analysis. These concepts and paradigms are then used to analyze the selected scenario case studies. For example, we look how the applied or perceived modes of thinking about the future and multiple stakeholder values are initiating enablers or barriers for the scenario process. In this paper we argue that this kind of reflexive inquiry can and does provide a sound basis for challenging current practice, learning from experience and better articulating our underlying theoretical premises. The outcomes of this inquiry are presented in [Section 4](#) including also implications for practitioners by elaborating elements of good practices and areas of improvement. In [Section 5](#), we further discuss our findings addressing how scenario practice can orientate innovation systems in the view of the grand challenges. Finally, in [Section 6](#) we summarize our findings and conclude with suggested points of departure for further research.

2. Material and methods

How can we learn about orienting innovation systems from future scenario practice? We use the word “practice” to describe the implementation or execution of a concept, plan, methodology or theory. Most practice is based on a set of theories or assumptions. Sometimes those theories are explicit, most often they are implicit. The connection between practice and theory (unlike that between theory and practice) has traditionally been ignored, to the detriment of both [26]. Reflexive inquiry draws on a social constructionist view of the world and provides a powerful approach that offers insights for academics and practitioners into how we constitute knowledge and realities in our thinking and research practice [27]. Reflexivity as a methodology [28] questions representation by suggesting that we are constantly constructing meaning and social realities as we interact with others and talk about our experience. We therefore cannot ignore the situated nature of that experience and the cultural, historical, and linguistic traditions that permeate our work [27]. This means that practice, such as scenario practice, is rooted in a particular moment and place.

In accordance with Cunliff [27] and to be consistent with reflexive inquiry, we first have to deconstruct scenario practice. In order to do so, three complementary questions on policy change are applied to analyze the case studies:

- (i) How can developing and using future scenarios present a window of opportunity to effectively drive decisions?
- (ii) How can developing and using future scenarios enhance the legitimacy for action?
- (iii) How can developing and using future scenarios provide evidence to decision-makers empowering the stakeholders involved?

The three questions represent a specific perspective linking action and decision-making with issues of (i) emergence, i.e. window of opportunity; (ii) legitimacy, i.e. truth claims; and (iii) empowering, i.e. stakeholder values [29]. This questioning takes then the form of a ‘turning back’ on knowledge, language, and representation to make them more transparent ([27], p.985, after Lawson [30]).

The empirical evidence is based on a sample of 17 scenario projects (see Appendix 1. for an overview of the cases). This paper reports on the reflexive inquiry that originates from several workshops with scientists and practitioners where the case studies have been articulated and analyzed in their context as part of the Cost Action A22 network.¹ In doing so, the workshops allowed for a systematic ex-post evaluation of similarities and differences between the chosen scenario projects. In the context of this paper, we will argue that this process of reflexive inquiry will provide the basis for creating new insights and adapting our underlying theoretical premises.

3. Concepts of innovation, futures thinking and scenarios

3.1. Innovation systems

Innovation involves the application of new ideas – or the reapplication of old ideas in new ways – to develop better solutions to our needs [31]. Innovation is invariably a cumulative, collaborative activity in which ideas are shared, tested, refined, developed and applied [32]. The concept of national innovation systems is rooted in evolutionary economic theorizing on socio-technical change [33–35]. The development of innovation theory over the past decades has involved a major reformulation, with innovation no longer seen primarily as a process of discovery, i.e. new scientific or technological principles, but rather as a non-linear process of learning [36]. An innovation system is never static; it evolves with alterations in the content of technologies and products as well as in the relationships among various other innovation systems. Due to the socially dynamic characteristic of innovation [37], new socio-technical (sub)systems will emerge over time [22]. By consequence, innovation systems are described as networks of actors and institutions that develop, diffuse and use innovations [38]. Hence, innovation leads to change only to the extent that agents are successful in taking advantage of the opportunities, i.e. agents need to develop capabilities [39].

Innovation in the 21st century differs from the model embraced in the last century (i.e. profit-oriented and nationally targeted) with a linear, technological and deterministic characteristic [15]. Although the innovation process is now much more open and receptive to social influences, further progress calls for a greater involvement of stakeholders who can introduce the necessary capabilities and interests in research and innovation to address the grand challenges. For instance, Hekkert et al. [40] highlight that stimulating knowledge flows (alone) is not sufficient to induce technological change and economic performance. There is a need for stakeholders to exploit this knowledge in order to create new business opportunities. This stresses the importance of stakeholders as sources of innovation.

The required characteristics of the new mode of public involvement are challenging: long-term forward-looking intervention, inter-ministerial, demand-side instruments combined and co-ordinated with supply-side instruments, based on foresight, and hence participative [15]. Our understanding of the unpredictable inter-dependency of multiple forces means that more experimental approaches to creating new solutions are necessary. Thus through trial-and-error and learning-by-doing

¹ The Cost Action A22 network was a four year program (2004–2007) entitled “Foresight Methodologies – Exploring new ways to explore the future” and funded by the Individuals, Societies, Culture and Health technical committee of the European Cooperation in the field of Scientific and Technical Research (Cost). The program was operationalized through a series of eight workshops, followed by an open scientific conference in July 2007. The main research questions were: What methodological issues are salient in relation to the identification of emerging trends and change?, How commensurable are different modes of modeling and other forms of dynamical representation? How can different communities of practice interact in an overall productive and interested way?

experiments in the policy process, new concepts and sustainable solutions can be found to grand challenges. Hence, the social dimension in innovation should be acknowledged as a legitimate research area and linkages with social systems of innovation and social innovation stakeholders should be strengthened so that innovation experiments include the inherent social dimension within the research community [15].

3.2. Futures thinking

Futures thinking is used for medium to long-term strategic analysis and planning. According to Jørgensen [41], citing Dreborg [42], there are three modes of thinking about the future, each with their own methodologies – the predictive, the eventualities and the visionary mode of thinking, see Table 1 for a more elaborate description.

As highlighted in Table 1, the different modes of thinking imply a focus on a different representation of the future. Representations of the future can be seen as metaphorical descriptions. Usually, these representations are mental images, but they can also be external representations, such as pictures or textual imagery [43].

One of the often-overlooked elements in the innovation process that hinders smooth communication and interaction within emergent networks is time [44]. Following Adam [12], time has many meanings beyond ‘clock time’. Adam argues that the meaning of time is socially constructed and that such meaning is performative. Futurists are of course used to deal with short, medium and long-term perspectives, but it has been shown that differences in the construction of time play a significant role in the construction of meaning about the future (e.g. of nanotechnologies [44]). The generic methodological requirement from this perspective is an explicit account of the construction of time within the context of the study at hand. For instance, time is considered to be historically and culturally specific. Different historical periods, different cultures, and different stages of the lifecycle all display different relationships to time. This means that situations are rooted in a particular moment and place and seen through the perspective of a certain set of lenses [45].

3.3. Scenario practice and related techniques

Reflecting the uncertain threats of the cold war, the development of scenario practice as a methodology for planning and decision-making probably started more than half a century ago in the field of war game analysis. The Rand Corporation in the US became a major center for scenario thinking and Herman Kahn, who joined Rand, explored the application of systems analysis and game theory in order to encourage ‘thinking the unthinkable’ [8]. Meanwhile in France, Gaston Berger started using scenarios to explore the long-term political and social future. He founded the Centre d’Etudes Prospectives and his approach to scenarios was primarily normative, i.e. scenarios intended to provide a guiding vision of the future for policy-makers [46]. Scenario building and planning was further developed for management purposes, for example through the works of Pierre Wack, Peter Schwartz and many others [8]. Since then, scenario approaches have continued to evolve and their use seems to be increasing again [18,47,48].

Developing and using scenarios are professional practices to support significant decisions, and therefore it needs to be more assured of its claims to knowledge (methodology). For instance, forecasting and modeling methods have a focus on what is known and what is unknown. This can encompass ‘What is likely’, in terms of probabilities for example, but it is still essentially working in terms of the same basic known–unknown dichotomy [8]. In contrast, explorative scenarios deal with different kinds of knowledge, ignorance and uncertainty, for example, socially constructed ignorance or ‘uncomfortable knowledge’ [49].

The identification of the motivation behind any scenario exercise appears to underpin the scenario typology described by Borjesön et al. [50], which reviews many other typologies before suggesting an alternative comprising three categories and six types. The categories arise from the kinds of question that a scenario user might use about the future: What will happen? What can happen? How can a specific target be reached? Each of these questions can be seen to evoke the motivation of a particular approach to scenarios. For example, in this typology “What will happen?” scenarios lead to predictive scenarios, in effect, forecasts, which look at what will happen as the likely development occurs. By contrast, “What can happen?” scenarios are normative scenarios – concerned with achieving particular future objectives – which lead to preserving and transforming scenarios. Preserving scenarios are used when the target can be met within an existing structure, while transforming scenarios feature a form of back-casting, asking what would need to be changed for the target futures to be achieved.

Although most reviews of scenario techniques distinguish between quantitative and qualitative techniques, the boundaries between approaches have become increasingly blurred by techniques that make use of both kinds of methods and information [51]. Hence, our brief overview of scenario techniques is not intended to provide a comprehensive classification or typology. Merely, its role is to describe the variety of current techniques that are relevant for this paper.

Table 1

Modes of thinking about the future.
Source: adapted from Jørgensen [41].

Modes of thinking	Type of futures in focus	Characteristics
The predictive mode	Probable futures	Working with indications of what will happen. Trying to find the most likely development
The eventualities mode	Possible futures	Openness to several different developments
The visionary mode	Preferable futures	Envisioning how society can be designed in a better way

The concept of the multiple-axes method is based on one of the approaches used by Pierre Wack [52]. It generates four contrasting scenarios relevant to a particular area of interest, which may be geographic or thematic, by placing a major factor influencing the future of the issue being investigated on each of the axes, which cross to form four quadrants if two axes are used. The factors chosen for the axes should be high-impact, high-uncertainty, and to ensure that the four spaces defined by their intersection are clearly differentiated. These spaces are then developed into scenario narratives, reflecting the influence of other events and trends in addition to those represented on the two axes.

Back-casting, inspired by the early work of Lovins [53], starts with defining a desirable future and then works backwards to identify policies and programs that will connect the future to the present. Back-casting scenarios explore the preconditions that could lead to this desirable future, including a palette of strategies to reach this situation [54].

The concept of roadmapping has its roots in science and technology planning [55]. A science or technology roadmap is like a highway roadmap that describes how one might proceed from a starting point to a final destination expressed as a vision. Like a highway roadmap shows the intersections between roads, a science or technology roadmap also shows the intersections between scientific steps or technologies [56]. A roadmap can take various forms, but generally comprises a time-based chart together with a number of layers, which provides a means to link technology and other resources to future products, as well as to innovation objectives and milestones [55].

The Delphi method is developed as a systematic, interactive forecasting method, which relies on a panel of experts. Delphi method is based on the assumption that group judgments are more valid than individual judgments. It is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. Key elements to accomplish this structured communication are: feedback of individual contributions of information and knowledge; an assessment of the group judgment or view; some level of opportunity for individuals to revise views; and anonymity for the individual responses [57]. This technique is often used in national foresights to guide innovation and national research policies [58–60].

All the above describe approaches to futures thinking during which (potential) inputs for scenarios can be produced. For example Delphi studies use statements about the future, roadmaps and back-casting use end-point states, while most of the other techniques described produce narratives or images of alternative future states. Practices are very diverse and often combinations of techniques [61]. These types of approaches are typical of those used in our analysis (see [Appendix 1](#) for an overview of the scenario cases).

4. Results and implications

The value of scenarios lies in the robustness of the claims to knowledge within the process of the scenario development. As this knowledge is (socially) constructed, an explicit reflexive account of the production of that knowledge is a methodological necessity, as it will reveal significant choices underlying the presented scenarios [61]. To structure our research, the scenario cases are evaluated using the three complementary questions on policy change mentioned in [Section 2](#) (Material and methods). An overview of our findings is summarized in the subsequent sub-sections (sub-sections 4.1–4.3). Each of these subsections includes a description of representation issues linked with the approach and methods used, input, process and main outcome. In addition, implications for practitioners are highlighted by elaborating elements of good practice and areas of improvement.

4.1. Window of opportunity

Leveraging the first perspective, i.e. window of opportunity, we looked at scenarios as a tool to support planning and decision-making. Our analysis indicates contrasting motivations between developing and using future scenarios in the case studies from [Appendix 1](#). When the motivation is oriented towards developing scenarios, the focus tends to shift towards building consensus within the scenarios, missing the opportunity to explore the potential for innovation in conflicting views. Although legitimate for several reasons, for example building a common platform for dialogue, a focus on consensus can take up too much resources [62], with a risk of diluting a sense of urgency. In addition, our analysis indicates that scenarios with a strong focus on consensus during the development are often too vague and too broad for defining tangible innovation opportunities. By reshaping the scenarios to reach consensus, they are often limited to accepted statements about the obvious. Some examples of national foresights are known to have experienced problems linked with a dominance of consensus, see for instance [63].

This is in contrast with scenario exercises, where the motivation is oriented towards using the future scenarios for strategic discussions. The focus here is less on which scenarios are “right” but is more oriented to whether the scenarios delineate the range of possible futures appropriately [64]. As documented by van der Heijden [65], the strategic discussion has its origin in uncertainty, both in the external environment and within the organization. Using inspirational scenarios (in this context, one could label them as simple in form but representing extreme uncertainties) can contribute strongly to triggering feelings of surprise and discovery. Responding to this emotive and cognitive disruption requires participants to think in ways that produce innovative and competitive solutions in a changing environment. The “DP21” scenarios (see [Appendix 1](#)) are a good example.

To synthesize our findings for the first perspective, we distinguish two groups of scenario practice. We argue that dependent on the dominance of one of the two motivations (respectively a. developing and b. using scenarios) a different scenario process is shaped and different types of outcome are achieved. Identifying these two groups of scenario practice is neither a typology nor a comprehensive classification. The two motivations are connected to the perspective used in the analysis (i.e. window of opportunity) and can be seen as a polarized view on this element of practice. Using a polarized view on motivations contributes in

our analysis a better understanding of the linkages between scenario design, methods used and related outcomes. For example, by analyzing the dominant motivation of the scenario cases we found a tension between incentives for consensus building and incentives for discovery. As an implication for practitioners, we recommend that careful design of scenario exercises is needed to achieve a balance between developing and using scenarios to strengthen the sense of urgency.

4.2. Legitimacy for action

Looking at the second perspective, i.e. legitimacy for action, our analysis revealed three groups of scenario practice in the case studies from [Appendix 1](#). The following sub-sections will describe the main characteristics for each of these three groups: sub-section 4.2.1 Framing boundaries, sub-section 4.2.2 Back-casting from targets and sub-section 4.2.3 Back-casting from principles.

4.2.1. Framing boundaries

A first group of scenario practice is characterized by a focus on framing boundaries. The “Prelude” scenarios² are a good example (see [Appendix 1](#)). An important input for the scenario work in this group are the comprehensive descriptions of the external drivers for change highlighting the uncertainty of future developments. This uncertainty is reflected in a distinguished set of possible long-term future images that are often derived from a multi-axes framework of the most important but uncertain drivers of change. Scenarios generated using the axes’ process are explorative rather than normative; they tend to focus on the strategic level although additional layers of detail can subsequently be added. The value of the set of scenarios lays in the capacity to explore boundaries. This method is excellent for presenting a rich picture of multiple facets of a potential future: when an experienced scenario writer or film-maker is engaged at the final stage, the set of scenarios produced can be very persuasive, even to a non-specialist audience. Narratives are a natural, resonating way for people to communicate, and can be helpful in dealing with complexity, as pointed out by Weick [66]. These narratives can create shared meanings and by doing so they legitimate the future since imaginations are owned by the individuals relating them [67]. Creating awareness for the unforeseen is most often an important objective and desired outcome of this group of scenario practice.

A technique underpinning these types of scenarios is described by Weiner & Brown [68] as the extremes that inform the middle. We found that adapting for change is often the general theme in the lessons learnt. Still, it is less obvious how these scenarios can be used for bridging today’s decisions with the future images. We found that crystallizing concrete policy initiatives for innovation from long-term future images, i.e. beyond twenty years, can be difficult. Most often, the scenarios are used to highlight important societal assets under threat. This links well with the concept of risk-society [69] and risk management. Our analysis suggests that this can be partly contributed to the selected process design for developing the scenarios. By having a strong focus on the external dimension (i.e. outward reflection), adapting for change is logically seen as the dominant response. In that sense the potential for innovation within the system (i.e. inward reflection) is less acknowledged.

When considered from the perspective of creating legitimacy for action we also suggest that the scenarios in this group could benefit from complementary techniques connecting the long-term future images to the present via stepping stones. Using roadmaps is an example of such a complementary technique for linking scenarios with internal innovation capabilities (i.e. inward reflection). This would help to address the imbalance between outward and inward reflection. Moreover, while participatory scenario-making provides visions for multiple futures, a roadmap only operates with one vision. Linking scenarios with technology roadmapping initiates an exploratory and creative phase to identify and understand uncertainties. Developing a set of scenarios acknowledges multiple rather than one future, equally plausible, whereas roadmapping provides a framework for condensing all information in one map and timeframe – revealing windows of opportunity – thus linking decision-making with future scenarios. The legitimizing aspect of this is the creation of a common understanding of challenges and establishing a common vision among the innovation stakeholders as a boundary framework before moving into technology roadmapping [70].

4.2.2. Back-casting from targets

A second group of scenario practice is characterized by a focus on back-casting from targets. “Getting into the Right Lane for 2050” and “AG2020” are good examples here (see [Appendix 1](#)). In this group, changes in the external environment are part of the scenarios. But in contrast with the first group, change is less described by framing very different long-term future worlds. Rather, the focus of the scenarios in the second group is oriented towards a sequence of clear targets linked with short-term stepping stones, i.e. 5–10 year. Breaking up the long-term in more tangible time periods helps understand the necessary steps for embracing change. By mapping time, we become clearer on where we have come from and where we are going. This ‘roadmap’ linking the necessary steps, contributes to the recognition that the long-term target is not only possible but also achievable. In addition, the interplay of the different contributions to achieve the targets becomes more visible. The foreseen outcome of long-term investments or policies, for example, can be visualized and confronted with a changing environment. Different from the above group, this one already leverages the combined use of roadmaps. We found that selecting areas for future opportunities are the general theme in the lessons learnt from this group. Often the focus is very much on elaborating areas of enhanced collaboration, technological cooperation and converging technologies. Clearly innovation is an essential feature of the scenarios.

² PRELUDE: PRospective Environmental analysis of Land Use Development in Europe.

The images of the future are focused on key internal developments (i.e. inward reflection) and often driven by technology or changes in our way of living.

Our analysis also suggests possible improvements for this group of scenario practice. Roadmaps directed towards a single target are likely to be inappropriate where policy intervention may direct technology towards a different trajectory altogether [70,71]. The innovation potential of the scenarios can be strengthened through broadening the system boundaries and enriching the future images. Flexibility, either avoidance of surprises or fast utilization of sudden opportunities, becomes one of the key issues. In order to avoid surprises the policy or strategy process should be able to open the scope of observation for periphery incidents and early, unstructured data that implicate potential discontinuities [72]. In addition, including perspectives from the different stakeholders can reveal new areas for innovation [73].

4.2.3. Back-casting from principles

A third group of practice is characterized by a focus on back-casting from principles. A good example can be found with the scenario practice developed by the Natural Step³ (see for instance “Givaudan” case in Appendix 1). The focal points of the scenarios are sustainability concerns and criteria. The principles can be seen as indirect and implicit representations of the future. The future plays the role of the time needed to introduce the necessary changes to comply with the envisaged principles. The concept of change is an implicit part of the scenarios developed in back-casting from principles but the focus is less on delineating the range of possible futures and more on a preferable future vision. Interaction between the organization and the environment is seen as the main driver. This is often reflected in the outcomes envisioning a preferable future and experiments towards that future.

Also for the third group of scenario practice, we suggest some areas of improvement with regard to legitimizing actions by adding a planning perspective via roadmaps or similar approaches. Comprehensive and well-designed roadmaps linking today's experiments with future images can improve the impact of the scenarios. In addition the success of the roadmaps can be tested for different possible future images. This will provide essential information about the robustness of the innovation potential.

The 3rd SCAR foresight exercise (see Appendix 1) also falls into this group with its focus on research priorities and innovation to meet necessary change and uncertainties in the agri-food sector facing resource constraints and environmental limits. In the project report, the insights of the foresight exercise are used to articulate the research priorities. Still, the implementation could be improved with regards to knowledge dissemination e.g. education and the scientific communities' involvement in policy discourse.

4.3. Empowering stakeholders

Developing and using future scenarios to inspire innovation do not only deal with the collection of data and models; they also involve the interaction of the stakeholders, their ideas, values and capacities for social change. Learning in such an interaction is not always an objective as such, but the process of exchanging knowledge is recognized to overcome some limits of conventional scenario practice [61]. Looking at the third perspective, i.e. empowering stakeholders, our analysis of the case studies from Appendix 1 revealed two groups of scenario practice: expert versus stakeholder driven.

In several exercises, expert judgment was the main input for scenario development. Involvement of stakeholders was not intentionally looked for. In reality, this might lead to limitations. Firstly, the expert (i.e. scientific) mind-set fosters expectations of regularity, simplicity and certainty in the phenomena and in our interventions [74]. But these can inhibit the understanding of the problems and the use of appropriate methods to their solution [47]. Secondly, while expertise has never been either as widespread or in such demand as today, public willingness to challenge that expertise has also never been as high. As a result of these two developments, we argue that the difference between experts and the wider public has become less relevant whenever one speaks of users and producers of knowledge.

Our analysis suggests that scenarios developed with broader stakeholder/expert participation will provide richer future images that go beyond the probable that is determined by the past and present [73,75]. As opposed to past scenario practice, we believe there is often no clear cut difference between experts and stakeholders: experts sometimes have a stake in the problem or solution discussed and stakeholders equally have their expertise. It is a key challenge to benefit from this rich and complex audience.

Also from this ‘empowerment’ perspective we suggest some areas of improvement. Stakeholder involvement, for instance, may be facilitated by conceptualizing the future as open and dilemmatic, and recognizing ambivalence as legitimate [76]. Thus the scenario process can be seen as frame for dialogue, not to reach consensus but to recognize other parties' point of view. Recognition then, is a heuristic that leads away from conflict into a broader understanding of the complexity of a disputed subject [62]. Although consensus can identify common grounds in contested territory, it should not be the primary goal of scenario processes. Rather we suggest that developing and using scenarios should be viewed as a systemized negotiation process among key stakeholders (social actors), investigating and utilizing potential future societal changes and developments, see also [62,77].

To synthesize this section on results and implications, we argue that our reflexive inquiry of the selected cases from Appendix 1 helped disclose several representation issues in scenario practice. Using a policy perspective, different groups of practice have been revealed. In the next section we will discuss our findings against the initial key question of how futures thinking and scenarios can help better cope with the grand challenges and how future scenarios can inspire innovation.

³ <http://www.naturalstep.org/>.

Table 2

Linking groups of future scenario practice from a policy perspective with modes of future thinking.

Policy perspective (representation)	Scenario practice (most characteristic)	Types of futures (main focus)	Techniques (example)	Modes of futures thinking
Window of opportunity (sense of urgency)	Using scenarios	Shaped by surprise and confrontation	Uncertainty matrix	Intuitive
	Developing scenarios	Shaped by convention	Consensus (Delphi)	Convention
Legitimacy for action (what)	Framing boundaries	Shaped by possibility	Extreme to inform the middle	Eventuality
	Back-casting from targets	Shaped by probability	S&T Roadmaps	Predictive
	Back-casting from principles	Shaped by preference	The natural step	Visionary
Empowering stakeholders (who)	Expert driven	Shaped by expertise and discovery	Expert panels	Technocratic
	Stakeholder driven	Shaped by interaction	Future workshops	Evolutionary

5. Discussion

Due to the social dynamic characteristic of innovation, new socio-technical subsystems are emerging [24]. Following a policy perspective, however, there is lack of exploitation of innovative solutions for orienting innovation in itself along more sustainable pathways [15]. For instance, there is a wide acceptance that the disconnection between economic growth and well-being is increasing. At the same time innovation has become one of the main engines of growth. However, these two overarching trends have not yet been reconciled [15]. In this paper we argue that issues of representation have played a part in this lack of exploitation. For example, when drivers of change are not only multiple but also mutable, it is not sensible to extrapolate the future from data and relationships of the past. Hence, it is important to recognize that representing scientific and technological diversity offers an important means to help foster more effective forms of innovation and promote social learning [78]. This complexity challenges the capacity of innovation systems to acknowledge the social dimension of innovation and to learn from experience.

It is widely accepted that a vision about the future is an essential element of a strategy [16,17]. In addition, several scholars state that scenarios constitute a major tool for considering the future in strategic planning [18,21,22]. The question that emerges is how we can learn from using and developing future scenarios to assist in the orientation of innovation systems? Developing and using scenarios can be considered a field of applied research, i.e. where particular methods are applied to ‘solve’ particular puzzles. Particular choices and uses of techniques will be influenced by the context in which applications are made. Contextual features will include, among other things, the morphology or physiology of the domain, the purpose and theoretical premises of the study, the community of practice being informed and the values inherent in the process. In this sense, no single discipline or particular prescribed set of methods can be considered to be optimal. However, the commonality of scenario applications is the orientation to the future and that the knowledge produced is uncertain. Therefore, being a professional practice to support significant decisions, developing and using scenarios need to be more assured of its claims to knowledge [61].

Following a reflexive inquiry methodology in the analysis of the scenario cases listed in Appendix 1, three complementary questions on policy change are applied to analyze scenario practice: (i) “How can developing and using future scenarios present a window of opportunity to effectively drive decisions?”; (ii) “How can developing and using future scenarios enhance the legitimacy for action?”; and (iii) “How can developing and using future scenarios provide evidence to decision-makers empowering the stakeholders involved?”. By questioning representation from a policy perspective and deconstructing future scenario practice, we were able to (re)construct findings to the above questions: (i) if a sense of urgency was established or was lacking (window of opportunity), (ii) what was and was not represented (legitimacy for action) and (iii) who was and who was not involved (empowering stakeholders).

An overview of our findings is presented in Table 2 that describes for each group of practice (sub-sections 4.1–4.3) the most common images of the future, an example of a characteristic technique and the dominant mode of futures thinking. By doing so, we are able to link issues of representation with groups of scenario practice.

Table 2 is a synthesis of our results and implications of the previous section. Instead of framing practice based on theory, future scenario practice is deconstructed into seven groups. These seven groups are further linked to the most characteristic theoretical premises, here expressed as modes of futures thinking. For example, we argue that a strong focus on developing scenarios and consensus increases a risk of diluting a sense of urgency. During the scenario exercise, consensus may not be appropriate to promote differences and to stimulate novel ideas. Based on this observation (sub-section 4.1), two groups of practice can be distinguished: one group using scenarios as the most characteristic feature, and another group with developing scenarios as the most characteristic feature. For these two groups, the scenario cases have been analyzed to disclose elements of theoretical premises. In the first group, we found that the scenarios are used for supporting strategic discussions about futures that are shaped by surprise and confrontation. Examples of supportive techniques are the use of an uncertainty matrix and the multi-axes method using factors of high uncertainty and high impact. Based on our reflexive inquiry used to analyze scenario exercises in their context, we can then attribute the most characteristic mode of thinking.⁴

Innovation is not only about invention, creation, or discovery, it is also about adaptation and emergence of new innovation systems [31]. Principles on how to orient innovation systems through future scenarios will require conditions for collaboration.

⁴ The groups are not (intended to be) a typology. Each of the case elements and aspects of different groups are present, therefore it is not possible to link groups with cases query. However, as described in the previous section, for each of the groups an example(s) of good practice from Appendix 1 is included in the text.

Table 3

Different modes of futures thinking for orienting innovation systems via future scenarios.

Modes of futures thinking	Future scenarios shaped by	Underpinning logic	Pros and cons with respect to orient innovation systems
Intuitive	Surprise and confrontation	Think “the unthinkable” and conceptualize future situations where uncertainties are high	Allows strong imagination including alternative futures that are competing Weak on acceptance, especially by decision-makers
Conventional	Convention	Agree on common accepted probabilities of change (rejecting extreme ideas)	Strong on acceptance and alignment, but often too vague, too broad to inspire innovation
Eventuality	Possibility	Explore contrasting futures and conceptualize future situations for the long-term where uncertainties are expressed differently	Allows rigorously exploring boundaries and complexity. Often an imbalance between outward/inward reflection limiting the recognition of its internal innovation capacity
Predictive	Probability	Better contextualize what we know to be prepared for upcoming situations	Allows defining (a sequence of) clear steps for innovation Weak on surprise and external change
Visionary	Preference	Envision how society can be designed in a better (e.g. more sustainable) way	Allows creating authentic alternative visions to guide innovation Weak on clear targets, surprise and external change
Technocratic	Expertise and discovery	Demonstrate technical feasibility and optimize technological development	Allows minimizing inconsistencies and defining areas for innovation Weak on complexity of socio-technological systems
Evolutionary	Interaction	Engage in sustainable pathways enabling transformations of innovation systems	Allows a systemized negotiation process linking a variety of social actors and creating the conditions for innovation Risk of not reaching out to key (technological) actors

The solutions developed should be socially reflexive and negotiated by the key actors [79]. However, it is also crucial to keep in mind the limitations of the scenario methodology [80]. Clearly, scenarios do not point to simple short-cuts into a more sustainable future [64]. Table 3 provides a brief description for each of the 7 dominant modes of futures thinking. For each of the modes of future thinking, we also include information on the proposed effects on or contributions to the enablers for orientating innovation systems through future scenarios (i.e. pros and cons).

Our analysis of the case studies listed in Appendix 1 suggests that a variety of modes of futures thinking, as articulations of theoretical premises, can be distinguished in future scenario practice. In addition, we abstracted different dominant modes of futures thinking linked within different groups. In reality, each scenario exercise is a mixture of different modes and practice is shaped by the image(s) of the future and the techniques applied. Combinations of techniques are possible and can be found in our case studies and in literature, see for instance [71,81]. To strengthen the enablers for innovation within the scenario process, the link between practice and theory, represented via the modes of futures thinking should be acknowledged when designing and implementing future scenario exercises. As described in Section 4 (results and implications) cross-fertilizations between the techniques of the different groups can enhance the innovation potential. However, no single recipe exists and our recommendations should be seen as ‘design principles’. Hence, the benefits from combining techniques for each of the groups become also clear from a theoretical point of view when looking at combination possibilities of the modes of futures thinking in Table 3.

To synthesize, we argue that future scenarios developed with a combination of well-designed modes of futures thinking will provide richer future images that go beyond the probable that is determined by the past and present. This enhanced support is needed, because as Hauschildt [82] clearly states: “the success of innovation is to a great extent dependent upon the activities and abilities of individuals who enthusiastically support it”.

6. Conclusions

In this paper we analyzed and discussed the applicability of future scenarios as narratives to represent different perspectives on present and future developments. Our use of a reflexive methodological approach with three complementary questions on policy change, supported the grouping of different approaches of developing and using future scenarios as a tool for orienting innovation systems. Our analyses of the scenario case studies from Appendix 1 revealed elements of good practice and implications on how to better address innovation through future scenarios. For instance, different modes of futures thinking have been identified through the process of deconstruction. In this paper, we argue that these modes of futures thinking are shown to contribute in different ways to orientating innovation systems. Hence, by using a reflexive methodology we were able to create a heuristic to learn from the process of developing and using scenarios. In addition, we also identified some points of departure for further refinement of current scenario practices with respect to innovation.

Firstly, and summarizing our recommendations for future scenario practice, we suggest that representation issues (i.e. what is, and what is not represented in the scenarios, who was and who was not involved, and whether a sense of urgency was established or was lacking) are an important feature in the design and application of future scenario practice. In this paper we argue that the limits of current practice are to a certain extent linked with representation issues. As acknowledged in the previous sections (see also Tables 2 and 3), cross-fertilization between scenario approaches and techniques, such as framing boundaries, roadmapping, and back-casting from principles can strongly enhance practice by enhancing representation. We also want to

acknowledge the limits of our analysis: i.e. using a policy perspective for doing an ex-post analysis of future scenario practice. Innovation systems are complex and dynamic and scenario practice is applied more widely than our sample. Therefore, when using reflexivity in research or in scenario practice, it is also essential to make one's perspective clear so that the claims to knowledge can be constructively critiqued and improved.

Secondly, we argue that the use of cooperative strategies, i.e. participatory scenario analysis, is required to produce a variety of possible, and not only probable or desired futures among the actors that develop, diffuse, and use innovations. Learning of participants is not always an objective as such, but the process of exchanging knowledge is recognized to overcome some limits of conventional research, particularly as far as grand challenges are concerned. Hence, we believe that developing and using scenarios should be viewed as a systemized negotiation process among key stakeholders (social actors), investigating and utilizing potential future societal changes and developments. This integrated approach, i.e. integrating different modes of futures thinking, is needed for orienting innovation along more sustainable pathways enabling transformations of socio-technical systems. However, a variety of representation issues exist, and more experiments and research are needed.

Thirdly, we want to emphasize that the social dimension in innovation systems should be acknowledged as a legitimate research area and linkages with social innovators and other social innovation stakeholders should be strengthened so that social innovation experiments inform the research community.

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Appendix 1. Overview of the case studies

1. AG2020	DG RTD (2011), Foresight analysis for world agricultural markets (2020) and Europe. www.ag2020.org
2. Danish Technology Foresight on Environmentally Friendly Agriculture	K. Borch, (in press) The Danish Technology Foresight on Environmentally Friendly Agriculture, in: K. Borch, S.M. Dingli, M.S. Jørgensen (Eds.), Exploring the future, The role of interaction in foresight, Edward Elgar, Cheltenham, in press
3. DP21	DP21 (2003), Dierlijke Productie & Consumptie in de 21ste eeuw. Last accessed on 29/06/11 and available in Dutch at http://www.kbs-frb.be/uploadedFiles/KBS-FRB/Files/NL/PUB_1338_DP21_Stakeholders.pdf .
4. Duwobo	Duwobo (2010), Transitie management duurzaam wonen en bouwen. Last accessed on 29/06/11 and available in Dutch at http://www.duwobo.be/index.cfm .
5. 2nd SCAR Foresight Exercise	EC (2008), New challenges for agricultural research: climate change, food security, rural development, agricultural knowledge systems. The 2nd SCAR Foresight Exercise. Last accessed on 29/06/11 and available at http://ec.europa.eu/research/agriculture/scar/pdf/scar_2nd_foresight_exercise_en.pdf
6. 3rd SCAR Foresight Exercise	EC (2011), Sustainable food consumption and production in a resource-constrained world. 3rd Foresight Exercise. European Commission DG RTD, Directorate E Unit E.4, Brussel.
7. Prelude	EEA (2006) Prelude (Prospective Environmental analysis of Land Use Development in Europe) scenarios. Available at http://www.eea.europa.eu/multimedia/interactive/prelude-scenarios/prelude .
8. The world in 2025	European Commission (2009), The world in 2025. Rising Asia and socio-ecological transition. Research*eu, Brussels. Last accessed on 29/06/11 and available at http://ec.europa.eu/research/social-sciences/pdf/the-world-in-2025-report_en.pdf .
9. Givaudan	Givaudan (2011) Sustainability, translating vision into action. Last accessed on 29/06/11 and available at www.givaudan.com .
10. Research Dialogue in Germany	E. Göll, Futur – the Research Dialogue in Germany, in: K. Borch, S.M. Dingli, M.S. Jørgensen (Eds.), Exploring the future, The role of interaction in foresight, Edward Elgar, Cheltenham, in press.
11. eFORESEE Malta	L.A. Pace, (in press) Strategic Planning for the Future: Malta's eFORESEE Experience, in: K. Borch, S.M. Dingli, M.S. Jørgensen (Eds.), Exploring the future, The role of interaction in foresight, Edward Elgar, Cheltenham, in press.
12. Getting into the Right Lane for 2050	PBL & Stockholm Resilience Centre (2009), Getting into the Right Lane for 2050. Netherlands Environmental Assessment Agency (PBL), Bilthoven, NL. Last accessed on 29/06/11 and available at www.pbl.nl/en .
13. Denmark Green Technology Foresight	M.S. Jørgensen, Case Denmark Green Technology Foresight, Phase 1, in: K. Borch, S.M. Dingli, M.S. Jørgensen (Eds.), Exploring the future, The role of interaction in foresight, Edward Elgar, Cheltenham, in press.
14. COOL Project	S. Stalpers, C. Kroeze, Dialogues in the COOL Project, in: K. Borch, S.M. Dingli, M.S. Jørgensen (Eds.), Exploring the future, The role of interaction in foresight, Edward Elgar, Cheltenham, in press.
15. Four scenarios for Europe.	UNEP/RIVM (2003). Four scenarios for Europe. Based on UNEP's third Global Environment Outlook. Last accessed on 29/06/11 and available at http://www.unep.org/geo/GEO3/pdfs/four_scenarios_europe.pdf .
16. Buiten de lijnen	VLM (2009) Buiten de lijnen. Vlaamse Land Maatschappij, Brussel. Last accessed on 29/06/11 and available in Dutch at http://www.vlm.be/SiteCollectionDocuments/Publicaties/Platteland/VLM_brochure_DEF.pdf .
17. Vision 2050: The new agenda for business.	WBCSD (2010) Vision 2050: The new agenda for business. World Business Council for Sustainable Development, Washington. Last accessed on 29/06/11 and available at http://www.wbcsd.org/web/vision2050.htm .

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