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Adaptive Foresight: Navigating the complex landscape of policy strategies

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Abstract

Adaptive Foresight has been developed at the crossroads of foresight and adaptive strategic planning. Innovation is seen as increasingly complex, interdependent and uncertain and therefore in need of broad and multi-disciplinary exploration and participation. The adaptive planning paradigm provides a natural guide for navigation of this complex landscape: one should consider whether strategic decisions should be deferred until more information is available and simultaneously whether to invest in (real) options which would facilitate the implementation of such decisions if taken some future time. This does not mean that all strategic decisions should be deferred. Rather it is the careful combining of commitment and opportunism that best enables actors to pursue their super-ordinate values and objectives. Compared to conventional foresight, Adaptive Foresight thus favours a more modest interpretation of the collective ability to "shape the future" and stresses the need to adapt to actions by others. Here it is equally important to be able to exploit the upside of uncertainty as to abate its downside. The purpose of this paper is to achieve a conceptual consolidation of Adaptive Foresight, to review in a fairly hands-on way methodological experience thus far, and to outline the substantial methodological challenges ahead.

Keywords: Foresight; Technology foresight; Adaptive planning; Real options; Scenario planning; Neo-Schumpeterian economics; Evolutionary economics; Social studies of technology; Policy strategy

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1. Introduction

When is a foresight process effective? At the end of a recent foresight and scenario development process in Austria, dealing with scenarios and options for establishing production–consumption chains based on renewable resources, the participants were asked for an assessment of the process and whether it had been useful for them to participate. One of the industrial participants spelt out very explicitly that by participating in the process his firm became aware of a mis-perception of the future potentials of the technological trajectory they had pursued so far and that as a consequence of participating in the process they were revising their own business and R&D strategy. This anecdote suggests that foresight can and does have an impact on decision-making, and that a main criterion of effectiveness is that it should lead to a reconsideration and modification of actual policy strategies because the perception and the expectations of actors with respect to future developments have changed as a result of the process. Other criteria such as a better understanding of future challenges and pathways or the formulation of alternative decision options are mere ancillary arguments. The litmus test is the impact on decision-making, either in the short-term or the long-term.

In order to have an impact on decision-making, it is necessary to create an explicit link between foresighting and decision-making. Decision-making in relation to innovation and new technology, be it from a company's or from a public policy perspective, is confronted with the need to navigate increasingly complex decision landscapes. This complexity is due to the increasingly interactive and multi-actor character of innovation processes, a development that – in conjunction with the new possibilities offered by information and communication technologies – has given rise to an internationalisation of research and innovation. This obviously makes the anticipation of future developments and their consequences more difficult than ever before.

To be perceived as useful and effective, forward-looking exercises must enable decision-makers to better understand and cope with this interactive, complex and inherently uncertain character of innovation. This requires first of all that these approaches are based on and reflect an appropriate understanding of the changing characteristics of innovation and decision-making. Secondly, they should contribute to the mobilisation and coordination of the decision-making by different actors. Thirdly, they must be able to deliver insights on possible strategies and options for individual actors on how to "change course" and direction, or at least enable to think "out of the box" about qualitatively different approaches and strategies. The purpose is to develop new things, to upset established agendas and give rise to new approaches.

New approaches to forward-looking decision support are currently being developed that take these requirements into account. Conventional forecasting approaches with their aim of predicting the future were based on a linear understanding of processes of socio-technical change that is simply an inappropriate representation of reality and thus misleading rather than enlightening with respect to informing decisions. The foresight tradition that has become quite prominent particularly in public policy takes into account the interactive character of innovation and stresses the need for participation as a means to enhance the coordination and mobilisation effect. However, although the dominant model of foresight pursues a more modest level of aspiration than forecasting, it strongly stresses the "collective ability to shape the future" and tends to under-estimate the limitations to which decision-making is subject in the face of interactive and globalised innovation processes.

To be able to shape the future to some degree, actors need to be able to adjust to external developments and other actors' strategies as they unfold and make sure they focus their shaping power on their highest priorities. Moreover, we would like to argue that while the collective dimension of foresight is important,

there is a need to move a step beyond collective processes and to guide decision-making of individual actors if foresight is to have a real impact.

In this paper, we suggest an approach to forward-looking decision support that addresses the aforementioned shortcomings of conventional foresight. Under the headline of Adaptive Foresight (AF) it combines elements from the foresight and adaptive planning traditions. It stresses that foresight needs to go beyond the level of a collective process and be brought down to the level of individual actors' strategies. As a consequence, we propose combining phases of open participation with closed processes of targeted strategy development. Further, it provides a more modest – and hence more powerful – basis for informing strategic decisions because it stresses both the need to adapt to changes in the environment and the ability to keep options open until we can use them effectively (or know they have become irrelevant).

The structure of the paper is as follows. In the next section we will take a look at the constituents of AF. Adaptive planning is given a relatively elaborate treatment. In the case of foresight, we primarily discuss the shortcomings of current practices that motivate AF. This is done in the context of the third constituent, viz. a perspective on innovation as complex and largely unpredictable. This chapter can be said to be theoretic in nature.

The third section, in contrast, is practice-oriented in providing a process outline and examples of AF. The concluding section provides a critical assessment of the potential of Adaptive Foresight, which leads us to highlighting some of the methodological challenges that need to be tackled in the future.

To us this linkage of theory and practice is really the essence of the paper: we want to develop foresight practices that properly reflect state-of-the-art innovation theory — and are also able in turn to contribute to enhancing theoretic understanding of innovation. This said we do acknowledge that some innovation theorists are likely to skip much of Section 3 while some foresight practitioners are likely to do the same for Section 2.

2. The three constituents of Adaptive Foresight

Adaptive Foresight as discussed in this paper has three main roots or constituents. (Technology) foresight is an obvious case simply from the name, as is adaptive planning — although that term is much less well established and therefore will be given more elaboration in what follows. But we would like to point also to a third main constituent, namely a perspective on innovation processes that is based on contemporary empirical and theoretical research as well as (some) practical experience.

For the purpose of this paper, the essence of this third constituent can be succinctly summarised in terms of the so-called Collingridge Dilemma [1]: Making choices about the directions of new emerging technological options is very difficult in the early stages of development because we know too little about their advantages and disadvantages, their costs and opportunities and risks. However, once we know enough about them to make informed choices, they have already become so entrenched that effective choices are not possible any more.

This dilemma mirrors the departure from a simple linear innovation model which we could observe during the past decades. Several interconnected research traditions have transformed our understanding of innovation processes and embraced notions of complexity, uncertainty and interactivity.[1] Even if certain

[1] In particular evolutionary and Neo-Schumpeterian economics as well as Social Studies of Technology have made important contributions [2].

tendances lourdes can be identified — like the development of electricity and propulsion technologies starting in the late 19th century and information and communication technologies in the present era, the ability to predict at an early stage which particular pathways and applications will lead to mass markets, niche markets – or failure – is scant.

Based on this realisation, any approach to policy or business strategy based on the idea of early identification of winners must be subject to serious doubts. From a modern perspective on innovation, it is on the contrary essential to accept that decision-makers are confronted with uncertainty and that their strategies need to take the strategic behaviour of other actors into account. The ability to shape the future is limited by the extent to which external developments (such as the strategies of other actors but also exogenous developments) can vary. And it is enhanced by coherent actions of a range of key decision-makers in research, policy, economy and society. In principle, it does not make a big difference whether this kind of argument is applied to company strategies or to national policies: it implies a need to accept a quite limited power to control the future.

The foresight tradition has embraced some of these insights. In particular, it has stressed the role of interaction and learning to improve the coherence and coordination between the actions of a wide range of actors and stakeholders. This coherence is facilitated, for instance, by shared problem perceptions and visions. But, as we will argue in the next section, this is not sufficient — at least not when it comes to informing actual decision-making, say, on what RTD projects to fund and which not to fund.

2.1. Foresight — recent developments, achievements and deficits

In the light of insights from research on innovation and technological change, much foresight thinking and practice have struck us as somewhat over-simplistic and in particular over-optimistic in its hopes, e.g. with respect to the ability to mobilise innovation system stakeholders to act according to visions of sustainable development, developed in a participatory foresight process. We, therefore, see adaptive planning as a way to overcome this lack of realism in much foresight work and bring it closer to a contemporary understanding of processes of innovation and technological change.

Over the last ten to fifteen years, forward-looking approaches under the headline of ‘foresight’ have acquired a prominent role as policy support tools. Foresight has become particularly important in science and technology policy [3,4], but also in relation to sustainability and other long-term, uncertainty-ridden policy issues.

There are several types of foresight approaches and methodologies, each aiming at different purposes and stressing different facets. For instance, the distinction between exploratory and normative types of foresight is quite a common descriptor, as is the degree of participation, or the audience and the purpose addressed.[2] Common to many foresight exercises is the development of either different scenarios, or at least a single desirable future, to capture possible future pathways.

Over the past few years, a number of general trends in foresight practices can be observed that reflect what could be regarded the mainstream of foresight. First of all, it has moved away from a forecasting-type focus on science and technology to an incorporation of first market and then also increasingly social considerations. Historically this trend is linked to the adoption of the term ‘technology foresight’ as

[2] For a typology to systematise foresight approaches, see for instance Barré’s typology [5], but also the empirically driven monitoring activities EUROFORE [6] and EFMN (www.efmn.info).

distinct from 'technology forecasting' and the like.[3] This broadening of the scope of forward-looking exercises can be interpreted as a reflection of the abandoning of linear models of technological change and the adoption of a systemic understanding of socio-technical change.

As a second important trend, foresight has become an increasingly participatory activity. Initially, foresight activities were mainly based on S&T expert opinion, but in line with the broadening of the scope of foresight, the notion of expert has undergone a re-definition. With respect to participation, one can observe similar developments in technology assessment where the growing prominence of social, economic, environmental and ethical concerns related to scientific and technological developments has led to a strengthening of participatory and constructive approaches [8,9]. Here, the aim is to negotiate consensus on risks and opportunities or at least achieve transparency about conflicting viewpoints, in order to contribute to a normative debate on desirable future development paths.

Finally, we can today see a strong emphasis on and belief in the contribution of foresight activities to shaping rather than predicting and controlling the future. The Delphi exercises in the 1970s and 1980s were strongly influenced by the linear idea that the consensus achieved in Delphi could serve as a forecast and thus as a foundation for taking preparatory actions to exploit emerging technologies. A similarly linear perspective but from a different angle holds for the "critical technologies" studies conducted in the US, in France and the Netherlands. They also relied largely on a predictive approach and combined it with the idea of being able to secure through national policy a leading edge in selected technologies [10]. Subsequently, forms of Delphi have been developed that do not strive to achieve consensus on future forecasts, but rather to map the diversity of opinion.[4]

Today, by bringing together in a foresight process not only experts, but in particular also decision-makers from research, industry, policy-making and society, a shared understanding of current problems, goals and development options is expected to emerge among those actors that have an important role to play in shaping the future. This converging understanding of the issues at play is expected to contribute to improving implicitly the coherence of the distributed decisions of these actors, in line with the shared mental framework developed. In other words, it is expected that the future be shaped by aligning expectations and thus "creating" a self-fulfilling prophecy. These so-called "process outputs" are often regarded as more important than the actual "substantive outputs" like reports and websites.[5]

In this sense, foresight processes provide a mechanism for collecting and focusing vague future expectations, and for developing shared views on requirements for individual and collective action to be taken. Moreover, they tend to be regarded as a means to actually realise the expectations on which they build by influencing agenda-setting and decision-making. However, although only very few impact assessments of foresight exercises have been conducted so far,[6] their actual and traceable influence on decision-making seems to vary to a great extent. In some cases (e.g. the UK Foresight Mark I) the influence seems to have been quite important because priority-setting in RTD policy was directly

[3] We here have in mind the UK foresight tradition as begun by Martin and Irvine [7]. Today, of course, also earlier technology forecasting approaches like the large Delphi studies introduced in Japan in the early seventies and later on adopted by Germany and other countries are often subsumed under the 'foresight' heading. For our purposes, however, the distinction between foresight and forecasting is useful.

[4] See, for instance, the pioneering work by Best and collaborators [11].

[5] Obviously, there are also certain types of foresight exercises that have a less pro-active intention by concentrating on the identification of future challenges and issues only rather than aiming at solutions.

[6] See in particular the experiences made in the UK — especially the most recent evaluation of the UK Foresight [12], in Germany in the context of the Futur process [13], and in Hungary [14].

influenced by its results. In many other cases, the impact chains are at least difficult to trace, because the influence on participants' mindsets and decisions is hard to observe, as well as the influence on the wider public debates.

Foresight, as it is practiced today, thus shows a number of shortcomings with respect to its impact on decision-making that can be summarised by the following three points:

- The benefits of the shaping power on processes, now emphasised by adherents of foresight, are not only difficult to observe and measure, there is also quite some scepticism as to whether this is really enough. Although foresight processes have developed into quite sophisticated and well thought-through activities, the subsequent processes of strategy development still lack a similar level of sophistication, for instance in terms of deriving basic strategies for dealing with the opportunities and threats that have been identified in the context of foresight exercises. At the same time, foresight is increasingly required to deliver coherent and co-ordinated support to the formulation of strategic agendas for action, both in the public and the private sector. Especially in policy circles, a more direct and sometimes even operational benefit is asked from foresight than serving as a shaper of mindsets and as a means to develop a reservoir of policy options. From the perspective of policy-making, this is quite understandable because any kind of publicly funded activity is regularly under scrutiny in order to test whether the resources have been efficiently and effectively spent.
- While the optimism as regards the power of foresight exercises to actually shape innovation processes is at least founded in some qualitative evidence, there are serious doubts about whether this influence really goes in the right direction with regard to the intended super-ordinate goals such as sustainability. Several critical questions can be raised with respect to the biases brought in by the foresight process itself: Can we really trust the expectations raised in a foresight exercise? How can individual actors, and policy-makers in particular, actually protect themselves against the fallacies of false promises and over-optimistic expectations expressed and brought to the fore in a foresight exercise? Should we not be more precautionary when aiming at seemingly desirable scenarios? It is commonly known that socio-technical change is tied to a wide range of uncertainties and ambiguities that cannot be fully anticipated (cf. above). While on the one hand (over-) optimistic expectations may be important to increase the momentum of a topic in public or political discourse, a naïve belief in these expectations may lead to a misallocation of resources and create deep disappointments at a later stage.
- A third main shortcoming of foresight relates to the "impressionistic" nature of many foresight exercises, where workshops and expert panels are taken as the main source of information for constructing scenarios. The findings run the risk of being not sufficiently rooted in a scientific base, where the best available and often diverging sources of knowledge ought to be brought together in an explicit way and their contributions to be positioned in a comprehensive framework.[7] A fact-based foundation is thus as crucial for the credibility of foresight as a critical assessment of the sources of knowledge. Therefore, a consolidated integration of analytical and exploratory scientific methods (e.g. system analysis and modelling) on the one hand and of participatory processes and interactions with experts and stakeholders on the other would help enhance the scientific credibility of foresight results.

[7] 'Environmental Scanning' along the lines suggested by Slaughter [15] and Voros [16] is an example of such a far more comprehensive framework than what is applied in most current foresight exercises.

Finally it should be pointed out that this criticism against what we sometimes call "conventional foresight" has very much to do with the understanding of innovation as complex and interactive processes. The even more traditional technology foresight standpoint developed from a more linear understanding of innovation does handle many of the challenges we discuss excellently (using best expert knowledge, regular updating to inform sequential decision-making). But this of course within the confines of linear innovation processes.

2.2. Adaptive planning

The type of (self-)criticism levelled in the closing part of the previous section is in no way new to the foresight community, and remedies are currently being proposed in a growing literature on "good practice".[8] However, it is our contention that in all three respects it is particularly useful to draw on insights from adaptive planning (AP). This approach, in our experience, is not well-understood by the foresight community, and therefore we claim to provide here a novel integrative framework for taking on several of the main weaknesses of current foresight practice.

As regards uncertainty, adaptive planning suggests postponing decisions until we know more about the usefulness of different options that are kept open in the meantime. It thus enables adapting swiftly to changing circumstances. Typically, of course, this comes with a price.

Secondly, as regards the demand to provide advice on how to actively shape the future, adaptive planning provides a framework for developing forward-looking strategies and options for individual actors.

Thirdly, adaptive planning takes into account the accumulation of knowledge and thus – at least over time – should be able to overcome the "impressionism" of conventional foresight, while on the other hand not capitulating to the conventional wisdom as might be the case if too harsh requirements to build on well established scientific results are imposed on foresight. At the stage of impressionist knowledge, adaptive planning thus recommends only guarded action, but by being sensitive to the degree of maturity of knowledge, it suggests more offensive action at later stages.

Adaptive planning (AP) as one of the constituents of Adaptive Foresight belongs to a strand of strategic planning that stresses the limitations to both foreseeing and controlling future developments. This strand of thinking has been developed by many researchers and practitioners over a considerable time-span. Unfortunately there is little concord on terminology and consequently a tendency for each author to start afresh. One explanation for this state of affairs is the proximity to commonsense thinking and everyday usage of terms like "robustness", "flexibility", "adaptivity", "agility", "resilience", etc.

Somewhat developing the conceptualisation by Eriksson [19], we will operate with the terms "robust" and "adaptive" as the highest level concepts. However, "flexible" will also be afforded a distinct role.

A key dichotomy to adaptive planning is the one between one-stage vs. sequential decision-making. The decision-making we have in mind here is of strategic character, i.e. it deals with issues like what assets to acquire as opposed to the operational decisions on how to deploy and use available assets. (Note that we have chosen to pursue this general discussion in the context of systems that deliver tangible products and services like fire protection, rather than in the context of innovation and technology development.)

[8] See in particular the online guide of the EU ForLearn project (http://forlearn.jrc.es/guide/0_home/index.htm), the FOREN guide [17] and the UNIDO Technology Foresight Manual [18].

2.2.1. One-stage decision-making, robust and flexible options

While much single-stage decision-making, naturally, takes place under full realisation that subsequent decisions will follow, it is surprising how not-so-old, authoritative texts on the subject fail to explicitly include sequential decision-making as a way for dealing with uncertainty.[9] Doing so they turn down to include in a rational decision framework, as an alternative or complement to various one-shot decision options, the possibility of sequential decision-making, designed to exploit progressively improved understanding as time goes by.

Combining insights on limitations to foresight (used here as an everyday term) and control, and the choice to at least theoretically rely on one-stage decision-making, one is led to an approach that first tries carefully to map available decision options as well as possible future developments. Typically scenarios of some kind(s) play a role in this mapping. Finally a solution, i.e. a single or, more typically, a package of decision options, should be designed such that it, if adopted, can be expected to work reasonably well across the whole identified span of possible future developments. It is well in line with everyday usage to term such a decision package solution *robust*.

However, at the level of options it is sometimes useful to make a distinction between two key dimensions: robustness and flexibility. Then we reserve the term 'robust' for options having the additional property of being *passive* or *fixed* in the sense that they do not require (human) monitoring of future developments in order to function under different future developments. Note that robustness at package level can be achieved by fixed options that are by themselves not particularly robust. But if a large span of uncertainty has to be considered, such a robust package solution entirely based on fixed options is typically very expensive — if at all possible.

This leads to considering non-fixed options. In the context of one-shot decisions these are *flexible* options. Such options may be acquired by a one-shot decision but do require active monitoring – and indeed decision-making, however of an operational as opposed to strategic nature – to perform their intended functions in the face of uncertainty.

By way of a simple example: In the face of the uncertainty that a fire might break out in one's house at some future point in time, one may opt for robust solutions in terms of insurance, built-in fire protection, acquisition of fire alarm and sprinkler systems etc. Another type of robustness is the one provided by a fire brigade. Here the hardware – the stations, the engines, the command and control systems, etc. – can be seen as fixed components. However, they will be of no value unless accompanied by the flexibility inherent in a well-trained cadre of fire-fighters.

2.2.2. Sequential decision-making and adding adaptive options

The fire example is also useful for starting off the discussion on one-shot vs. sequential (strategic) decision-making. In the context of that example there is obviously no scope for sequential strategic decision-making in the sense of acquiring fire-protection assets once information on a beginning fire starts coming in…[10] Instead any strategic decision-making has to take place well in advance of receiving

[9] An example is the Handbook of Systems Analysis from the 1980s with only quite cursory remarks on the subject ([20, p. 240], [21, p. 259f]). On the other hand, the most cited pioneering work on sequential decision-making was published as early as 1968 by Gupta and Rosenhead [22].

[10] This does not, of course, rule out that sequential strategic decision-making might be highly relevant to, say, investment planning for fire-fighting.

information on any particular fire and consequently it will have to build on more generic knowledge on different sorts of fires, their probabilities and the like.

Innovation, however, is not particularly like a fire in this regard. Rather, innovation processes tend to be drawn-out affairs with big opportunities to learn and reconsider over time. It is here and in other domains with similar characteristics – e.g., energy production systems or national security – that *adaptive* options should be added to the fixed (either robust in their own right or contributing to package level robustness) and flexible ones. By this we mean (in the world of more tangible products and services) decision options that do not in themselves amount to tangible operational assets but create the possibility to later acquire such faster, less expensively, or with greater probability of success than otherwise.[11]

Adaptive planning then is strategic planning that handles uncertainty by considering robustness, flexibility, and adaptivity within a common framework. A proposed package of decision options resulting from an AP exercise will typically consists of both robust (fixed and flexible) and adaptable parts.

Turning more specifically to innovation and technology it must first be observed that many of the neat conceptual distinctions useful for, say, infrastructural systems here turn fuzzy. Few truly fixed options are useful, e.g. no innovation-oriented research programme can be successfully sustained for a longer period without skilful management. And whether that management counts as operational or strategic – key to distinguishing between flexible and adaptive options – is not so easy to say.

Still we have found it quite practical in RTI policy to distinguish between robust and adaptive technology options, i.e., respectively, technologies that can be seen to be useful for a wide range of future conditions and those that may be worth pursuing because they are valuable in certain futures but not in others. But here too the reality is often more complex. For example, many technologies embody characteristics of both robustness and adaptivity, i.e. in general terms they are beneficial in all scenarios, but their specific shape depends on the conditions of the respective scenario. In fact, many technologies tend to have a double-edged character, because they can be beneficial under certain circumstances and detrimental under others. It will depend on the context of use and on often politically defined framework conditions what kind of impact they will have. Embedded systems, to take an example from the information and telecommunication technologies, are expected to have a very positive impact within an optimistic information society scenario. The same technology, however, can be abused in a 'big brother' type of scenario when used for invading the privacy sphere of individuals.

The matter is further complicated by the fact that policy options can have an impact at different levels. For instance, they can refer to the promotion of individual technologies (e.g. an R&D programme) as well as to the structural settings of the innovation systems (e.g. liberalisation of energy supply). Moreover, the impact and effectiveness of policies depend on their time of implementation.

2.2.3. Portfolios of options

We have so far used the term "package" to catch the need to combine a number of elementary options to achieve a robust, and perhaps adaptive, solution. Such a package can be of two different types. Early frameworks for strategic planning build on a structural approach: Typically a handful of alternative structures – a type of visionary scenarios – are constructed and then tested against, e.g., external scenarios of some type. In a one-shot exercise, the idea is to find the most robust such structure, perhaps a combination of those originally envisaged achieved by "buying and selling" elements between structures. In a sequential planning exercise the typical approach is to try to construct a first-period structure that is

[11] Sometimes an adaptive option can be inherent in an operational asset.

adaptable enough to allow the second-period decision to go for any of the considered visionary structures at reasonable lead-time and budget.

While this is a natural approach, e.g. when considering the development of a highly integrated production facility like a steel plant, it is hardly appropriate in all situations. In particular the increased modularity of technological solutions that is a key tenet of the "network economy" is an argument for considering elementary options as more loosely coupled. This suggests an approach more inspired by portfolio selection in financial economics. However, it must be kept in mind that despite advances in modularity, real options display much more complex patterns of interrelation than do financial instruments.[12] This has to be considered in a successful AP framework.

2.2.4. Commitment vs. opportunism

A final problem area to consider in connection with AP is commitment and entrenchment. These are often the same thing, viz. such that entrenchment is when other actors are committed to something that I dislike…

Adaptive strategies can be said to be strategically opportunistic, and in technology and innovation policy they are sometimes criticised on the ground that they fail to provide the commitment necessary for, e.g., business actors to involve themselves with an emerging technology, which is in turn often a precondition for it to mature through learning-by-doing and learning-by-interacting.[13] This is a valid comment, to which we have a three-fold reply:

- History abounds with examples of failed attempts at promoting, e.g., new energy technologies through early policy commitment [27].
- Adaptive planning does not mean to keep all options open as long as possible. Rather it is to carefully strike a balance between strategic commitment and strategic opportunism, e.g. in view of the above bullet [19].
- Adaptive options in technology and innovation policy should be seen not only as laboratory RTD, but can also include pilots and demos and other activities to enable learning-by-doing and learning-by-interacting.

3. Adaptive Foresight: predecessors, principles and processes

3.1. Early attempts of bringing together foresight and adaptive planning

The preceding section outlined the conceptual foundations of Adaptive Foresight. The term "Adaptive Foresight" itself was introduced only recently [28,29] but it is based on experiences made by the authors over the past ten years in a number of European and national foresight and policy strategy processes. To briefly sketch its prehistory, the first inspirations for Adaptive Foresight can be traced back to the EU-funded project FANTASIE,[14] where the complex forecasting and assessment type of approach initially

[12] Dixit and Pindyck [23] and Copeland and Antikarov [24] have prepared two very useful texts on real options theory.

[13] See for instance the emphasis put on learning processes in protected spaces which is core to the approaches of Strategic Niche Management [25] and Transition Management [26].

[14] FANTASIE — Forecasting and Assessment of New Transport Technologies and Systems and their Impact on the Environment, a project funded by European Commission and conducted between 1996 and 1999 [30–32].

planned proved difficult to pursue to the letter. Another experience that led the way towards Adaptive Foresight was the use of scenario methodologies in the first Swedish National Foresight exercise.[15] Based on these experiences, the first two projects designed according to an embryonic version of the AF approach were ICTRANS[16] and the Nordic Hydrogen Energy Foresight.[17] Also the priority-setting approach of the EU-project FISTERA adopted elements of AF.[18]

In parallel, experiences were made with Strategic Niche Management[19] and Transition Management[20] as approaches to devise forward-looking policy strategies for long-term transformations of infrastructure and sectoral innovation systems towards sustainability. These projects focused on strategy and programme development in research, technology and innovation policy, and stressed the interdependencies with other policy areas and other innovation actors.

Finally, and most recently, several projects have been conducted in the Austrian context, dealing with strategy development for research, technology and innovation policy at national and regional level.[21] These projects stress in particular the need to understand Adaptive Foresight as a continuous monitoring, exploration and adaptation process and to move beyond collective and participatory foresight processes by also considering targeted and "closed" process elements in order to bring foresight fully to bear on decision-making.

3.2. Principles and process of Adaptive Foresight

"Adaptive" in Adaptive Foresight can be usefully understood in at least three different ways:

- Adaptive with respect to the balance between the ability to shape and the need to adapt to the future. This is a key tenet of adaptive planning. Conventional foresight approaches have tended to stress the ability to shape the future by initiating participatory processes involving key actors, while underestimating the influence on the future course of events of external developments that are beyond the influence of these actors. Especially from the perspective of small countries the adaptive element is crucial for devising policy strategies.
- Adaptive with respect to the need for making foresight an iterative monitoring and learning process to adjust visions, goals and an strategies at different levels to actual developments in reality. Also this is an immediate consequence of and an input into adaptive planning.
- Adaptive with respect to the balance between participatory elements and closed internal processes. This realist perspective on policy support is more an insight emerging from practical experience as will be outlined in what follows.

[15] For the methodological aspects of the first Swedish National Foresight exercise, see Eriksson and Stenström [33].
[16] ICTRANS — The Impact of ICT on Transport, a project funded by the DG JRC-IPTS and conducted by the ESTO network in 2002/2003 [34].
[17] For the Nordic Hydrogen Energy Foresight, see Andersen et al. [35].
[18] FISTERA — Foresight on Information Society Technologies in the European Research area was funded by the European Commission between 2002 and 2005 [36].
[19] This approach was developed in the context of an EU-funded project SNM-T. See for instance [37,25,38].
[20] Experiences with the approach of Transition Management have been made in Austria and in particular in the Netherlands [39,26,40].
[21] At the moment, two projects are about to be finalised at national [41] and regional level [42] in Austria. A predecessor project at national level was conducted in the area of transport technology policy [43].

It should be clear from the two last bullets above that Adaptive Foresight does not come with a one-size-fits-all implementation. Also it is still quite young a practice. Therefore, any process outline must be seen as provisional. With these caveats, we do believe AF to be a good answer to many of the queries currently harboured in and around the foresight community. Therefore, to help disseminate the approach this section is devoted to a process outline. To serve this purpose the outline strives to be as hands-on as is possible within the limited space available.[22]

3.2.1. Relationship to clients and stakeholders

Adaptive Foresight is designed to help decision-makers develop strategies. You can do a research project using many of the ideas from AF, but the full benefits can only be realised in a consultancy project working closely with a client. Typically this direct client acts on behalf of a broader and less well-defined entity, which we call the *addressee*. For example the client could be the director of a particular division of an Austrian ministry or the project leader of the Swedish national technology foresight (a consortium consisting of several governmental, industry and labour organisations), and the addressee, respectively, Austrian federal innovation policy or the Swedish national innovation system. This situation indicates that the political setup around an AF project can be rather sensitive, potentially involving many stakeholders of which some represent other – and equally legitimate – aspects of the addressee than the direct client.

Especially when it comes to defining policy strategies, where the fundamental orientations and guidelines for policy need to be discussed as a basis for triggering and framing more specific initiatives, it is extremely difficult if not impossible to involve a broader audience. Hidden agendas and political bargaining position cannot be discussed in an open, not to mention public, setting. This holds for private firms as well as for government bodies. On the other hand, these debates are essential for consolidating forward-looking insights and making them effective in policy-making. For the sake of bringing foresight to bear on policy-making, we argue that it is necessary to set up policy-preparing exercises that are of a rather closed nature as a complementary element to public and participatory foresight exercises. Although current foresight practices recognise the importance of client and policy orientation, the explicit inclusion of "closed" settings as part of foresight methodology is still uncommon among foresight practitioners, and not widely accepted among policy-makers, either.

In early phases of opinion-building, open consultation and participation are necessary to exchange information, define key dimensions of concern, and improve our ability to sense and assess future developments in their socio-economic and technological dimensions. At later stages, however, when individual actors need to make up their minds about their strategies and concrete decisions, such forward-looking consultations need to be kept internal to the client organisation[23] in order to protect its knowledge and improve its ability to act. These internal processes need equally the support of foresight specialists and should thus be considered more explicitly by the corresponding communities. Finally, when it comes to implementing strategies, an opening up of forward-looking processes may be necessary again, for instance in order to ensure coordination and cooperation between different actors and stakeholders.

[22] An alternative, more theory-led, presentation of AF can be found in [29].

[23] There may be situations where AF practitioners can give this type of support to several participants of a foresight exercise. But this of course requires that there be no direct conflicts of interest and that the original client gives his full consent.

3.2.2. Phase 1: initial analysis and review

Before looking ahead, it is necessary to conduct a solid retrospective analysis of the field of investigation, i.e. of recent and current developments along the lines of the perspective on complex innovation processes. This phase is conducted through back-office work, discussions with the client and perhaps interviews with a limited number of other experts and stakeholders.

And even before starting such analytical work, two initial clarifications need to be achieved — or at least begun. First of all, one needs to clarify the *focal issue* of the strategy development exercise, i.e. the main question or problem that the addressee of an exercise would like to have tackled. In government-led exercises, these focal issues are usually related to societal goals at fairly aggregate levels ("How can we achieve an overarching transition towards a more sustainable energy supply system?"). In the private sector, focal issues can be much more specific, dealing for instance with the future positioning of a firm or key investments to be made.

Secondly, the *analytical boundaries* of the innovation system that determines the evolution of the focal issue need to be clarified. Here we find it useful to distinguish between factors under the control of the addressee, those that s/he can influence but not control, and those entirely external, i.e. beyond the addressee's influence. Although these dividing lines are seldom unambiguous in the type of policy development situations AF has so far been used for, they are generally quite enlightening at a conceptual level.

It is our experience that a good initial focal issue is important for a successful first workshop, while analytical boundaries have their relevance more in the back-office work and therefore can more easily be reconsidered during the process.

There are several typical elements and aspects that need to be addressed in the course of an innovation system analysis[24]:

- Actors;
- Interactions and decision-making processes; which are framed and guided by
- Organisational and institutional structures, e.g. with regard to the internal organisation of the addressee or relevant market and regulatory conditions;
- Socio-technical knowledge base, i.e. the entirety of the distributed knowledge that is available to the different actors;
- The process dynamics, by which these different elements of innovation systems are coupled.

3.2.3. Phase 2: drafting of exploratory framework scenarios[25]

The first forward-looking and interactive element of an AF project is typically a workshop with experts and stakeholders. Depending on the available time such a workshop can be used to start off several of the phases, but exploration of external drivers[26] is always a useful exercise to include in such an initial workshop. After all, it is external developments that drive the need for adaptation.

[24] The understanding of innovation systems analysis as used here is based on the conventional actor-oriented approach as pioneered by Freeman [44] and Lundvall [45] in the late 1980s and early 1990s, which has undergone a number of modifications in the meantime. More normatively oriented, functional innovation systems approaches take a different stance on innovation system analysis [46].

[25] The methodology outlined in this section is largely based on the so called Shell/GBN tradition [47]. The workshop methodology is also inspired by Eden and Ackerman [48].

[26] As mentioned under Phase 1 this boundary is not always clear and there is no point in policing it sternly. It is, however, important that participants do devote considerable attention to truly external developments.

While there are many ways to use such knowledge, the alternative preferred in AF is to develop a set of *multifaceted framework scenarios* (also known as context or external scenarios). The reason for this preference is that such scenarios can, in a way useful also for non-experts in innovation research, convey the notion that the complex innovation system logic discussed above may develop over time in alternative, qualitatively different, ways. In order to be useful a set of scenarios should be:

- Relevant with regard to current strategic issues. Even though scenarios depict future developments it is current policy-making they shall inform.
- Plausible in the sense that they start from (aspects of) the current situation and develop in ways consistent with established knowledge.
- Challenging in two different ways: each scenario should present interesting strategic issues, and the whole set of scenarios should represent the full range of most salient such issues as well as possible (for tractability the number of framework scenarios is normally held at just three or four). Ideally all scenarios should present an interesting mix of challenges, rather than being "good" or "bad".[27]

An external drivers' workshop is performed in a structured brainstorming format where participants first get to "upload" their ideas on drivers. This can be done in a verbal dialogue where the facilitator(s) in a *tour de table* format asks each participant at a time to enter a new idea, which the facilitator captures with a broad bullet-point marker on, e.g., an oversize Ovalmap post-it[28] and posts it on the wall such that all participants can read it (which means that sitting around a table is not a useful configuration). An alternative or complement is to let participants write down their own postings and post them. This should be done continuously to allow other participants to develop and respond. After this brainstorming phase the input is clustered and the participants invited to prioritise by voting, e.g. using little colour stickers. In the case of external drivers it is often useful to have participants distinguish between drivers that are important and stable (say, green stickers) and those that are important and uncertain (say, red stickers).[29] Obviously, these "manual" techniques can also be replaced or enhanced by the use of electronic workshop tools.[30]

After discussions in plenary and possibly syndicate work, which may deepen insight on the drivers and modify the priorities, the highest priority factors – and particularly those of the uncertain type, which are likely to create trend-breaks – form a useful starting point for drafting framework scenarios.

Before the actual sketching, for high quality at least one additional work-step is required. One possibility is to perform an additional brainstorming session where participants are asked, typically in small group, to devise little storylines that combine in interesting ways prioritised uncertain drivers. Scenario skeletons can then be derived by clustering such storylines based on consistency — the so-called *inductive* approach.

The *deductive* alternative is to analyse systematically the "scenario space" spanned by the most prioritised uncertain drivers. This should be done in a small group, not as a plenary exercise. It will then typically turn out that some such variable combinations are unlikely (i.e. more or less inconsistent), others hard to distinguish from other scenario candidates and therefore not so useful. It is also useful to start

[27] These criteria for good framework scenarios are developed based on a set of criteria often used in the Shell/GBN tradition, see e.g. [47, p. 187].

[28] Available on www.ovalmap.com.

[29] A dozen tokens of each colour to place freely among clusters is often a practical number.

[30] See for instance the experience made in the context of the project FISTERA (Foresight on Information Society Technologies in the European Research Area) [49].

identifying a hierarchy of driving variables such that some are seen as more fundamental/independent and others as more derived. Sometimes it is useful to present this work in the form of a "scenario cross", i.e. a 2 * 2 matrix in two selected variables, or some alternative such crosses for different variable pairs. A problem with that, however, is that some participants may get the fallacious impression that the two variables of the cross are the only independent ones.

3.2.4. Phase 3: specification of exploratory framework scenarios

In either of the cases at the end of Phase 2, the scenario ideas need much additional development. Often the scenario ideas are developed further at the initial workshop in syndicate work where each group takes care of one embryonic scenario. Here it is useful to shift between a more creative storylines approach and a more systematic one, starting to specify each scenario in terms of key drivers and other descriptors of relevance to the focal issue.

However, the work of scenario specification must always be continued back-office after the workshop. A part of this work is to sharpen the driving logic of each scenario and the contrasts in this regard within the whole scenario set. This is the key to making the scenarios challenging. Often it is also necessary to further research the key scenario variables and their relationships through literature study and expert interviews. This is to ascertain plausibility. This work may also be usefully supported by (normally simple) simulation models. It is not uncommon that the scenario ideas derived at the workshop have to be considerably modified at this stage, but it is important to do so only for good and explainable reasons in order to ensure the "ownership" of the scenarios by the participants of the process.

3.2.5. Phase 4: formulation of collective visions and objectives

The normative dimension can also be usefully addressed at the initial workshop. At this point, goals and values of the different actors come into play. A possible starting point is therefore a debate on visions related to the focal issue of the exercise. This is useful in order to clarify shared (or diverging) policy and/or societal goals, ambitions and underlying values of the actors and stakeholders involved. This discussion can be held already before the initial scenario work (Phase 2) or informed by the scenario ideas developed in that phase. The latter is preferred when workshop participants are feared to have a (too) high degree of initial consensus (e.g., "the only thing we need to get innovation going is lower taxes"); then multiple scenarios can help create useful variety. A variant of the structured brainstorming format described under Phase 2 could be used also here.

This phase suggests the dimensions, along which alternative policies are to be assessed against the exploratory scenarios. It is important to consider this in Phase 3, making sure that the scenarios can "answer" the right questions. The visions and objectives are also an important input to Phases 5 and 6.

3.2.6. Phase 5: identification of challenges associated with each framework scenario

The challenges – opportunities and threats – are what connect the framework scenarios with the addressee's area of responsibility. Their exploration could usefully be started at the initial workshop, based on the scenario ideas developed in Phase 2 (and perhaps the beginnings of Phase 3). It should then be further developed in conjunction with the back-office work in Phase 3, and if possible continued at a subsequent workshop when well worked-out framework scenarios are available.

In addition to structured brainstorming, simple gaming can be a useful methodology here to identify how different types of actors could choose to position themselves and interact under various framework scenarios. In back-office work also the same types of simulation models as in Phase 3 can be useful.

3.2.7. Phase 6: identification of collective pathways (multiple backcasting)

A common type of backcasting work in a multiple framework scenarios context is to identify bifurcation points and early warning indicators. This has a role also in AF. But a type of backcasting more distinctive for AF is to identify a "best possible variant" of each framework scenario and key decision points to get there. This approach is useful because it helps capture the "room for manoeuver" available to move towards a collective vision, but within the confines of the respective framework scenarios.

Moreover, by staging the pathways leading to the realisation of different scenarios, it is possible to identify needs for action and intervention that can serve as an important input to the subsequent portfolio analysis. In principle, this stagewise backcasting of the scenario pathways allows also discussing the appropriate timing of policy and other measures, for instance in terms of 'windows of opportunity' for introducing a new technology or starting a policy initiative. By developing consistent pathways, the backcasting exercise represents a second level of testing the credibility of a scenario.

Methodologically, backcasting tends to rely on qualitative methods in order to capture the full range of aspects that can potentially come into play in the course of a scenario pathway, but in particular consistency checks can also be supported by means of quantitative tools.

3.2.8. Phase 7: identification of collective strategies (portfolio analysis)

So far, individual scenarios have been developed, refined and analysed. Each of the scenarios and pathways can be characterised in terms of technologies and policies that have been realised. The options delivered by the scenarios have also been assessed with respect to our focal issue.

From today's perspective, portfolio analysis then looks across the scenarios in order to assess and select those technology options and corresponding policies that promise to be either robust or adaptive (or both). In other words, robust options are fairly easy to identify because they are positively assessed in all or most scenarios. Adaptive options have been identified as part of Phase 6 when possibilities are sought to move the basic scenario in a more desirable direction. Adaptive options are thus either crucial for avoiding major negative impacts or for exploiting specific opportunities in a single scenario. These kinds of insights should then serve as an input for today's policy-makers to prioritise, for instance, emerging technologies and design corresponding policies.

Methodologically, interactive methods can be used to discuss different options from a range of viewpoints. In order to come up with new and fresh ideas for policy options, comparative analysis of other countries' practices can be instructive.

3.2.9. Phase 8: identification of individual objectives, roles and options

As has been discussed above, going from collective work to working with the individual client organisation is a key aspect of AF. The phase-by-phase methodology is, however, not so much affected. Therefore it suffices to say that this is the counterpart at the individual client organisation level of Phases 4–6.

3.2.10. Phase 9: identification of individual strategies (portfolio analysis)

In analogy to Phase 8, this is the counterpart at the individual client organisation level of Phase 7.

3.2.11. Phase 10: realisation and coordination

Developing policy options and portfolios, and even policy strategies is just an input to actual policy design and implementation. In other words, so far we have been mainly discussing the early phases of the

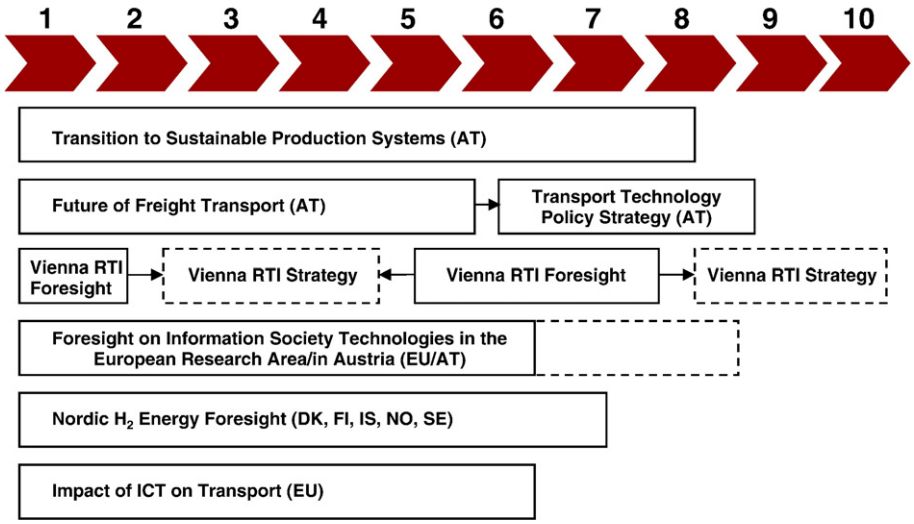

Fig. 1. Positioning recent forward-looking activities in the framework of Adaptive Foresight.[31]

policy process. The actual design and implementation of specific policies, and the learning processes that take place in the course of the policy cycle from design to implementation represent the wider context to which Adaptive Foresight processes are supposed to contribute.

If the principles behind AF are to be effective, they thus need to be closely tied not only to policy design, but also to policy implementation and learning, at strategic as well as at operational level. More specifically, the experiences made in the course of hands-on implementation need to be monitored and fed back to strategy development. In other words, AF should be interpreted as part of a broader continuous learning process that comprises the implementation and evaluation of specific policy measures as well as a monitoring of relevant developments in policy at large. Strategy development, policy design, implementation and learning should thus not be understood as distinctly separate phases but rather as a continuous process of mutual adjustment. This adjustment refers to goals and objectives, to the identification of new socio-technical options, to the growing knowledge and understanding of their impacts, to the design of new types of policy options and to their integration into portfolios.

One of the main difficulties of this kind of strategic approach to policy-making consists of the fact that all actors involved are autonomous and can recur to individual strategic and adaptive (and thus interdependent) behaviour. This is why issues of policy coordination – both between different policy areas and between public and private actors – have started to play such an important role in policy-making. Within such a comprehensive setting, the impact of guiding policy strategies should not be underestimated because in particular public policy strategies fulfill an orienting function for many private actors as well, and in the best case play an implicit coordinating function for their decision-making.

In practice, processes of scenario developments and portfolio analysis will hardly be conducted on a continuous basis but at best be repeated every few years, for instance in line with an update of the overall technology and innovation policy strategy. The practical tools and methods are available, based on many

[31] For Details on these projects, see footnotes 14–21.

years of experience with foresight, adaptive planning, evaluation and monitoring; what is still missing is the integration of these methods in a continuous and long-term strategy development process.

Fig. 1 summarises important experiences thus far with AF, based on selected Austrian, Nordic and European projects in which the authors have been involved. These projects cover a range of different application areas like production systems, transport and mobility systems, regional innovation systems, information and communication technologies and energy technologies. Some of the processes indicated are currently still about to be finalised or being implemented. The figure shows to what extent the ten phases of the AF model have been covered in this selection of recent foresight projects. Real world implementations of AF do not necessarily contain all process steps. Especially the "individualised" phases 8 and 9 as well as the implementation phase 10 represent emergent developments, which have not been tested frequently yet.

4. Adaptive Foresight: assessment and methodological challenges

In a nutshell, we see Adaptive Foresight as a promising attempt to circumvent the aforementioned Collingridge Dilemma. More specifically, we believe that it is powerful in overcoming some of the shortcomings of conventional foresight by adopting notions of adaptive planning:

- it strengthens the rational basis of decision-making by capturing often implicit assumptions, expectations and underlying values about the future explicitly in different scenario images and corresponding pathways;
- it makes forward-looking policy strategies more realistic by acknowledging the limitations to actively shaping the future, as reflected in the notion of adaptive elements in strategies and path-dependence in the context of scenario development;
- it is defensive in accepting the need to adapt to external developments beyond a single's actors influence, and offensive by keeping options open until their time has come (or they can be discarded);
- it enhances the effectiveness of forward-thinking by including both collective and single-actor processes, even if some typical difficulties of foresight processes (e.g. number and selection of participants, influence of opinion-leaders, etc.) remain;
- it supports strategic thinking about portfolios of options across different scenarios and during different phases of the policy cycle.

However, Adaptive Foresight is still at an early stage of development and testing. Further development of the approach is needed particularly in the following three respects:

- The AF approach as outlined in this paper is based on experience from small developed countries. But the basic argument, we contend, nevertheless applies also to large countries. In a globalised and interdependent economy, not even the largest countries are in a position to fully dominate technological development, but need to be prepared to respond to unexpected developments.
- The notion of adaptivity seems also very relevant from the perspective of developing countries that strongly depend on foreign markets and technologies. While the general process model outlined above may serve as an orientation, the question remains open of how to design AF processes that are in line with the specific situation of a country. More specific and differentiated guidelines are needed that build on a broader range of practical experiences with the AF approach.

- AF offers a learning framework rather than just an impressionistic one. It allows adapting to the advancement of knowledge in the course of an AF process, especially when designed as a "rolling" or continuous activity over many years. However, this ability to take continuously on board new insights still needs to be built explicitly into the process, both within individual AF cycles and along the implementation of several such cycles. Looking at the experiences made so far, this has not been achieved, not the least because most AF-inspired processes have been conducted quite recently and in general as "one-shot" activities. Models still need to be developed of how to establish AF as continuous learning activities within public and private institutions.
- The strength of AF could be further enhanced by building – where appropriate – on new modelling approaches. An example in this spirit is the Pardee Center at RAND who work with large scale modelling of what they term deep uncertainty represented by very large scenario sets, sometimes over periods of hundreds of years [50]. This work is conceptually akin to AF but the financial resources necessary for this approach are rarely available in the settings we are used to working in. We also tend to prefer a larger role for verbal reasoning as opposed to mathematical modelling when it comes to capturing the intricacies of innovation. Still, computer assistance for managing and navigating the complex information bases that adaptive planning necessitates should be a priority.
- Another issue is bringing the real options approach to bear at more than just the conceptual level. So far, thinking in terms of real options in the context of foresight is still in an early stage of development. Such applications are well in line with early ideas on using real options for bridging the gap between strategic planning and investment [51]. Since then, the development in the field has been targeted towards less complex applications in the corporate sector (e.g. exploitation of raw materials). First attempts to evaluate research portfolios systematically from a real options perspective have been made [52] — this is at least potentially a step towards greater complexity. Only a fraction of the efforts have been spent on even more complex societal applications. One implication of this is the tendency to use forecasts — i.e. a predicate, rather than an explorative approach to future uncertainties. Therefore, one of the challenges is to merge a methodological approach emphasising structural uncertainty with a real option analysis without the necessity of an optimal market.

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