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“All who claim to foretell or forecast the future are inevitably liars, for the future is not written anywhere – it is still to be built.” (Godet and Roubelat, 1996), p. 164

I. Introduction¹

The purpose of this report is twofold. To begin with, it seeks to set out the objectives of, and methodologies for, the development of socio-economic and environmental scenarios for the European Union up until 2050 and thus attempts to lay some of the groundwork for scenario development itself. In addition, the report undertakes to place scenario building in a wider political and socio-economic context by discussing the objectives and limitations of scenario building and by explicating the role of scenarios in policy making.

The report is structured as follows. In section II, the report compares forecasts and scenarios with a view to highlight common aspects and differences, both from a conceptual and a practical point of view. In section III, the report discusses in more detail the purpose of scenario building against the background of the policy objective to reach sustainability. Section IV, finally, examines some of the methodological issues involved in scenario building and sketches out how scenarios can be built in a meaningful and feasible manner.

It should be emphasised that the report is largely exploratory in nature. That is, it seeks to identify critical issues and questions but does not claim to provide definitive answers or solutions. The report is, in this respect, akin to one of the key purposes of scenario building itself. Accordingly, scenarios are not only developed as long range planning tool, but also with a view to foster and facilitate communication and reflection (Bradfield, et al., 2005).

II. Forecasts vs. Scenarios

1. Distinguishing forecasts and scenarios

A common distinction between scenarios and forecasts turns on the fundamental purpose of both types of exercise: forecasts seek to predict future events. They claim to foretell what will or, at least, is likely to happen in the future, weather forecasts and business cycle forecasts being perhaps the most common examples of this kind. Scenarios, on the other hand, seek to identify what may plausibly happen without attaching, as a rule, a certain probabil-

¹ This report owes a lot to the fruitful discussions which the first author had with Rob Maas during his stay at IES. Helpful comments from several colleagues are also gratefully acknowledged.

ity to any specific event (de Jouvenel, 2000).² Thus scenarios describe future situations and the course of events or actions which can take society (or any other social entity for that matter) from the initial state of affairs to a future situation (Bishop, et al., 2007, Godet and Roubelat, 1996). As a consequence, forecasts can be falsified by actual events while scenarios cannot – unless, of course, the underlying assumptions of the scenario are exactly met because that would then indicate that some of the causal relationships postulated by the developer of the scenario were weaker or even non-existent. Scenarios remain therefore plausible no matter whether future reality has any resemblance with a scenario or not. Plausibility only means that a scenario does not contradict our current knowledge about nature and society. Hence the number of plausible scenarios is also much greater than the number of likely forecasts (unless the likelihood of each forecast is allowed to assume arbitrarily small values).

Although the distinction between probability and plausibility as distinguishing hallmarks of forecasts and scenarios respectively is not always adhered to in practice or even shared by all authors (Godet and Roubelat, 1996), thereby testifying to a grey area between forecasts and scenarios (Börjeson, et al., 2006), it is perhaps the most significant difference. However, there are also other disparities. These disparities relate to the level of detail (which is usually greater in the case of scenarios given that these often take the form of extensive narratives) or the time horizon. Whilst the time horizon of rigorous forecasts seldom goes beyond several months or even years, scenarios may cover up to several decades or even centuries as in the case of population scenarios.

Arguably more essential than the above factual differences appear to be the underlying conceptual divergences between forecasts and scenarios. Forecasts assume that the future is somehow fixed and that, not only but also for this very reason, it can be discovered.³ The objective of forecasts, then, is to be able to respond proactively to impending events with a view to lessen their (negative) impacts or benefit from the opportunities they provide. Forecasts seek, in that sense, to reduce uncertainty and chart out the territory through which mankind is going to wander on its predetermined path to eternity. Scenarios, by contrast, are based on the view that the future is nothing that has to (or can for that matter)

² As argued below, plausibility is often used as an indicator of likelihood. Thus more plausible events are considered to be more likely. If this is the case though, then the distinction between plausibility and likelihood may be not as clear-cut as some authors seem to suggest.

³ If the future was not fixed, then there would be nothing to discover in the first place. Still, man may not be able to discover that future because it is somehow shielded from him, for instance as a result of insufficient cognitive capacities.

be unveiled, but something which mankind construct itself (de Jouvenel, 2000, Lindgren and Bandhold, 2003). Or to put it in the words of Bertrand de Jouvenel “in terms of the past, Man’s will is in vain; his freedom, nothing, his power, non-existent, (...) The past is the place of deeds or facts that we can know” (and also interpret in many different ways!). On the other hand, “for Man, as a thinking subject, the future is uncertainty, whereas as for an active subject, the future is freedom and power” (de Jouvenel, 1972) quoted in (de Jouvenel, 2000). Seen from this perspective, scenarios do not seek to reduce uncertainty as there is nothing about which one could be certain in the first place. They do not provide a map but rather the blueprint(s) of a future that is yet to be decided upon (de Jouvenel, 2000) and that, in this sense, is fundamentally uncertain.

The above assumption is at its heart a philosophical conundrum whose solution, if there is any, has strong transcendental connotations, for it relates to the role of man in history: Is man the subject or the object of history? Does man make history or does history make man as it were? Depending on the answer (or the attitude) to this question, the purpose and scope of forecasts and scenarios are bound to change fundamentally: Obviously, the view that man is the maker of history sits rather comfortably with a strong role of scenarios. For a future that is essentially open is also a future that man may shape to his needs and according to some plan. At the same time, there seems to be a fundamental tension between the underlying objective of forecasts, namely to know future events in order to respond to them, and the conviction that the future can be predicted because it is in a deep sense already “given”. That tension stems from the fact that if forecasts allow people to act *differently* or at all (and surely that is the most frequent justification of forecasts), then the future cannot be given either. After all, the more one is of the opinion that the future can be predicted, the less can it be influenced.

Note that this conclusion does not change once the notion of the future shifts from a deterministic to a probabilistic one. As Robinson has noted, this shift did not mute the interest in predicting the future. On the contrary, “the key regulative ideal, and test of legitimacy, of the new sciences was held to be their predictive power” (Robinson, 2003). Yet as Robinson also observes, this predictive tradition ... flies in the face of typical human experience related to thinking about the future, which is strongly goal-oriented” (Robinson, 2003) and thus assumes, if tacitly, that it is up to man to decide how the future is supposed to look like and that man is obliged to make sure his goals come true.

Leaving these somewhat philosophical issues aside for a moment, there are also more pragmatic reasons for being sceptical about forecasts. In the remainder of this chapter, these limitations shall briefly be discussed. As it turns out, some of the above concerns will be further strengthened while in other respects, the distinction between forecasts and

scenarios becomes less clear-cut. Moreover, there are reasons to suggest that scenarios face problems of their own which, if overlooked or downplayed, seriously hamper the meaningfulness of scenarios.

2. Limits of forecasts

There are at least five aspects which render forecasts difficult to make and which may threaten their very reliability:

- Complexity of systems
- Insufficient knowledge
- Role of human volition
- Surprise events
- Reflexivity of knowledge

Complexity of systems: In complex systems, the interrelationships and dynamics are often poorly understood and even more difficult to model. In this light, the widely adopted *ceteris paribus* condition can hardly be claimed to hold in the context of policy appraisals (Nijkamp, 2007). Moreover, the boundaries of the system under investigation may not be known with sufficient accuracy and this imposes further limitations on the predictability of its behaviour. Last but not least, prediction is often done following a reversed logic of explanation. That is to say, a model that is able to explain the present correctly (on the basis of a set of assumptions and law-like relationships) is then used to predict the future by inserting a somewhat modified set of assumptions for the point in time for which the prediction is to be made (“if assumptions x , y or z hold, then events a , b or c will or are likely to occur with probability p_a , p_b or p_c ”). However, in complex systems, the former may be impossible right from the start. That is, it may never be feasible to model complex systems comprehensively and hence explain fully why such systems behave the way they do. But if this is the case, then predicting the future on the basis of such an incomplete model is likewise bound to fail (Batty and Torrens, 2005)

Insufficient knowledge: Many drivers and parameter values are unknown or difficult to estimate, either because of data limitations or because of uncertainty about the “true” model. Hence, unbiased estimates may only be obtained if the true model is known but this begs of course the question of how the true model looks like in the first place. Concomitantly, econometric estimates can only be as reliable as the data which have been used for their calculation. Thus sampling and reporting errors, data gaps or non-existing data for important parameters or variables render estimation difficult if not impossible and are therefore likely to impose limits on prediction as well.

Role of human volition: As already pointed out above, predictions do not only satisfy people's curiosity, they are also supposed to serve as the basis for action. Implicit to this view is the assumption that people are free to act and make decisions which are not fully determined by the present state of affairs and which, for this very reason, cannot be predicted themselves. Human volition brings therefore an element of indeterminacy into the picture, which becomes the more important the further one tries to look into the future and the more decisions can be made.

Surprise events: Related to the previous observation is the notion of surprise events such as 9/11 or Fukushima. Such events, while not predictable as such in any meaningful sense, i.e. beyond saying that they are bound to occur sooner or later, may change the course of (predictable) history in ways which would not have occurred without these events. Characteristically, the probability of any specific surprise event is very small, if it can be determined at all. At the same time, surprise events have by definition a very strong impact (Mietzner and Reger, 2005). Predictions are therefore based on the assumption of a surprise free future, on a future, that is, which contains nothing (or nothing important) which could not have been predicted if only one had tried hard enough. But if this assumption does not hold, then predicting the future faces a considerable dilemma. Arguably, surprise events are the most notorious results of human volition, but natural disasters, technological innovations or scientific breakthroughs can also be, or lead to, surprise events and can have equally far-reaching consequences. To be sure, the definition of what counts as a surprise event is likely to change in the course of time, mainly due to scientific progress and the accumulation of empirical evidence. For instance, improved knowledge about the causes of tsunamis in conjunction with the installation of alarm systems has made it possible to forewarn people who live in risk-zones. Hence, tsunamis have ceased to be surprise events in the way they used to be until recently. But this proviso does not invalidate the point about surprise events as such, it only qualifies its significance to some extent.

Self-reflexivity of knowledge: The last and arguably most challenging limit to forecasts is firmly located in the social realm itself. Following Giddens, it will be referred to as the self-reflexivity of (social-scientific) knowledge (Giddens, 1990). The key point of the following considerations is that people act on knowledge. This knowledge may not be – and indeed mostly is not – scientific knowledge writ large, but a mixture of experience, everyday notions and broad assumptions about how things “work” (Rosenbaum, 2012). Of course, this knowledge may not be fully correct, but usually it is not plainly wrong either. After all, people knew before Newton that apples fall to the ground. Surely, to bring in the notion of gravity and to describe the behaviour of apples in precise mathematical terms is a much better (in the sense of “precise”) explanation of the behaviour of apples than the pre-Newtonian account. But for most practical purposes, our everyday knowledge is sufficient as

it tells people to beware of falling apples in an autumn orchard. Thus even our everyday knowledge has instrumental value, it is in a fundamental sense *action relevant*.

Importantly, predictions too can be directly action relevant knowledge. That is, predictions do not only prompt people to act, they also tell people if implicitly *how* to act. Thus there is a potential link between the subject matter of the prediction (which event or state of affairs is to be predicted) and the implied action (what would be the correct response to the predicted event or state of affairs). Occasionally, this link is rather trivial. The natural response to forecasted rain is to carry an umbrella which keeps us dry, nothing more. However, in other cases the link is complex and the implied actions may even influence the future in ways which either reinforce or undermine the predicted events. Climate policies are a case in point. Thus if, as a consequence of predicted large scale climate changes, policy makers will take decisive action to cut climate gas emissions, then the predicted climate changes may not happen or not to the extent predicted. In the end, it occurs what would best be termed a self-destroying prophecy. The predicted event did not materialise *because* it had been forecasted.

But predictions may also have the opposite effect. Consider that eminent economists predict a recession. What would be the implied action? Of course, the answer to this question depends very much on the actors involved. As for investors and consumers for instance, both groups may become more reluctant to invest or consume because the former are afraid that the planned investments might not pay off in a deteriorating economic environment while the latter reckon that the probability of becoming unemployed might increase and thus the need to make precautionary savings. As for policy makers, the response might be to tighten expenditures or to increase public outlays depending on their objectives as policy makers. But if investors get “cold feet” and cancel investment plans while consumers cut consumption expenditures, then aggregate demand will decline and thus prompt the predicted event, namely a recession. Incidentally, the same reasoning can be developed for an up-swing where the optimism generated by higher forecasted growth may bring about precisely the investment and consumption increases which will generate that growth.

It should be noted that the second example differs from the first in an important respect. While the functioning of the Earth’s climate system is independent of our knowledge of that system, the same cannot be said about the economy. Unlike the climate system, economies are made up of people and institutions, both formal and informal (North, 1991). People and institutions make decisions and behave in ways which depend not only on their objectives

and the constraints they are facing (as traditional micro-theory would have it) but also on their beliefs and convictions including their views on how the economy functions.⁴ Thus the functioning of the economy and our knowledge about the economy are intertwined in ways which do not exist for the climate system. But as Kenneth Boulding observed more than 40 years ago, “where knowledge is an essential part of the system, knowledge about the system changes the system itself” (Boulding, 1966). Thus economics and economic behaviour are interdependent. Indeed, as MacKenzie has observed, financial market theory has provided avenues for arbitrage behaviour which has brought about what the theory has predicted (MacKenzie, 2008). Thus financial markets function the way they do because finance theory has developed tools which, at the end of the day, prompt the behaviour that is implied or predicted by that very same theory.

The upshot of this point is that forecasts have the potential to change the very environment for which they have been developed. They may be verified or falsified not because they were right or wrong from the beginning, but because they induced behavioural responses which *made* them right or wrong.

3. Limits of scenarios

As already pointed out, scenarios aim at developing plausible stories, their aim is not to produce likely predictions. From this it follows that, *prima facie*, the considerations in the previous section do not have the same bearing on scenarios as they have on forecasts. A scenario exercise maintains its validity even in the face of the results of human volition or other surprise events since it does not claim to predict the future. In fact, scenario building may be seen as a means by which the implications of surprise events or human volition can be simulated and hence explored. Thus precisely their partly counterfactual assumptions render these scenarios interesting in the first place.

A similar argument can be made with respect to the implications of complexity and insufficient knowledge. Rather than helping to predict what may be the consequences of perhaps as yet undiscovered (and therefore as such unknown) facts, scenarios may help to gauge the size and importance of such knowledge gaps. The point here is that it is often (if not always) impossible to know what one does not know. And if that is the case, then one cannot know what one would do if one knew, for that would require to know the still unknown. However, it may still be possible to assess the significance of ignorance by assuming – again counter-

⁴ The rational expectations approach acknowledges the importance of expectations but then postulates that economic actors form expectations on the basis of a correct model of the economy. Moreover, this model is assumed to be the model the modeling economist is using for her analysis.

factually – that one possesses knowledge of some kind or another. Thus scenarios can explore the consequences of having technologies which are hitherto unknown but would allow mankind to say, produce energy at zero marginal costs (or fly to Mars within a couple of days for that matter). An example of this kind of study is the book by Robert Laughlin on future solutions to the energy crisis (Laughlin, 2011).

However, there are also some caveats with respect to scenarios. To begin with, it should be noted that likelihood and plausibility are not totally independent concepts. On the one hand, the likelihood of an event may serve as a measure of its plausibility. Thus what is expected to happen given previous experience(s) is more plausible than something else which is not expected to happen (Bishop, et al., 2007), for instance because it never happened before. On the other hand, implausible events are often considered to be unlikely. Because present knowledge suggests that something cannot happen, it is often concluded – and understandably so – that the said event is also unlikely to happen unless hitherto unknown factors intervene. Be that as it may, the point is that unlikely scenarios, even if they are plausible, may not be relevant. Why should anyone care about a scenario which has zero probability of being realised? After all, while available data and current knowledge do impose restrictions on the number and kind of forecasts which can be produced at any point in time (i.e. not everything will be predicted at any given point in time), there are no equivalent restrictions on the number and content of scenarios unless the notion of likelihood is somehow brought in again. Put differently, unless an additional criterion is introduced in order to distinguish between scenarios, selecting among them is prone to lead to rather arbitrary results.⁵

A related point has to do with the notion of path dependence. While plausibility is often meant to denote scientific validity and technological feasibility, path-dependence may still make some scenarios more likely than others: what is possible in the foregoing sense may be factually impossible or extremely difficult to achieve because the required steps cannot be made in time. In other words, what is already in place, be it physically or institutionally, is bound to shape the immediate future in significant ways and arguably to a much greater extent than conventionally assumed. Thus, although cell phones or the internet may have been difficult to imagine in the 1950s and 1960s and although both are having significant

⁵ Arguably, this is the reason why some authors distinguish between possible scenarios, i.e., everything that can be imaged; realisable scenarios, i.e., all that is possible, taking account of constraints, desirable scenarios, i.e., which fall into the possible category, but which are not all necessarily realizable. See Godet, M., and F. Roubelat. "Creating the future: The use and misuse of scenarios." *Long Range Planning* 29, no. 2(1996): 164-171.

impacts on important aspects of human life in developed and many developing countries, many constituent parts of the world in those decades have not changed at all (Bishop, et al., 2007) simply because what was already there in those days continues to impose restrictions on what society can and cannot do today. Just imagine for instance the extent to which the structure of medieval European cities influences the implementation of different transport systems in these cities. But if this is so, then scenarios must not only be plausible, they also must take into account the starting point from which they are supposed to evolve and the implications of that starting point for the chain of events that leads to the conceptualised future. Failing to do so would not strip these scenarios of their meaningfulness; rather it would turn them into a different literary form better known as science fiction.

A challenge that is specific to the development of scenarios given their broader range compared to forecasts has to do with the internal consistency of scenarios. Unlike forecasts which tend to have a narrow focus and make use of only a limited set of models, scenarios may span the globe as it were and may cover a multitude of sub-scenarios for every (or almost every) aspect of human life and the environment. See for instance the book by Raskin et al. "Great Transition - The Promise and Lure of the Times Ahead" (Raskin, et al., 2002). But if these sub-scenarios give more than just a qualitative account of a possible future, then they have to make assumptions concerning the parameters and starting values which the employed models use in order to flesh out the scenarios quantitatively. Moreover, the outputs of one model may in turn be the inputs of another and vice versa, thereby calling for a simultaneous solution of the whole system of models or at least an attempt to approach such a solution iteratively (Jansson, et al., 2008).

In the absence of such a solution and without checking the underlying (tacit) assumptions for consistency, scenarios may be less plausible than their narrative suggests. Checking the consistency of underlying assumptions is therefore a crucial element in the context of scenario building. The paper will return to this issue below.

III. Purpose of Scenario Building

1. General considerations

Scenarios may be developed with various purposes in mind (Bradfield, et al., 2005): For businesses, scenarios may be a long range planning tool that helps them to test business plans in various contexts and under different sets of assumptions. In the context of crisis management, scenarios may provide simulations of future crisis situations with a view to develop strategies that help to deal with such situations. For policy makers, finally, scenarios may serve as an instrument for stakeholder involvement in that scenarios help policy makers to lay out the implications of different policy options ("what if ...") in a comprehensive

and transparent fashion and thus provide a basis for discussing these options with stakeholders. In each case, scenarios may help to organise information (Akgün, et al., 2012) and reveal hitherto unknown dynamics and interrelationships

In a policy context, scenarios may be particularly important for a number of reasons. To begin with, it should be born in mind that policy measures are often bundles of different actions rather than singular items. And these bundles may be designed to address objectives which are in turn multi-dimensional. Hence assessing the potential effects of such policy measures necessitates the development of a comprehensive analysis, which goes beyond the identification of simple cause-effect-relationships between one measure and one objective. Implicit in the previous observation is the possibility that measures may affect more than one policy objective, if only indirectly, and that the effect may be either positive or negative. For instance, measures designed to spur competition may indirectly boost growth, taxes that aim at internalising negative externalities may have adverse distributional consequences or increasing social benefits may improve equality but may also lower work incentives and thus hamper potential growth.

No matter whether these specific examples hold up to closer scrutiny or not, the point is that (1) policy measures may lead to conflicts between different objectives because one objective is achieved at the cost of another objective and (2) they may affect different groups in society differently because costs and benefits are not shared equally. Importantly, moreover, distributional effects are not confined to different groups within a country but may also have a strong spatial dimension in that the natural environment as well as the economic structure may expose countries in different ways to the consequences of policy measures. But if this is the case, then policy makers need to know who is affected by how much and how the picture would change under different assumption and with alternative policy options and time frames. Without being able to provide such a comprehensive analysis, winning political support may be the more challenging the longer the time frame of the proposed measures and the more far-reaching the associated changes.

2. Scenarios and sustainability

Beyond the more general objectives of scenario building in the context of policy making which have been highlighted in the previous section, there are at least three more specific purposes that are of particular relevance from the perspective of sustainability assessments.

The first purpose relates to the assessment of the vulnerability of ecological systems with respects to plausible futures and the resilience to possible shocks or adverse developments more generally. The issue here is whether and to what extent plausible futures are likely to violate certain thresholds which have been identified as being essential for the continuous functioning of the Earth's ecological systems (Rockström, et al., 2009, Rockstrom, et al.,

2009) and to what extent, as implied by the most widely accepted definition of sustainability, meeting the needs of present generations is likely to compromise the possibilities of future generations to meet their needs (WCED, 1987). To give a concrete example, it could be explored what happens (or would be required) if certain emission ceilings were to be introduced with a view to reduce the probability of an increase in mean surface temperatures above 2 degrees Celsius (Pelletier, et al., 2012). Relatedly, it may be asked what happens if such thresholds are violated to a significant degree and whether ecological systems can be expected to return after the shock to the previous equilibrium. If the scope of sustainability analysis is widened to include also social entities, then the issue might be how such entities adapt to, and mitigate the adverse effects of, environmental changes or other constraints which cannot be avoided and how vulnerable these entities would be with respect to fundamental changes to the framework conditions under which they operate.

The second purpose of scenario building in the context of sustainability assessments is to explore the effects of policy choices on the development of possible futures relative to the baseline scenario (quite often the status quo), in particular if the baseline scenario involves the violation of one or several of the aforementioned global thresholds or boundaries. Thus the issue to be examined here is whether these policy choices – if they aim at achieving sustainability as conceptualised previously – are sufficient to avoid the violation of the thresholds or restore a sustainable level thereof, and – if they aim at achieving other policy objectives – whether there is likely to occur a conflict between these objectives and sustainability.

The last purpose, finally, turns the previous one around as it were and seeks to identify possible pathways for reaching policy goals or objectives (backcasting). Thus instead of taking policy choices as given with a view to exploring their consequences, a backcasting approach takes the policy objectives as given, for instance a set of parameter values which purports to characterise a sustainable society, and then seeks to identify the policy choices necessary to achieve these objectives. Seen from this perspective, scenario construction is also an essential component of transition support (Akgün, et al., 2012, Wiek, et al., 2006). Backcasting will be discussed in more detail in the following section.

Note in this context that a long time frame forms part and parcel of any sustainability strategy. This is widely acknowledged in the literature. See for instance the Brundtland report (WCED, 1987). For one thing, it is emphasised that “moving green growth from religion to reality will ... require a technological and economic transformation akin to those of the emergence of steam, rail or information technology. That transformation will not come through a focus on one technology or another, nor through reliance on short-term job creation, nor from abstract appeals to economic efficiency. Rather, it will require attention to

the restructuring of the energy system as a whole, the opportunities present in the transformation for widespread economic activity, and the role that policy must play in structuring and facilitating that systems transformation” (Zsyman and Huberty, 2012). Concomitantly, it is observed that the acceleration of technical, economic and social change necessitates a long-term vision: “the faster you drive the further your headlights must shine” (Godet and Roubelat, 1996). Path-dependence, as discussed above, implies moreover that many decisions that will shape society in 20 or 30 years’ time have already been taken or will be made soon. Hence the finding by Robinson that a scenario time frame of 40 years is often appropriate (Robinson, 2003). Taken together these considerations imply that maintaining a safe operating space for humanity (Rockström, et al., 2009, Rockstrom, et al., 2009) requires considerable lead times which traditional forecasts are conceptually ill-equipped to deal with.

For another, it is argued that sustainable development requires the development of a political constituency which sustains the required social and economic changes (Robinson, 2003). For that to be possible, however, sustainability must become more than a slogan. Voters are only likely to subscribe to a full blown sustainability agenda if they are in a position to assess what the imputed social and economic changes imply for them and their descendants. But that requires in turn that policy makers are able to describe in some detail the “alternative worlds” which they propose to construct, all the more so as these worlds may exhibit features which differ radically from accustomed ways of life in conjunction with trade-offs which may touch upon every aspect of peoples’ lives. This is all the more so once sustainability is to be understood from the start in a more comprehensive manner which covers both social and economic aspects in the sense that criteria for social and economic sustainability are to be defined *sui generis* rather than treating the socio-economic implications of sustainability strategies as mere side-effects of environmental sustainability policies. Not only would this arguably require a multi-attribute welfare concept (Pezzey, 2004), it would also raise the issue of how to deal with conflicting signals from such a set of indicators (Pelletier, et al., 2012). Again, scenarios rather than forecasts constitute the most suitable instruments to address such issues.

3. Backcasting

As already alluded to, scenarios are also important for yet another reason. Although there is still considerable uncertainty as to what a comprehensive notion of sustainability implies, in particular once socio-economic parameters are taken into account together with environmental criteria in a systemic approach, there is by now a rich literature on how to conceptualise sustainability in ecological or bio-physical terms, for instance (as already pointed out), in terms of thresholds or planetary boundaries which humanity should not cross in order to maintain a safe operating space for present and future generations (Muradian, 2001, Rock-

strom, et al., 2009). Given this characterisation, it may then be asked what its achievement within a meaningful time-frame would require in terms of policies, behavioural changes or institutional reforms. Thus which changes would be needed from now on in order to reach the predefined targets, be these global thresholds or more specific objectives, such as transport related emission targets (Börjeson, et al., 2006, Miola, 2011)?

A backcasting approach so conceived has several advantages compared to a scenario which aims at finding an efficient solution to a societal problem, here sustainability, by applying some sort of optimising algorithm in a forward looking manner. First of all, backcasting is not subject to Herbert Simon's critique that optimal solutions are often unknown or unknowable and that satisficing behaviour (the individual level version of backcasting) is therefore the only option (Simon, 1979). What is more, optimising may be too much "entrenched in present solutions, possibilities and limitations" (Börjeson, et al., 2006), thereby blocking the search for innovative solutions and the exploration of alternatives. In particular in a situation where many unknowns are part of the equation (Which technologies are available? Do people's preferences change? How is the global political context?), would such an approach appear rather risky as it would involve placing all eggs in only one basket as it were. Höjer and Mattsson claim moreover that in a backcasting study, there is no need to distinguish between external and internal factors. For only by keeping everything internal without imposing (external) restrictions is it possible, or so these authors argue, to identify factors which are crucial for reaching the predefined targets (Höjer and Mattsson, 2000). In an optimizing study, by contrast, such an approach would be impossible in that optimizing is based on the assumption that some factors can be modified while others remain fixed (constraints). Having said this, some environmental or physical parameters are inevitably external restrictions or constraints. Optimization techniques may therefore still be used as long as their weaknesses are well documented and hypothesis are well suited to the problem at hand.

It should also be noted that backcasting involves a much stronger normative element than does exploratory scenario building. After all, the choice of a suitable characterization of sustainability is an inherently normative exercise which requires, or at least implicitly presupposes, a notion of distributive justice (Pelletier, 2010). Without such a notion, and arguably other normative predispositions, e.g. regarding the notion of welfare, no allocation criteria could be determined in an unambiguous manner. Thus, although they should in principle be based on sound scientific knowledge, sustainability criteria cannot be determined in a purely scientific manner and should not be presented as such either.

IV. Methodological Considerations

1. Is there a common methodology?

The literature on the methodology of scenario building is rather diverse and there seems to be no generally accepted approach. Thus Bradfield et al. observe that opinions differ with respect to the framework to which scenarios belong (e.g. planning, thinking, forecasting, analysis and learning) while pointing out that there is virtually no aspect of scenario building on which there is a consensus as exemplified by contradictory definitions and diverging principles and methods (Bradfield, et al., 2005). Nor is there much theoretical research on scenario building (Chermack, 2005) for that matter, although scenarios may still be distinguished with reference to project goal, process design, and scenario content (van Notten, et al., 2003). Last but not least, the former authors emphasise that there is also a multitude of models and techniques. These range from basically narrative approaches which do without a lot of heavy “machinery” to rather sophisticated exercises which employ computerized techniques at various stages of the process. Bishop et al. for instance distinguish between no less than 8 categories of techniques, each of which comprises in turn several variations (Bishop, et al., 2007):

- Judgement (genius forecasting, visualization, role playing, Coates and Jarratt)
- Baseline/expected (trend extrapolation, Manoa, systems scenarios, trend impact analysis)
- Elaboration of fixed scenarios (incasting, SRI)
- Event sequences (probability trees, sociovision, divergence mapping)
- Backcasting (horizon mission methodology, Impact of Future Technologies, future mapping)
- Dimensions of uncertainty (morphological analysis, field anomaly relaxation, GBN, MORPHOL, OS/SE)
- Cross-impact analysis (SMIC PROF-EXPERT, IFS)
- Modeling (trend impact analysis, sensitivity analysis, dynamic scenarios).

However, no technique is highlighted as being crucial or even mandatory for scenario building. Rather (Bishop, et al., 2007) emphasise that each method has specific strengths and weaknesses which range from the difficulty of using the technique to the degree of creativity it encourages. In addition, techniques may also differ with respect to the outputs they produce (different numbers of scenarios, kernels or logics, probabilities of different alternative conditions, elaborated stories or end-state descriptions etc.).

Are there nevertheless some common conceptual elements? At least certain features are claimed to be broadly constitutive of the ‘scenario method’ namely (i) systems analysis, (ii) retrospective, (iii) actors’ strategies and, finally, (iv) elaboration of scenarios (Godet and

Roubelat, 1996). Yet Gausemeier et al. distinguish five phases of scenario development and management including (i) scenario preparation with the assessment of the decision field; (ii) scenario-field analysis with the identification of key factors; (iii) projections on possible developments; (iv) scenario development; (v) scenario transfer to the decision-field (Gausemeier, et al., 1998) which do not seem to accord with Godet and Roubelat's. Finally, these five phases overlap, but only partly so, with the three steps identified by Börjeson consisting of the generation of ideas and the gathering of data followed by their integration and finally consistency checks (Börjeson, et al., 2006). So even at a more conceptual level, there seems to be only limited agreement on what should or has to be part of a scenario and of the process of its gestation and what should not or has not.

Arguably, the lack of a methodological consensus may also be a virtue. For if the behaviour of a social or human system depends on the context in which the system operates, then any methodological approach which, implicitly or explicitly, is contingent upon that context would run the risk of becoming a straightjacket (Saritas and Nugroho, 2012). In other words, scenarios that are developed using context dependent methodologies run the risk of artificially narrowing down the range of plausible futures. Moreover, modelling techniques are mostly designed to deal with incremental changes, while structural breaks and discontinuities are outside their scope (Börjeson, et al., 2006) or at least much more difficult to model. Yet precisely such breaks and discontinuities become more likely the further scenarios attempt to reach into the future. Thus the existence of these breaks and discontinuities can no longer be ignored. Hence, while pathdependence often ensures that things do not change as much as some "futurists" have suggested, surprise events may set history on a completely different track. And if this is the case, then marginalist or any other type of incrementalist modelling does not take us very far and it becomes even more important to understand what happens during and immediately after surprise events and what shapes the resulting development path.

2. Qualitative requirements for scenario building

Rather than adding to the above debate by providing yet another set of methodological core elements, the following section shall discuss whether there are some qualitative requirements for scenarios beyond the rather general criterion of plausibility discussed above. There are reasons to suggest after all that such qualitative requirements may also provide some methodological guidance in the sense that they hint at the importance of certain steps or procedures.

In reviewing the literature, several qualitative requirements can be identified. An important requirement emphasised by several authors is *internal consistency* (Bradfield, et al., 2005, Van der Heijden, 1996). Thus scenarios should not suffer from internal contradictions be-

tween either sub-scenarios, or underlying assumptions or both. While this criterion is rather straightforward as far as the headline elements of scenarios are concerned, after all, contradictory statements can be spotted immediately, it is more difficult to fulfil for the assumptions which underpin (a set of) scenarios. Not only would these assumptions have to be identified (which by definition is difficult if they are implicit rather than explicit), they also would have to be quantified or at least described in sufficient detail in order to be compared against each other. And this may turn out to be a rather challenging task.

An example may help to illustrate what it at stake. In the context of a sustainability scenario, energy efficiency is clearly one of the key parameters and so are therefore assumptions concerning the future development of this parameter and the impact technical progress may have on it. At the same time, it goes without saying that the development of energy prices has a considerable impact on short and medium term growth and investment. Now here is the problem: Since energy prices are likely to be among the key drivers of energy efficiency, substantial increases in energy efficiency may only be achievable if energy prices increase further. Thus higher energy prices may be among the implicit assumptions underlying increases in energy efficiency. If this is the case, then, evidently, the assumption would be inconsistent with assuming in the context of the economic model that energy prices increase only moderately and thus do not hamper future growth. How can consistency be checked systematically? An instrument which can be used in this respect is morphological analysis as suggested by (Ritchey, 2011) and used for example in (Bertrand, et al., 1999). Its advantage is amongst other things that this method makes it relatively easy to deal with even a large set of assumption and hence an even larger set of configurations of such assumptions.⁶

Related to the notion of internal consistency is the requirement of *external consistency*. This notion stipulates that a scenario be consistent with other scenarios. While being considerably weaker than the criterion of internal consistency, it may be particularly important when

⁶ A scenario which can be described in terms of 5 parameters and where each parameter can take 3 different (quantitative or qualitative) values may consist of $3^5=243$ configurations of parameter values. Checking all configurations would therefore be rather time-consuming, even for small numbers of parameters and values. Morphological analysis is based on the insight that assumptions have only to be checked pairwise. The reason is that, if a specific combination of parameter values is logically (or otherwise) impossible, then it is superfluous to check the configurations which contain this pair for additional inconsistencies. In the previous example, this principle implies that instead of checking all 243 configurations, it suffices to investigate only 90 (variable 1+2→9 pairs, variable 1+3→9 pairs etc. summing up to 90 pairs altogether). Concomitantly, while adding another parameter with again three values would increase the total number of configurations to $3^6=729$, the number of pairs would increase only by 45 to then 135.

an institution develops various scenarios for different purposes. Making contradictory assumption in these scenarios would undermine their respective credibility as customers or addressees would obviously question the rationale for choosing x in scenario S_1 and y in scenario S_2 . By contrast, scenarios developed by different institutions or researcher need not be consistent. On the contrary, they may be interesting precisely *because* their underlying assumptions are different, reflecting in turn different views on both drivers and structural parameters.

Implicit to the requirement of consistency is of course that *key assumptions* of scenarios should be made explicit so as to enable the reader to assess drivers and constraints, or what Börjeson et al. have referred to as internal and external factors, in terms of their plausibility and consistency.⁷ In the present context, key assumptions relate to the subscribed to notion of sustainability, i.e. whether a strong or a weak notion is used and how the notion is conceptualised. They relate to the functioning of the economy, i.e. whether it is neoclassical or Keynesian and, based on this, to the imputed link between sustainability and economics: should the objective be to get prices right (as the neoclassical approach would have it) or should there be a stronger focus on institutional/regulatory measures? Last but not least, the role and number of discontinuities (i.e. shifts from existing trends to new emerging trends) (Saritas and Nugroho, 2012) should be clarified, in particular if such events are crucial for obtaining specific results.

Another qualitative criterion is whether and to what extent scenarios highlight *signposts or indicators*. The reason is as follows. Scenarios are possible futures. More often than not, several such futures are not only plausible as discussed above but at least not unlikely within the context of a given scenario building exercise. Hence it is more than just pure chance that one such scenario becomes reality, even though no probabilities can be attached. As argued before, pathdependence is a possible reason for some scenarios being less unlikely than others. For the addressees of a set of scenarios, it is therefore of considerable importance to be able to identify signposts or indicators which signal that a given story is about to occur (Van der Heijden, 1996) with a view to identify *ex post* the scenario which is closest to the unfolding reality. It follows that each of the scenarios of the set should comprise one or several distinctive signposts or one or several indicators with distinctive thresh-

⁷ Importantly, since internal factors can controlled by the actor or the actors concerned, while external factors cannot (Börjeson, et al., 2006) the distinction between external and internal factors also points to the opportunities for action which are implicit to a specific scenario. In a backcasting exercise, where such a distinction is less meaningful, it has instead to be specified how the endstate is to be defined from which the scenario is to unfold backwards.

old values such that passing a signpost or a threshold value can be taken to indicate that actual events are consistent with a specific scenario.

If no probabilities can be attached to a set of scenarios or if all of them are equally plausible,⁸ then the question is also how to select amongst a possibly very large number of scenarios those which are to be presented to the addressees or customers of the scenario building exercise. After all, there is no logical upper limit to the number of scenarios that can possibly be produced at any moment in time. Indeed, as the above discussion of morphological analysis has already indicated, even a small number of parameter with only very few values can produce a very large number of configurations. Morphological analysis is therefore important to reduce the number of configurations to a more manageable magnitude. However, more often than not, this will not suffice as even after eliminating configurations which are redundant in terms of consistency, there may still be a substantial number of configurations left.

In addition to asking which scenarios are consistent and plausible, it may therefore also be asked to what extent a scenario depends on particular assumptions and how robust its storyline is with respect to modifications of these assumptions. These are the objectives of *sensitivity analysis*. The underlying philosophy of such an analysis is that scenarios which lead to the same results over a broad range of assumptions are generally more robust and hence more significant than scenarios which depend crucially on very peculiar assumptions. In addition, sensitivity analysis may also be useful to test the resilience of future scenarios under extreme conditions (Saritas and Nugroho, 2012). Although the very nature of surprise events and shocks makes it difficult to imagine their implications and ramifications, the ability of surprise events and shocks to reconfigure the subsequent path of events raises the issue of whether a scenario is not bound to become meaningless in the face of such events. If not at all or if only in few cases, then this may indicate that such a scenario is more robust than others which do not exhibit the same degree of resilience.

3. Assessing and comparing scenarios

Once alternative scenarios have been defined a robust methodology to assess and compare them is necessary. In the light of promoting sustainable development, sustainability assessment may represent the right tool. Following the current debate in sustainability science, sustainability assessment calls for:

⁸ As discussed above, some authors argue that it does not make sense at all to attach probabilities to scenarios.

- *adopting a holistic approach* for understanding dynamic interactions between nature and society, thereby assessing the vulnerability and resilience of complex social-environmental systems.
- *moving from multidisciplinary towards transdisciplinary* approaches. Multidisciplinary approaches are characterised by the un-integrated application of more than one disciplinary methodology to analyse a topic from different perspectives (Wickson, et al., 2006); inter-disciplinary approaches integrate methods, concepts and theories, transferring them from one discipline to another to achieve a common understanding of complex problems (Wickson, et al., 2006), while transdisciplinarity is characterised by:
 - functional integration of different methodologies and epistemologies;
 - co-production of knowledge through collaboration and participation of different stakeholders;
 - strong links with the specific social/local context and institutional setting from where sustainability problems originate;
 - inclusion of all values and common goods perceptions in the identification of the solutions (subjective and normative dimensions) (Lang, et al., 2012).
- *adopting a normative function* (capability to provide direction through visions and goals). Sustainability science addresses the normative question of how coupled human-environment systems would function and look like in compliance with a variety of value-laden goals and objectives such as global thresholds. Moreover, it addresses the strategic and operational question of which viable transition pathways for coupled human-environment systems and strategies for finding solutions to sustainability problems can be identified (Wiek, et al., 2012).
- *promoting social learning and mutual feedback* (learning through doing and doing through learning) leading to co-production of knowledge with other stakeholder groups, such as business, politicians and society in a common process of problem identification and resolution. The current debate is on how far sustainability science has fulfilled the claims related to its transformational function (Wiek, et al., 2012, Wiek, et al., 2012).
- *dealing with risk and uncertainties*. Adopting at least a probabilistic approach for the assessment of scenarios is compulsory to support decision making in a robust manner (Funtowicz and Ravetz, 1993).

When the correct framework to undertake sustainability assessment has been defined, one of the available appraisal methodologies can be adopted. Among these are extended cost-benefit analysis, cost-effectiveness analysis and multi-criteria analysis.

- *Extended cost-benefit analysis* is a modification of conventional cost-benefit analysis (CBA) to accommodate concerns about sustainability (Dixon and Hufschmidt, 1986, Pearce and Markandya, 1989). The key concept consists of the valuation of costs and benefits in terms of total economic value, defined as the sum of use value, option value

and existence value. Use value is the normal economic value assigned to a commodity such as a natural resource. Option value is the difference between the discounted expected future use value of an item and the value that the relevant group or society is willing to pay for it today to conserve it for future use. Existence value is the measure of value assigned to a commodity by the relevant group to keep it in being, regardless of any possible value the commodity may have in the future.

- *Cost-effectiveness analysis* is a tool usually adopted if a full scenario valuation is impossible or if the uncertainties behind it are too high. In this case it may be possible to define explicit objectives for the proposed intervention and then to consider the alternative ways in which those objectives might be achieved. Alternatives are compared in terms of their costs in order to determine which is the most cost-effective. The obvious limitation of cost-effectiveness analysis is that it does not allow the comparison of interventions directed at different objectives.
- When multiple objectives are in place and the scenarios are still too complex to convert all the attributes of some possible intervention to money costs and benefits (van Pelt, 1993), *multi-criteria analysis* (MCA) may represent the best option (Pétry, 1990). MCA may be done informally or by using more formal methods. In the latter category there is a range of methods available along with computer software for applying some of them. While MCA is a flexible method that appears to be well adapted to analyses for policy planning, the complexity and the demands it places on decision makers to be explicit about their objectives and values may limit its use.

4. Quantitative requirements for scenarios

In addition to the qualitative criteria outlined above, there are also two more quantitative criteria. The first one concerns the number of scenarios to be produced within the context of a scenario building exercise. Essentially, the problem can be couched in terms of a compromise between the significance of individual scenarios and the relevance of the whole exercise. While a baseline scenario is indispensable in order to make a comparison between the baseline and alternative specifications and thus derives its significance precisely from that purpose, there is no upper limit to the number of additional scenarios that can be developed other than resource constraints on the part of the developer. At the same time, scenario building becomes irrelevant in view of a multitude of scenarios. So while a larger number of scenarios increase the probability that any single one contains interesting aspects, producing too many scenarios runs the risk of leaving the customers or addressees in a state of limbo. Or to put the issue differently, scenarios should be *substantially* different and not just simple variations on the same theme (Mietzner and Reger, 2005). Hence scenarios which can hardly be distinguished from each other should be eliminated from the set, thereby also reducing the overall number.

A similar compromise between significance and relevance has to be found for the scope of a scenario, i.e. the number of areas or variables covered by the scenario and the level of detail that is used. Obviously, many of the qualitative criteria discussed above can easier be fulfilled for scenarios with only limited scope in view of the fact that such scenarios tend to be less complex and thus involve fewer assumptions whose consistency has to be checked and fewer causal relationships whose plausibility is at stake. Also, such scenarios may pose fewer problems when it comes to carrying out sensitivity analysis both with respect to assumptions and surprise events. At the same time, scenarios with a narrow scope are akin to a plot with only few characters and locations. They may still be interesting, but more often than not, they are not likely to attract much attention. This is so because they either differ too much from the world as perceived by addressees or customers of scenario analysis; hence a sufficiently rich and detailed picture is mandatory. Or, as de Jouvenel has put it, “it is better to sweep wide and large to glean the macrotrends rather than forge highly sophisticated tools for segments of realities that generate quantitatively precise forecasts that are generally wrong” (de Jouvenel, 2000).

V. A pragmatic proposal for building scenarios

1. Scenario development

Developing sustainability scenarios for Europe for 2050 is a considerable challenge given the likely scope of the resulting scenarios and the length of the time horizon, all the more so as such a task has to be carried out with human and financial resources which are quite limited compared to other institutions or companies which develop scenarios for relatively narrow issues such as Shell. In the following, a proposal will therefore be sketched that takes into account the constraints but also the comparative advantages that are available in-house.

Given the above restrictions, building scenarios will have to rely to a considerable extent on *sub-scenarios* which have been developed by others for specific areas and purposes but which are nevertheless also relevant for sustainability scenarios, be it because they define the political context in which environmental policies have to be carried out in Europe itself, be it because they define the environmental challenges at a global scale together with the policy responses if any to these challenges. Thus the suggested approach involves in large parts the interpretation and assessment of existing work together with some adaptations where these are needed.

Broadly speaking, three different types of relevant sub-scenarios can be distinguished. These sub-scenarios differ inter alia with respect to their endogeneity for the purpose of building environmental scenario:

- Global political and environmental scenarios (e.g. those developed by ICCP). These scenarios are exogenous, i.e. they will be taken as given.
- European socio-economic and political scenarios. These are in part exogenous, in part endogenous, i.e. there will be some feedback from (the development of) environmental scenarios in the sense that presumably not every socio-economic and political scenario is compatible with every environmental scenario. In addition, existing socio-economic scenarios for Europe need to be updated in order to take recent developments into account.
- European environmental scenarios: these are by and large endogenous, i.e. they can be developed in-house and are based on the particular competences and models available locally, in particular LUMP, life cycle analysis and the development of environmental indicators.

In addition to combining sub-scenarios from various sources, it is also suggested to use a *nested approach* which starts from broad qualitative assumptions and subsequently moves towards more specific numeric hypotheses and quantitative relationships. The latter can then also increasingly be based on formal models and on the integration of such models. The rationale for such an approach is that both building scenarios and using complex models for this purpose requires, or so it seems, a lot of experience and hence learning by doing. Moreover, model-based scenario building presupposes that the exogenous variables and parameters of the models are identified and then calibrated, estimated or otherwise numerically specified. But not only does this task require some time; it should also be approached at an early stage so as to allow cross checks with qualitative assumptions.

As regards the time horizon, it is suggested that the scenarios focus in particular on the period 2030-2050. These two dates are significant insofar as in 2030 most of the currently existing capital stock is still in use while by 2050 most of the capital stock will have been replaced (with the exception of housing and parts of the infrastructure). However, key decisions regarding for instance energy supply or transport will have to be made relatively soon, but no later than 2030 for the period up to 2050. Therefore, the political and economic situation during the next two decades will have an impact on developments up to 2050 even if there remains considerable uncertainty about longer term political and socio-economic trends and developments.

How many scenarios should be developed? Given the above considerations, this question can be broken up into separate questions for each sub scenario. As for the global perspective, probably no more than two scenarios should be considered, one of those boiling down to what essentially would be an extrapolation of current trends and developments and hence could serve as baseline while the other should perhaps be a slightly more optimistic scenario with respect to international agreements on environmental issues. This would have

the advantage of limiting the number of scenarios to be considered given that the focus of the exercise is on Europe rather than on global developments. Hence more variety is more important for Europe. An alternative might be to use all four scenarios that have been developed by IPCC. While this would then be more time-consuming, it would also avoid having to select among the IPCC scenarios. As for socio-economic and political developments in Europe, the issue is trickier. For instance, previous Commission work has proposed no less than 5 political and economic scenarios for Europe (Bertrand, et al., 1999). Arguably, these scenarios have not been invalidated by events during the last decade and thus remain relevant. At the same time, the financial crisis and its political and economic ramifications hint at the possibility that European integration may take a completely new turn, which none of the scenarios developed by Bertrand et al. anticipates. Thus additional scenarios may be necessary.

The key issue is of course the number of environmental scenarios that is to be considered. There are reasons to suggest that at least 3 scenarios should be developed. The most obvious scenario is the baseline. In terms of policies, the baseline should take into account all legislated policies plus those which are very likely to be legislated in the near future under the assumption that everything is implemented in the foreseeable future. In addition, however, a scenario with a more ambitious environmental agenda should also be included. Such an agenda would aim at a comprehensive greening of the European economy and would also comprise measures which are currently being discussed, e.g. as detailed in the 2005 Environment Outlook (Anonymous, 2005), but which have not been firmly put on the policy agenda. In view of the 2050 time horizon, however, some of the latter may be seriously considered in the decades to come. Thus an “optimistic” environmental scenario should take them into account.

The last environmental scenario to be considered would differ significantly from the two previous cases in that it would not take policies as given with a view to assess their suitability to achieve certain objectives by 2050. Instead, resulting from a backcasting exercise, this scenario would seek to identify the policies and otherwise exogenous conditions under which a sustainable Europe can be achieved by 2050 and the pathways these policies would imply. Of particular interest in this context would of course be the ramifications and implications for key socio-economic variables such as GDP growth, employment or distribution. Thus this analysis would primarily be interested in the potential costs and benefits of a policy agenda that aims for instance at ensuring that certain threshold values are not exceeded (Rockstrom, et al., 2009), at least to the extent these thresholds make sense at European level. In addition, such an approach would also make it possible to investigate consistency across policy targets within the environmental domain broadly conceived (e.g. whether the targets for biofuels are consistent with the resource efficiency strategy) and

therefore help to identify trade-offs. For this purpose, the backcasting exercise has to rely to a much greater extent on quantitative modelling since only quantitative modelling is suitable to gauge the magnitude and therefore the importance of such trade-offs.

2. Key elements

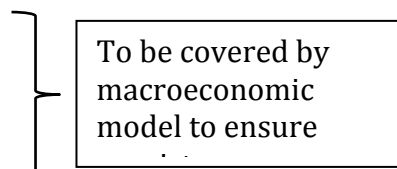
Preliminarily, the three types of sub-scenarios alluded to above should consider the following actors and variables/parameters.

1. Global

- a. Global environmental governance
 - Climate policies and agreements
 - Biodiversity policies
 - Other variables to be identified by examining the relevance of global policies to sustainability goals
- b. Global socio-economic situation
 - GDP growth
 - Population
 - International trade
 - Migration flows
- c. Global environment
 - Climate
 - Bio-diversity
 - Water
 - Resource-availability

2. European socio-economic and political situation

- a. European governance and politics. This would build on previous Commission work (Bertrand, et al., 1999) which has to be updated and checked for consistency with global scenarios. Relevant issues are:
 - Future of European integration
 - Key political developments in Member States
- b. Socio-economic situation
 - GDP growth
 - Population
 - Distribution of income



- Employment

3. European environmental scenarios:

a. Inputs

- Drivers (consumption patterns, energy use depending on prices and availability, transport and agriculture, water use, raw materials use and extraction)
- Technologies (innovation, prices ...)
- Policies (prices, regulations, public investment)

b. Outputs

- Environmental indicators
- Spatial distribution of environmental impacts at MS and, to the extent possible, at regional level
- Distribution of costs and indirect socio-economic effects, e.g. as a consequence of job losses in some industries or increasing prices for some goods and services, to the extent possible

c. Specific assumptions have to be made for consumption patterns and technology:

- Consumption patterns
 - Transport (fuel prices increase only moderately + significant increase in fuel prices)
 - Food and Water (current patterns remain unchanged + homogenisation along US-lines + homogenisation along South European lines)
 - Housing (current pattern + move back to the city)
 - Energy for heating and electricity (current pattern + strong increase in demand from emerging economies)
- Technology
 - Base-line: Trend extrapolation
 - Available but not yet used technologies (2030-2050)
 - Major technological breakthroughs/emerging technologies (nano, bio)
 - Life-time of investment goods and consumer durables
 - Retro-fit possibilities for investment goods and consumer durables with long life-times
- Policies (regulation, pricing, investment in R&D and infrastructure)
 - Base-line scenario: Europe 2020 continued
 - Green revolution: fundamental changes in all areas of life
 - Backcasting scenario (additional policies follow from assumption of reaching sustainability by 2050)

Evidently, this list should neither be taken as exhaustive nor as definitive as it will only emerge in the course of the further analysis which elements can and should be integrated into the scenario building exercise and which elements cannot or should not.

3. Important steps

Despite the fact that, as discussed above, there are no unambiguously agree-upon methodological recommendations, there are reasons to suggest that the first steps that are to be taken are relatively straightforward (de Jouvenel, 2000, Mietzner and Reger, 2005) due to the fact that these steps are by and large exploratory in nature. Thus it is certainly useful to start the analysis by trying to identify the variables that presumably influence the problem that is to be investigated or more generally the situation for which a scenario is to be constructed.

Once this has been done, the next step could be to study the causal relations among variables with a view to identify those which are likely to play an important role in the context under study. This could for instance be achieved by using a cross-impact matrix, possibly in conjunction with dedicated software, in that such a matrix makes it possible to detect variables which exert a strong impact of others or are strongly impacted by others or both. It has been argued in this context that network analysis may be a powerful approach in that it is able to analyse both the whole system of relations and parts of the system at the same time and hence may help to explore the otherwise hidden structural properties of the systems (Saritas and Nugroho, 2012). Moreover, the latter may also facilitate the identification of appropriate sub-systems of variables with a view to develop (or confirm the use of existing) subscenarios.

During the third step, possible futures of each variable would be explored against the background of three questions: (a) What is the past development of this variable? (b) What is its tendential development (logical extrapolation)? (c) What are the curves and potential breaks which could block the tendential development? (de Jouvenel, 2000). The third step is therefore the step with which scenario building proper can be said to begin. And it is also at this point that the consistency of assumptions would have to be checked as discussed above.⁹ In addition, it is also important to address the other issues highlighted above. For instance, should surprise events be included and if so how many? As argued before, such

⁹ Other authors have suggested more steps, but in terms of substance, there does not seem to be a big difference between the core steps identified by de Jouvenel and those suggested by other authors.

surprise¹⁰ events may alter the chain of events in fundamental ways while their likelihood increases as the time horizon of the scenario moves towards the future. So their potential to disrupt a scenario is also likely to increase. At the same time, there is no logical limit to the number and nature of such surprise events and their inclusion would therefore add to the problem that there is no logical upper limit to the number of scenarios to be considered. So in the interest of keeping the number of scenarios at a manageable level, it is also important to avoid too many surprise events. Moreover, possible surprise events should arguably be selected in such a way as to focus on events which are already “inbuilt” as it were. Such events could then be derived by thinking through the implications of reaching certain extremes or discovering hitherto unknown facts. For instance, a surprise event could relate to what happens if a critical threshold value is violated or if an important technological breakthrough, which was not to be expected, is achieved.

A second issue that needs to be clarified at this point concerns the quantification of policies and of their effects, i.e. the policy variables. Thus to what extent can policies be described in quantitative terms in the first place and if so, to what extent can their effects then be assessed not only qualitatively but also quantitatively? These issues are obviously important once model-based scenarios are being built for such models usually presuppose numerical inputs that go beyond values of zero and one for the absence or presence of a policy. On top of that, there is the issue of quantifying the effects of policies on key variables of the scenario. While this may be relatively straightforward for well-established policies and short and medium term effects in well-known contexts, none of this can be taken for granted for the long-term effects of new policies that are to be implemented under conditions which are likewise hardly known for sure. Note at this point that the issue of quantification is relevant for both forward-looking scenarios and backcasting. In the former case, the problem boils down to translating legislated policies into figures that can be used as inputs for quantitative models while in the latter, the challenge is to derive the required policies in quantitative terms from the path leading to the imputed sustainability targets.

VI. Conclusions

The main conclusions of this report are as follows:

¹⁰ Surprise events cannot be predicted as such. Still, it is possible to explore the consequences of imagined surprise events.

- Forecasts claim to foretell what will or, at least, is likely to happen in the future.. Scenarios, on the other hand, seek to identify what may plausibly happen without attaching, as a rule, a certain probability to any specific event.
- Forecasts have the potential to change the very environment for which they have been developed. They may be verified or falsified not because they were right or wrong from the beginning, but because they induced behavioural responses which made them right or wrong.
- A challenge that is specific to the development of scenarios given their broader range compared to forecasts has to do with the internal consistency of scenarios. Thus scenarios may be less plausible than their narrative suggests because the underlying assumptions are simply not consistent. Checking the consistency of underlying assumptions is therefore a crucial element in the context of scenario building.
- Policy measures may lead to conflicts between different objectives because one objective is achieved at the cost of another objective and they may affect different groups in society differently because costs and benefits are not shared equally. If this is the case, then policy makers need to know who is affected by how much and how the picture would change under different assumption and with alternative policy options and time frames. This information can be provided by building appropriate scenarios.
- Voters are only likely to subscribe to a full blown sustainability agenda if they are in a position to assess what the imputed social and economic changes imply for them. But that requires in turn that policy makers are able to describe in some detail the “alternative worlds” which they propose to construct.
- While there is no agreed-on methodology for scenario building, there are certain steps that have to be followed as a matter of logic. At the same time, there are certain qualitative and quantitative criteria which should be adhered to in order ascertain meaningful and relevant results.

Building sustainability scenarios for Europe in 2050 is a considerable challenge. However, it provides a good opportunity to integrate different research streams and competences into a coherent and interesting product which is likely to draw the attention of policy makers and other scientists as well as the general public.

Given the constraints under which scenario building has to be carried out, an approach should be adopted that is both realistic and relevant. This paper has attempted to provide a blueprint for such an approach while acknowledging that many of the pertinent questions it will raise may not be known at present and even if they are, cannot be addressed immediately.

However, precisely this challenge can also be turned into a considerable advantage. Scenario building is not a mechanical exercise whose outcomes are by and large determined by the

methods and data that are used in the process, but a reflexive endeavour which informs and transforms those who undertake it. Thus beyond, and independently of, the scenarios which result from the exercise (and which may be more or less interesting in their own right), there are also the insights which are generated in the process and which may have considerable value as such.

VII. Literature

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Abstract

The purpose of the report is twofold. To begin with, it seeks to set out the objectives of, and methodologies for, the development of socio-economic and environmental scenarios for the European Union up until 2050f. In addition, the report undertakes to place scenario building in a wider political and socio-economic context.

The report is structured as follows. In section II, the report compares forecasts and scenarios with a view to highlight common aspects and differences. In section III, the report discusses in more detail the purpose of scenario building against the background of the policy objective to reach sustainability. Section IV, finally, examines some of the methodological issues involved in scenario building and sketches out how scenarios can be built in a meaningful and feasible manner.

The report is largely exploratory in nature as it seeks to identify critical issues and questions. The report is, in this respect, akin to one of the key purposes of scenario building itself. Accordingly, scenarios are not only developed as long range planning tool, but also with a view to foster and facilitate communication and reflection.

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