THE METHODOLOGICAL BASIS FOR LOW CARBON SCENARIOS – LESSONS FROM THE WIDER POST-WAR SCENARIO TRADITION

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Nick Hughes (n.hughes10@imperial.ac.uk)

Imperial College Centre for Energy Policy and Technology

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Introduction

Thinking about and planning for the future is central to energy policy analysis, particularly in the context of long term decarbonisation targets, which are growing in importance on many national policy agendas. It is common for long term energy futures analysis to draw on the concept of the 'scenario', or 'description of an imagined sequence of events' (OUP, 1989), and in a range of studies across energy and climate policy literature as reviewed by Hughes and Strachan (2010), the term was used in this general sense to indicate the potential for different future outcomes. However, typically such studies offered little explanation of any underlying theory or methodology of scenarios. Other studies (e.g. Mander et al, 2008; Gomi et al, 2010) refer briefly to a broader scenario tradition, but focus on one particular methodology (e.g. Robinson, 1982, 1990) as the basis for their approach.

There is an extensive scenario literature which pre-dates the use of the concept for considering low-carbon futures. Since the Second World War, scenarios have been widely used to support strategic planning, in a range of commercial and public policy contexts. Reviews and chronologies of this tradition have been undertaken for the purpose of informing the ongoing development of scenarios for the corporate environment (e.g. Bradfield et al, 2005). However, there has been less work exploring in depth the broad post-war scenario building tradition for the specific purpose of informing the ongoing development of energy and low carbon scenarios.

The aim of this paper therefore is to review this wider scenarios literature, to summarise its key insights, and explicitly link these to the process of building low carbon scenarios. Section 2 provides a broad overview of the field through comparing a number of scenario typologies to highlight what appear to be the most fundamental components of scenario approaches. Section 3 offers a more discursive review of the history of scenario building since the Second World War. Section 4 discusses the main insights from both parts of the review, and Section 5 highlights their implications for low carbon scenarios.

A review of scenario typologies

The ability to plan for a range of possible future outcomes can be recognised as a natural quality of the human mind (Schwartz, 1991, p. 31). Scenario thinking may therefore be thought of as nothing more than 'an attempt to effect improvements in a natural activity of the mind' (de Jouvenel, 1967, p. 6), and scenario methods descriptions of how particular groups interpret this transposition from an internal and personal process to an external and communal activity, in the particular context in which they operate. Given the potential for significant variation in how different individuals could interpret this task, and the range of different contexts in which future planning is a relevant activity, it is perhaps not surprising to find that scenario methods are many and various.

Imposing some methodological order on the resulting wide range of scenario literature is a challenge to which a number of authors have risen through proposing 'typologies' of scenario methods. A number of such typologies were identified and reviewed for this paper (Table 1).

Author and date	Title
Amara (1981)	The futures field: searching for defnitions and boundaries
Börjeson et al (2006)	Scenario types and techniques: towards a user's guide
Bradfield et al (2005)	The origins and evolution of scenario techniques in long range business planning
Dreborg (2004)	Scenarios and structural uncertainty
Ducot and Lubben (1980)	A typology for scenarios
Godet and Roubelat (1996)	Creating the future: the use and misuse of scenarios
Heugens and van Oosterhout (2001)	To boldly go where no man has gone before: integrating cognitive and physical features in scenario studies
Huss and Honton (1987)	Scenario planning – what style should you use?
Mannermaa (1986)	Futures research and social decision making – alternative futures as a case study
Marien (2002)	Futures studies in the 21st Century: a reality based view
Masini (1993)	Why Futures Studies?
McDowall and Eames (2006)	Forecasts, scenarios, visions, backcasts and roadmaps to the hydrogen economy: a review of the hydrogen futures literature
van Notten et al (2003)	An updated scenario typology

***Table 1**: Scenario typologies reviewed for this paper*

Scenario typologies differentiate the scenario literature across a range of different categories. Contrasting methodological approaches to generating scenarios offer natural dividing lines for scenario typologies, and 'formal', 'computational', 'model'-based, 'quantitative' and 'technical' approaches are often contrasted with 'intuitive' or 'qualitative' approaches (Börjeson et al, 2006; van Notten et al, 2003; McDowall and Eames, 2006; Bradfield et al, 2005; Huss and Honton, 1987). However, rather than viewing these distinctions as impermeable boundaries, Börjeson et al (2006) and van Notten et al (2003) suggest that the integration of qualitative and quantitative, formal and intuitive methods within scenarios is beneficial, despite methodological challenges.

Some authors have made distinctions according to where the benefit of the scenario process is perceived to lie. Thus processes where insights from the content of the scenario itself lead directly to action or decision support (van Notten et al, 2003) are contrasted with processes of a more 'hermeneutic' nature, designed to foster social communication (Mannermaa, 1986) and where 'the insights and learning arising from the process are more important than the reliability of the end product, the scenarios' (Bradfield et al, 2005).

Most of the typologies agree that a scenario is not an isolated vision, but a description of a succession of events through time. However, some typologies

allow for both arrangements, in comparing 'snapshot' with 'chain' scenarios (van Notten et al, 2003) or 'visions' with 'backcasts' or 'pathways' (McDowall and Eames, 2006). Further distinctions are drawn in some typologies between 'complex' or 'panoramic' scenarios with a broad cross-societal sweep, and more 'simple' scenarios which focus on particular problems applying to smaller sectors of society or the economy. The former are often more appropriate for social policy scenarios, the latter more likely to be associated with specific business planning activities (van Notten et al, 2003; Börjeson et al, 2006; Marien, 2002; Bradfield et al, 2005).

Perhaps one of the most frequently employed means of categorising scenarios is via a description of the relationship of the hypothetical scenario to its potential realisation at some point in the future. In these terms a scenario might be 'probable', or merely 'possible', or, in the context of a certain defined set of values, 'preferable' (Börjeson et al, 2006; Amara, 1981). The distinction between scenarios presented as 'possible' and those presented as 'preferable' forms a key axis in several typologies. The terms 'exploratory' (Godet and Roubelat, 1996; Heugens and van Oosterhout, 2001) and 'descriptive' (Ducot and Lubben, 1980; McDowall and Eames, 2006; Bradfield et al, 2005) are used to group scenarios presented as explorations of possible futures in the absence of a value set imposing a view of a preferable outcome. Where such a value set is consciously allowed to impact upon the scenario outcome, scenarios are often said to be 'normative' (Ducot and Lubben, 1980; Heugens and van Oosterhout, 2001; Godet and Roubelat, 1996; McDowall and Eames, 2006; Bradfield et al, 2005). Terms such as 'visions' (McDowall and Eames, 2006), 'visionary' (Dreborg, 2004) and 'utopian' (Masini, 1993) have also been used to convey normative qualities of scenarios.

A slightly different axis emerges when the 'possible' is contrasted with the 'probable'. In some typologies, approaches which generate 'predictive' or 'most probable' scenarios (Dreborg, 2004; Bradfield et al, 2005; Mannermaa, 1986; Huss and Honton, 1987) emerge as distinct from those which assign equal probabilities to scenarios, or those which avoid probabilities altogether. Other typologies stress the importance of 'emancipatory' scenarios which challenge or question the commonly held view of what is most probable at any given time (Mannermaa, 1986)

This review of scenario typologies confirms that the scenario literature is broad, diverse and continually evolving, and as a result a single, comprehensive typology has not been agreed upon, much less a definitive scenario 'method'. Nonetheless, a number of recurring themes in typological arrangements can be observed, and due to their recurrence in typologies it is reasonable to assume that these constitute important elements of scenario construction. These are summarised in Table 2.

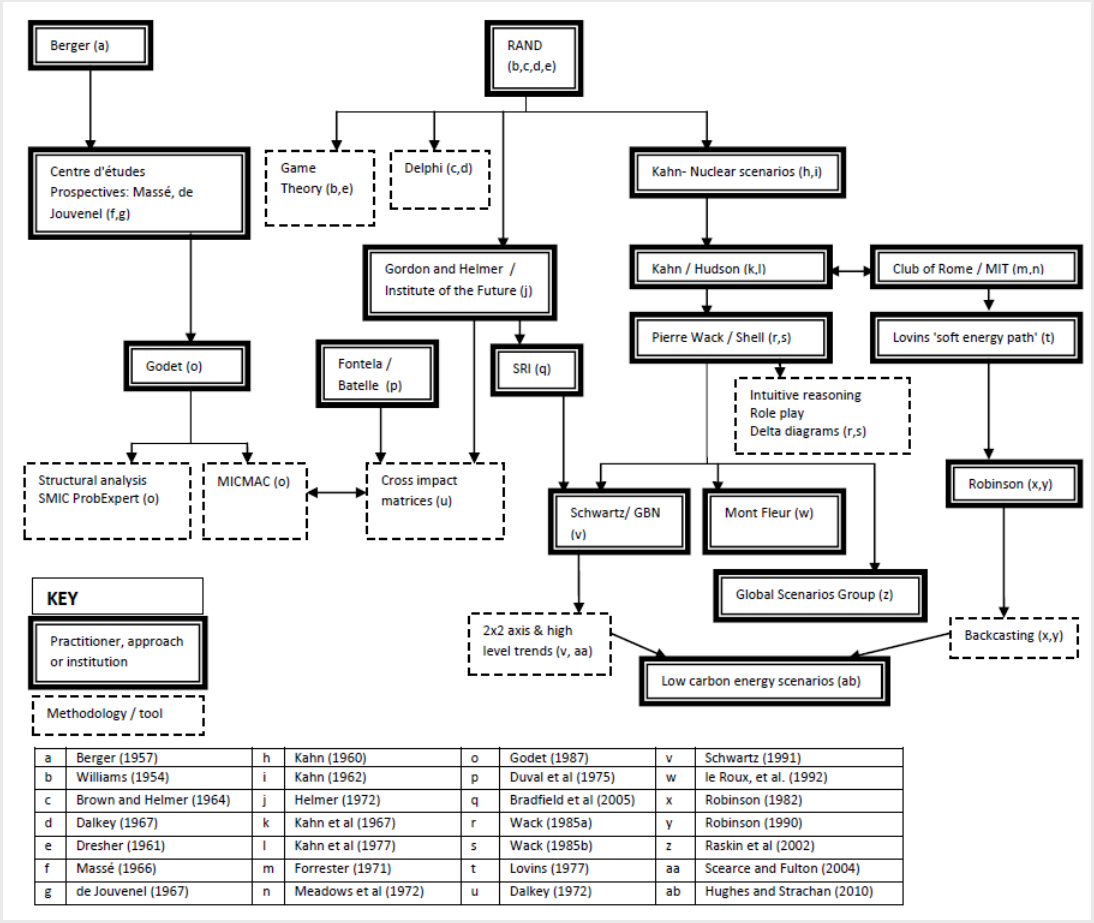
Key scenario categories and objectives	
Methodology	Qualitative / intuitive – Quantitative / formal
Aim of process	Learning – Decision Support
Structure	Chain – Snapshot
Scope	Focussed – Panoramic
Content	Possible – Probable – Preferable

***Table 2**: Key scenario categories and objectives emerging from review of typologies*

The appropriate balance of these themes depends on the context of the individual scenario exercise. Hence, in order to understand how the balance between these themes is struck in practice, the next section considers some real scenario processes in context.

A review of the scenarios literature

This section presents an overview of the use of scenarios since the Second World War, with more detailed attention given to some selected processes. The literature reviewed in constructing this narrative is summarised schematically in the form of a broadly chronological 'family tree' (Figure 1). This arrangement is intended to show patterns of influence, departures and correspondances between scenario approaches. However, it deliberately avoids the firmer methodological distinctions drawn by more conventional typologies, acknowledging that, as shall become clear through the following discussion, the development of scenario techniques is in practice characterised as much by idiosynchratic additions of individual practitioners according to the needs and constraints of particular contexts, than by full reproduction of pre-established methodologies.



a	Berger (1957)	h	Kahn (1960)	o	Godet (1987)	v	Schwartz (1991)
b	Williams (1954)	i	Kahn (1962)	p	Duval et al (1975)	w	le Roux, et al. (1992)
c	Brown and Helmer (1964)	j	Helmer (1972)	q	Bradfield et al (2005)	x	Robinson (1982)
d	Dalkey (1967)	k	Kahn et al (1967)	r	Wack (1985a)	y	Robinson (1990)
e	Dresher (1961)	l	Kahn et al (1977)	s	Wack (1985b)	z	Raskin et al (2002)
f	Massé (1966)	m	Forrester (1971)	t	Lovins (1977)	aa	Scearce and Fulton (2004)
g	de Jouvenel (1967)	n	Meadows et al (1972)	u	Dalkey (1972)	ab	Hughes and Strachan (2010)

Figure 1: *Family tree of scenario practitioners and approaches*

Origins: RAND and La Prospective

Figure 1 indicates two important points of origin for post-war scenario techniques – the US based RAND corporation, and the French movement which would come to be known as *La Prospective*, founded by Gaston Berger.

RAND (Research And Development) was founded in the US in 1946 as a 'fully autonomous research organisation under exclusive contract to the Air Force' (Ghamari-Tabrizi, 2005). Its founding reflected a growing recognition within the US armed forces of the major uncertainties associated with the new post-war environment, relating to the already accelerating arms race, the new emerging geopolitics, and the developing strategies of the Soviets.

From its founding, RAND was self-consciously a multi-disciplinary organisation – as one early recruit commented, 'it seemed to me that we needed just about every facet of human knowledge to apply to the problems… we were about to face' (Ghamari-Tabrizi, 2005). RAND was quickly populated with practitioners of economics, political science, psychology, and various other branches of social science as well as mathematics. The diverse backgrounds of the employees produced contrasting approaches: 'By temperament or training, they gravitated

to opposing forms: compact studies correlating limited combat objectives with fixed budgets, or grandly speculative affairs spiralling around society, nature and war. The quantitative studies often aimed toward an ideal of omniscient information management. Its opposing pole invoked an intuitive holistic gestalt' (Ghamari-Tabrizi, 2005). Both of these 'opposing forms' would become highly relevant to the ongoing development of scenario techniques, and the balance between them one of its most frequently recurring considerations.

The early years at RAND saw the development of Game Theory, which sought to systematically analyse possible outcomes of interactions between actors under varying conditions (e.g. 'zero sum' or otherwise, perfect or imperfect information), employing matrices and other mathematical manipulations to derive outcomes for 'games' with very high numbers of potential strategies (Williams, 1954; Dresher, 1961). Researchers at RAND also developed the Delphi technique, for improving the reliability of estimates made by groups of experts, in the absence of precise information (Brown and Helmer, 1964; Dalkey, 1967).

However, RAND was also pioneering in the use of more intuitive techniques such as role playing and war gaming exercises, in which outcomes of particular situations were generated by using human participants to take on the roles of the players of the 'game' – such as military generals on opposing sides – and to act according to the objectives of the role they had been given. Although such approaches did not allow consideration of the sheer range of combinations of variables available to computationally driven gaming simulations, they permitted experimentation with and testing of the complex human elements of decision making, which are less amenable to representation in formal models (Ghamari-Tabrizi, 2005). Needless to say however, the challenge which any participant in such games would have in accurately intuiting and representing the motivations of actors in different countries and cultures, was significant, and could throw doubt on the outcomes (Linstone, 2006).

Significantly, RAND's researchers also began to see the need to combine intuitive and quantitative approaches, particularly where data gaps due to uncertainties and unknowns had to be filled in order to run models. One researcher remarked, 'we have to do some things that we think are right but that are not verifiable...' (Ghamari-Tabrizi, 2005).

In France during the same period, futures techniques were being developed in a very different context. Less concerned with geo-political strategy, the French origins of strategic scenario planning were originally concerned with the building of a better future within the nation's borders.

The origin of the French tradition of scenario planning which came to be known as *La Prospective* dates to 1957, with the founding by Gaston Berger of the Centre d'Etudes Prospectives. His work was continued through the 1960s by Pierre Massé and Betrand de Jouvenel. Massé introduced the principles and methodologies of La Prospective to the Fourth French national plan (1960-1965) (Bradfield et al, 2005).

In the early Prospective work, the positioning of the main implied user of the scenarios (the French Government), and the boundaries of the system being considered (the state of France) created a significantly different emphasis from

the RAND exercises, in which US strategy was considered in the context of a number of external uncertainties. La Prospective from its origin laid less emphasis on reacting to external events, rather seeking to identify elements which lay within the sphere of influence of the scenario user, who could thereby play an active role in forming the future: 'What is important is to find points of fulcrum on which we can exert pressure, thereby deflecting the course of events in one direction rather than another' (de Jouvenel, 1967, p. 113)

The early Prospective thinkers however also realised that though the national Government was a powerful actor, it was not an all-powerful one, and that the construction of a desired future would require consent from a range of societal actors. La Prospective therefore developed the idea of 'scientific utopias' (Bradfield et al, 2005) through which a number of different actors in society could be convinced to share the same goal and thus work together: 'It is not so much about divining the future as constructing it, not so much about foreseeing a probable future as preparing one that is hoped for. It amounts to making desirable ends a powerful enough lever to act on the present' (Massé, 1966, p. 337, my translation).

Developments: cross impact matrices and simulation for characterising business environments

RAND had also been the scene of early development of cross-impact matrix techniques, in particular by Gordon and Helmer. An early application was a 1966 study for Kaiser Aluminium (reported in Gordon and Hayward, 1968). Cross-impact matrices are probabilistic tools for establishing the most likely combinations of events with individually defined probabilities, based on the cumulative probabilities of the sequences. On leaving RAND Gordon and Helmer set up the Institute for the Future where they continued to apply these techniques to producing scenarios for corporate clients (Bradfield et al, 2005).

La Prospective too evolved and became less closely linked with French national planning, increasingly applied to industry and commercial strategy. One of the key figures in this development has been Michel Godet, whose work, whilst continuing to emphasise the multiple possibilities of the future, is in other ways quite contrasting to earlier La Prospective exponents. His work has developed a number of customised tools concerned with assessing actor strategies, testing relationships between them, and assimilating expert views to assign probabilities to scenarios (Godet, 1987; Godet and Roubelat, 1996)). One of the key benefits of this formalised and systematic approach is the potential for uncovering 'hidden variables' – significant factors and possible outcomes which can be missed at an intuitive level of analysis can be uncovered by computational tools able to explore large numbers of combinations of system variables (Godet and Roubelat, 1996). In its systematic approach to processing probability assessments of experts (SMICProbExpert) and the use of matrices to uncover hidden or secondary dynamics arising from interactions of these events (MICMAC), Godet's approach has many similarities to that developed by Gordon and Helmer (as indicated in Figure 1).

Developments: intuition in actor characterisation – RAND, Hudson Institute and Shell

Perhaps the most well-known of RAND's alumni was Herman Kahn, in no small measure due to the notoriety he achieved for his work exploring scenarios of nuclear conflict. A prolific producer of scenarios, and a charasmatic performer

when presenting them (Ghamari-Tabrizi, 2005), Kahn is also credited with first borrowing the term 'scenario' from the film industry and coining it within the realm of public policy oriented futures work (Kleiner, 1996). For these reasons he is often referred to as the father or originator of the scenario 'method'. However, it is unclear how meaningful such epithets are when, as has been observed in this paper, the diversity of the field is such that there is no obvious candidate for a single definitive scenario method. Moreover, prolific though Kahn was as a writer and orator, he did not bequeath a clearly identifiable or reproduceable scenarios approach. His approach was highly idiosynchratic, and the content and structure of his scenarios bore the strong imprint of his own particular personal talents – a quick mind, an elephantine memory for facts and figures, a sense of humour and an almost childlike enthusiasm for whatever challenge or problem currently engaged him (Ghamari-Tabrizi, 2005). However, he also had a reputation with some of his collaborators for a a lack of focus and rigour (Ghamari-Tabrizi, 2005). A later commentator felt that 'Kahn's negligent way of presenting his ideas' obscured their 'overall consistency', and that this 'lack of systematization and order was probably the crucial shortcoming affecting on the long run Kahn's impressive intellectual legacy' (Aligicia, 2004).

Despite these drawbacks, at least two aspects of Kahn's original and creative processes have exerted important influences on the subsequent practice of scenario building. The first is the importance of multi-disciplinarity throughout Kahn's thinking and for scenarios in particular, which provide a broad canvas within which insights from contrasting disciplines can be creatively fused. Multi-disciplinarity was central at the founding of RAND, and remained crucial to Kahn's conception of the ideal 'think-tank' when he founded the Hudson Institute in 1961(Aligicia, 2004). The second is the elevation of intuition as a valid tool for assisting thinking about the future, where hard data is unavailable or models reach the limits of their scope. The use of intuitive reasoning also had a precedent at RAND, and for Kahn it was a crucial step to enable the tackling of important questions for which gaps in data and uncertainties remained pervasive, and which therefore remained unassailable to more strictly disciplined academic approaches (Singer, 1996).

Kahn's scenarios of nuclear conflict, first set out publically in *On Thermonuclear War* (Kahn, 1960) and *Thinking About the Unthinkable* (Kahn, 1962), argue that the serious consideration of such unpleasant outcomes is vital to gain a better understanding of what civil contingency preparations may increase the chance of more people surviving a nuclear attack should it occur, and of what diplomatic or political actions would be most likely to either escalate or diffuse a crisis, increasing the strategic ability to avoid nuclear conflict entirely.

This latter line of thought was developed more fully through the concept of the escalation ladder, in *On Escalation* (Kahn, 1965), which it has been argued was Kahn's most material contribution to maintaining the peace during the Cold War (Coates, 1996). In *On Escalation*, Kahn explores why actors may have rational reasons to engage in escalation tactics. The positive implication of this is that if actors have rationally engaged in escalation, they should be open to rational persuasion to de-escalate. This was a useful characterisation of the cold war stand-off at a time when there was a tendency to view the intentions of the Soviet enemy as largely unknown but essentially malevolent. Kahn's ladder is grouped into seven seperate stages, seperated by threshold points. He identifies acts which would be rational within each stage; passing through the threshold to

engage in an act of a higher stage represents an act of escalation. Crucially, it is equally possible to move 'down' the ladder as well as 'up'. 'The ladder indicates that there are many relatively continuous paths between a low level crisis and an all out war, none of which are necessarily or inexorably to be followed' (Kahn, 1965).

The assumption of full and equal actor rationality on which the ladder concept is based, however, may itself be questioned. In the context of explaining that strikes on cities would have no rational justification for either side until the very highest rungs of the ladder, Kahn nonetheless acknowledges that none of this 'is necessarily understood by the governments and war planners of either side. If one side or the other decided to go to war, it might, simply because of this lack of thought, attack cities' (Kahn, 1965). History indeed suggests that the hawkish views of US high level military advisors such as Generals Curtis Le May and Tommy Powers, were not so squarely in line with Kahn's rational view of things (Isaacs and Downing, 1998). This indicates the great challenges that unknown or hard to define actor motivations can introduce to scenario thinking.

The popularisation of the notion of scenarios through Kahn's work was influential upon the Royal Dutch Shell Company in developing its own scenario planning capability. From the late 1960s, the possibility of significant discontinuities in the oil markets was becoming increasingly evident. Shell undertook a Horizon Planning study looking forward as far as the year 2000, which indicated that current rates of growth in oil demand would quickly dimish spare capacity, causing the balancing source of oil supply to be in the Middle East (Wack, 1985a).

However, managers in oil companies were continuing to plan their investments as if the stable and low oil prices which had been observed for decades were bound to continue into the future (Kleiner, 1996). They simply had no other conceptual framework – or 'mental map' (Wack, 1985a) – on which to base their investment decisions.

In 1972 a newly established in-house scenarios team, led by Pierre Wack, presented to Shell's senior management a set of scenarios which, as Kahn's had done, combined quantitative data and qualitative insights. Using both quantitative calculations and estimates of oil reserves and demand patterns, and intuitive methods similar to those pioneered at RAND, including role plays of the key system actors under different situations (Kleiner, 1996), the team had reached an important and powerful insight: 'no nation had both ample reserves and ample absorptive capacity, that is, the motivation to produce these reserves' (Wack 1985a). Figure 3 demonstrates this graphically, arranging countries into a grid along the dimensions of available capacity and motivation to produce.

***Figure 2**: Schematic comparing 'absorptive capacity' and 'available reserves' of major oil exporters, showing that no country (Group IV) had both the motivation and resources to increase supply (Source: Wack, 1985a)*

This led to the conclusion that unless oil importing nations were prepared to act together to radically reduce their consumption of oil (a policy which Shell unsuccessfully lobbied governments to adopt (Kleiner, 1996; Wack, 1985a)), a supply curtailment was a virtual certainty (Wack, 1985a).

Although the 'Shell approach' to scenarios is often used as shorthand for purely qualitative or intuitive scenario approaches, in the 1972 scenarios, the integration of intuitive and quantitative types of information was central to the process. Wack observes that 'scenarios can effectively organise a variety of seemingly unrelated economic, technological, competitive, political, and societal information and translate it into a framework for judgement- in a way that no model could do' (Wack, 1985b).

Another aspect worthy of remark is the strength of certainty of the conclusion delivered by these analyses. While scenarios are often associated with emphasising uncertainty, the Shell 1972 scenarios were able to emphasise significant levels of certainty about the future, due to events already in motion. Wack, while emphasising that 'no single "right" projection can be deduced from past behaviour', nonetheless advocates that an analysis of the interdependencies of the current system, and events which are already 'in the pipeline', can reveal 'pre-determined' as well as 'uncertain' elements of the future (Wack, 1985a; 1985b). Thus, scenarios can show that while some areas of the future remain mobile, other areas are already fixed, which increases

certainty about the future. However, the degree of certainty which Wack was able to invoke is due in large part to the assumption that the motivations of the key actors were known and fixed – a condition which was particular to the relatively focussed market study that Shell was undertaking at this time.

Due to the clear link of the 'predetermined' elements of the scenarios to visible aspects of the present, the scenarios were able to take on another important role – that of enabling managers within the company to confront certain inevitable aspects of the newly emerging business environment, but which were uncomfortable because they conflicted with the managers' previously established world view, or 'mind map'. By setting out a logical sequence of events, shown to be plausible evolutions from the present based on the motivations of the actors in question, the scenarios engaged managers in a learning experience, at the end of which they had developed new ways of seeing the world, as well as a new language in which to express this new paradigm (Wack, 1985a). The sequential, storyline structure of the scenarios also had the useful benefit of providing important signposts which could be used to indicate that a certain type of pathway was being followed. This structure made managers better able to distinguish the important 'signals' from the vast 'noise'of information with which they were continually confronted, by offering them 'a variety of hypotheses that guide observation' (Wohlsetter, 1967, in Wack, 1985b).

Long range trends and broader scopes

After almost two decades involved in considering the multiple possible outcomes of near term military strategies, from the late 1960s onwards, Herman Kahn, along with colleagues at the Hudson Institute, turned his attention to broader cross-societal descriptions of longer term futures. Works such as *The Year 2000: A Framework for speculation on the next thirty-three years* (Kahn and Wiener, 1967), *The Next 200 Years* (Kahn et al, 1977), and *The Coming Boom* (Kahn, 1982) are of a different tone to the earlier works focussed on near-term strategy, actor-interactions and outcomes. These later works are characterised by a broader scope and a longer time frame, as a result of which outcomes cannot be derived through hypothesising actions and counter-actions of clearly identifiable actors who are already visible on the current world stage. Instead, the broad and long term outcomes are generated at the macro level, through the identification from history of waves or trends perceived to be fundamental, and the broad quantitative extrapolation of these trends into the future. For example, the argument of *The Coming Boom* is founded on Kondratieff's theory of long range economic cycles. Even more fundamentally, each of these works is underlain by a particular world view, which ultimately sees untramelled human endeavour and scientific development as the necessary and sufficient condition to avoid breach or exhaustion of natural limits and resources. One commentator has described *The Next 200 Years* as epitomising 'the 'technoliberal' paradigm in futures studies, the resolute conviction that all problems are soluble by the judicious application of science, technology, sound capitalist business principles, and Western-style liberal democracy' (Wagar, 1996). Despite being an original and often iconoclastic thinker, Kahn's scenarios reflect an unswerving belief in, or an unwillingness to admit challenges to, this fundamental world view (Coates, 1996).

A quite different world view was famously presented by reseachers from the Massachusetts Institute of Technology (MIT), in *World Dynamics* (Forrester,

1971) and *Limits to Growth* (Meadows et al, 1972). The assumptions underlying the MIT model are, by contrast with Kahn, that the earth has real and non-elastic biophysical limits, and that humanity's ability to extend those limits through technological innovation and ingenuity is itself limited. The debates that followed these publications are well-known and ongoing. In particular, the report was criticised for omitting consideration of political and social value changes, which 'may be the most important dynamic element in the whole system', and for the omission of technical change, claiming that, 'the inclusion of technical progress in the MIT model in sectors from which it is omitted has the effect of indefinitely postponing the catastrophes which the model otherwise predicts' (Freeman, 1973). The MIT team criticised their critics for unfounded 'technological optimism' (Meadows et al, 1973).

One of the key functions of scenarios, wrote Pierre Wack, is to challenge strongly held 'mental maps' or 'worldviews' (Wack, 1985a). Armed with this insight, it is tempting to criticise both the Hudson Institute and MIT approaches, on the grounds that their methods were so coloured by the authors' pre-existing world views that the scenarios generated merely reflected these. However, it would be unfair not to acknowledge the significantly greater challenge of describing broad cross-societal dynamics over long time periods, in comparison for example to the essentially single sector and near term scenarios produced by Wack and his team at Shell in the early 1970s. The latter were characterised by known technologies and actors whose motivations were easy to define and could reasonably be assumed to hold constant. The broad scope and long time frame of the former type of scenarios mean that they are characterised by technological uncertainty and a diverse range of social actors, whose motivations are complicated to define, and cannot be assumed to hold constant for the duration of the time period being studied.

The legacy of the debates sparked by the MIT and Hudson visions are two opposing poles in the view of humanity's relationship with nature - an *ecocentric* view which emphasises biophysical limitations of natural systems, and explores a rational societal response to this collective understanding, and a *cornucopian* or *technocentric* view which emphasises the ingenuity of technology and human innovation in delivering solutions to environmental problems (Turner et al, 1994). These contrasting poles are enduring archetypes in more recent scenario studies which aim to consider the possibility of deep societal changes over decadal timeframes, of which low-carbon scenarios are key examples (Hughes and Strachan, 2010). Such studies often use a '2x2 matrix', as suggested by the US-based Global Business Network (Schwartz and Ogilvy, 1997), to structure such polarised world views, and to represent them as broad driving forces leading to alternative scenarios (e.g. Nakicenovic and Swart, 2000; OST-DTI, 2001). The 2x2 matrix therefore offers a framework for contrasting several 'world views', and by including them all presents a scenario set which as a whole purports to be value neutral. However this framework in itself does not necessarily challenge these world views, question their plausibility or demonstrate how the future scenarios they present can be brought about or avoided.

Other researchers argue that rather than claiming an objectivity which they can never truly achieve, producers of scenarios should openly acknowledge the value-driven nature of their work, and be explicit about this. In a series of papers, Robinson (1982, 1988, 1990) argues that the presentation of modelling

and forecasting as objective and predictive obscures the extent to which present political choices can affect future outcomes. He argues therefore for a shift 'from predicition and likelihood to feasibility and choice' (Robinson, 1988). As such the explicit definition of a desirable future (according to a certain set of values) provides the justification for present decisions, an approach which Robinson calls 'backcasting'.

Robinson cites Amory Lovins' 'soft energy paths' (Lovins, 1977) as an example of this approach, and in outlining a backcasting methodology (Robinson, 1982, 1990) focusses on sustainable energy examples. As set out in these papers his approach is based on defining in quantitative and qualitative terms a future energy system, including summing assumed future energy demands, efficiencies of energy technologies, and energy supply options, and ensuring that supply and demand are 'balanced'. In a final step the 'social, environmental, political and technological implications of the scenarios' (Robinson, 1982) are analysed. This approach of focussing primarily on the technical feasibility of a desired end point defined by quantitative targets (e.g. energy balances and emissions constraints), with the policy implications drawn out in a subsequent separate step, has become a common template for a certain type of low carbon scenario, described elsewhere as 'technical feasibility studies' (Hughes and Strachan, 2010).

Multi-actor transitions – the Mont Fleur Scenarios

The activity of envisaging a desirable future is often naturally stimulated at times of transition. Such a period took place in South Africa between 1990 and 1994, when the country evolved from an apartheid state, to a fully representative multi-party democracy. During this time a number of 'forums' took place at which South Africans discussed the way forward for their country (le Roux et al, 1992). One of these processes was structured around the production of scenarios, and was facilitated by a former Shell scenario planner, Adam Kahane. In their report of the process, the authors emphasise that 'there is no standard method of developing scenarios', but describe the process as one of logical and open discussion between participants: 'The scenario process is logical. There is no place in the core of a scenario conversation for positions or values. Instead the discussion is about facts and logic: can you convince your fellow team members that the story you are putting forward is plausible?' (le Roux et al, 1992)

In the use of intuitive, discussion based techniques to identify possible outcomes via analysis of key actor motivations, this process – which produced what became known as the 'Mont Fleur Scenarios' – was in some ways an heir to the early Shell scenarios. However, the context of this process was quite different. While the Shell scenario process was internal to a single company, Mont Fleur was a multi-stakeholder process, drawing together politicians, activists, academics and business people from across the ideological spectrum, 'to develop and disseminate a set of stories about what might happen in their country over 1992-2002' (le Roux et al, 1992). Thus, rather than focussing on challenging members of a particular organisation to abandon their outdated 'world view', they were focussed on trying to find common ground between actors whose world views were likely to be somewhat conflicting.

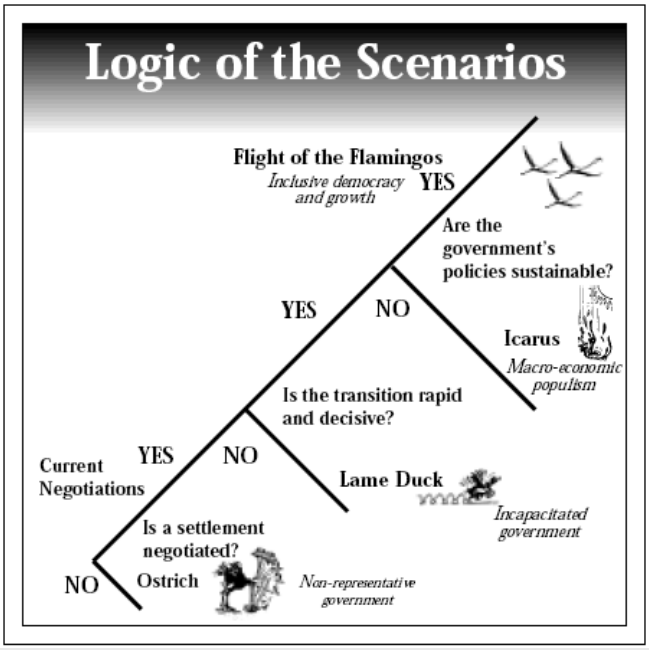


***Figure 3**: The logic of the Mont Fleur scenarios*

The discussions focussed on attempting to elicit agreement, as far as possible, around the likely outcomes of particular combinations of events and actor decisions moving forward from the present. Political and economic failures led to unsuccessful outcomes in three of the scenarios, but in a fourth, '*Flight of the Flamingos*', an inclusive political settlement combined with cautious but sustainable economic policies led to long term growth. Although the participants differed substantially over some of the details which would bring such a scenario about – differences which reflected the broad political mix of the group – the process did identify much common ground around the broad pre-conditions for success and demonstrated the roles of key social actors in the transition. The text accompanying the scenarios emphasised that 'Scenarios imply the future is not fixed but can be shaped by decisions and actions of individuals, organisations and institutions.' (le Roux et al, 1992). The scenarios provided the basis for a commonly held understanding of a future *not yet experienced*. The process of logically thinking through the outcomes of the various courses was a learning experience, enabling greater understanding and compromise between participants. Thus it was found that scenarios 'find and enlarge the common ground' (le Roux et al, 1992) between diverse actors.

The Mont Fleur scenarios suggest a slightly different approach for explicitly normative scenario thinking. Whereas the backcasting approach is predicated on being able to define, quite precisely, what the desired end point will look like, the Mont Fleur approach allowed for the inclusion of divergent world views, attempting to focus on commonalities rather than differences. Further, the Mont Fleur approach, though looking for successful and desirable outcomes, did not presuppose them – indeed the pathways that led towards less favourable outcomes were as informative as the pathway that led to a more favourable outcome.

Discussion

This paper has undertaken a review of previous typologies of scenario methods, followed by a more discursive account of the history and development of scenarios since the Second World War. The key insights from both of these sections are now discussed, and the paper concludes with reflections on the relevance of these insights to low carbon scenarios.

The review of scenario typologies revealed that the scenario literature is diverse and heterogeneous, and that it is extremely challenging to arrange such a spectrum of work into categories which are precise, non-overlapping, as well as comprehensive. However there were a number of common themes which emerged from the various authors' arrangements of the literature, which suggest issues that regularly emerge as being important to scenario practitioners (Table 2). Each of these issues did indeed feature in the discussion of the history of scenario techniques, which followed in the subsequent section. However, rather than emerging only as opposite poles of contrasting scenario techniques, these issues more often emerged as a spectrum, from which different scenario authors chose different emphases, or blends of ingredients.

Qualitative and quantitative, intuitive and formal approaches

Although the historical review does show different balances between the use of formal, quantitative approaches to generating scenarios, and those which rely to a greater extent on intuitive or qualitative approaches, a key insight is that scenario thinking can be at its most powerful when it integrates a variety of methodological approaches, formal and intutive, quantitative and qualitative. The scenario approach is less a single methodology, than a broad canvass on which to creatively and flexibly integrate insights from various disciplines.

Learning and decision support

The typological literature also suggests a distinction between approaches which see scenarios primarily as learning or 'hermeneutic' tools, and those which place greater emphasis on the specific content of the end-point scenario as a means to informing decisions in respect of the future. It is clear that the learning experience of undertaking scenario work is in most cases important, and scenarios can offer a new 'language' for a different way of seeing the world, through which participants challenge pre-conceived 'world views'. However, it is not the case that the value of such process-based learning is an opposite or incompatible objective to that of providing specific insight on decisions to be made in the context of an uncertain future. Rather, it should be the case that such learning directly contributes to better decision making. Ultimately, if a scenario process does not in some sense contribute to better decision making, its purpose remains unclear.

Chain or snaphot – the benefits of a temporal link

The typological literature identifies that as well as being chains or sequences of events, scenarios can also be single future 'snapshots'. However, in the historical review the majority of the processes were characterised by a more detailed exploration of the temporal link between possible futures and the actual present. In fact, many of the processes found that a detailed exploration of

present conditions provided important information about the future, sometimes revealing 'pre-determined' as well as 'uncertain' elements (Wack, 1985b).

A 'chain' scenario has important benefits. The causal chain demonstrates the plausibility of the scenarios by showing that each event they describe is a 'descendant of the present' (De Jouvenel, 1967). This can be particularly important in cases where the scenario is hard for users to accept, either because it is uncomfortable or undesirable, or because it does not conform to a strongly held 'world view'. Further, the causal chain emphasises that scenarios are not just for speculating about distant futures, but can be used as guides for understanding the significance of events *as they begin to unfold*, increasing the users' chances of making early and good decisions. Used in this way, scenarios improve the users' abilities to discern the relevant 'signals' in the 'noise' of information they receive in real time (Wack, 1985b).

Actors, scope, and the balance between the possible, probable and preferable

The historical review covered scenarios focussed on relatively narrow sectors and over short time frames, as well as those with a more panoramic, cross-societal scope. As well as affecting the content and nature of the scenario exercise, the scope has a significant effect on the assumptions which can be made about the motivations and actions of the actors in the scenario, which in turn affects the balance between the possible, probable and preferable. Scenarios with a near-term time frame, and which are focussed on a particular market or business environment, are usually able to define actor motivations with some confidence that such motivations can be known and will remain constant for the entire period examined by the scenarios. Due to this clarity with which actor motivations are understood, such scenarios are more able to offer insights about developments in terms of their likelihood, probability, or even inevitability. Due to the apparent immutability of the actor motivations, such scenarios are likely to present to the scenario user very limited options for preventing or influencing the events they described. Rather the implication of such scenarios is to give the scenario user information to protect herself against the events that are to come.

In other cases scenarios involve actors whose motivations are less clear, perhaps because it cannot always be guaranteed that actors will act 'rationally'. In such cases it becomes harder to frame scenarios in terms of 'probability' – rather, the framing becomes more about possibilities, which are contingent upon certain actor positions and motivations. This greater uncertainty implies, potentially, greater choice. If actor motivations are not fixed, it may be that the scenarios suggest to the scenario user strategic options for attempting to influence or direct actions of other actors. Critically, the extent to which this is the case depends upon the agency of the scenario user with respect to these other system actors.

The scenarios reviewed which attempted to look at broader societal prospects over much longer time frames had difficulty in identifying specific system actors and the particular roles they might have in bringing about the changes described. Rather, such scenarios tended to refer to generalised world views about how human society at large was expected to evolve, which were translated into assumptions used to generate scenarios. Such scenarios can be the least conclusive in terms of offering strategic insight to decision makers, as the outcomes are not explained in terms of the actions of identifiable actors, and

are ultimately vulnerable to the criticism of merely embodying a particular 'world view'.

For other authors scenarios should be less concerned with exploring the balance between the possible and the probable, but should rather focus on the description of preferable futures. This perspective rejects the possibility of a purely objective view of more or less likely actor interactions, and elevates the role that conscious choices can have in affecting the future. It asserts the free will of actors to develop different motivations and change their behaviour, and tries to demonstrate the collective benefits of all actors choosing to behave in ways which in aggregate would lead towards a desirable future. Of course, such scenarios remain entirely hypothetical unless they can be used to show how the relevant actors can be encouraged to make the necessary choices that would lead towards this desired end. Some would argue that the desirability of the end point scenario itself provides this impetus – if all actors can agree that a certain scenario represents something worth striving for, they may be sufficiently incentivised to identify and carry out their own roles in that transition. Such scenarios it is argued, make 'desirable ends a powerful enough lever to act on the present'(Massé, 1966, p. 337, my translation). If successful, such scenarios have not one but multiple scenario users, and their key aim is to build consensus among these diverse actors, all of whom are required to act to bring about the desired transition.

Table 3 sets out the relationship between expectations of actor motivations, and relative agency of the scenario user(s), to the balance between the possible, probable and preferable, in some of the scenario processes discussed in the previous section.

Process	Type of scenario user(s)	Expectations of scenario user(s) concerning behaviour of system actors	Agency of scenario user(s) to influence system under consideration	Type of outcomes considered	Type of insight delivered
Shell 1972 oil market scenarios	Single company	Predictable, fixed	Low	Probable	Protective
Kahn 1960 - 1965 Nuclear / escalation scenarios	Government / military	Largely predictable, though with some uncertainties	Medium	Possible	Protective and proactive
La Prospective, 1960-1965, French National Plan	Government	Malleable – directable by scenario user, though some consensus required	High	Preferable	Proactive and consensus building
Mont Fleur Scenarios, 1992	Multiple stakeholders	Range of behaviours considered	As individuals, low; as collective, medium to high	Possible and preferable	Consensus building

Table 3: *Comparing expectations of system actor behaviour, agency of scenario user, types of outcomes and types of insights in different scenario approaches*

Table 3 also suggests three kinds of objective for scenario building.

- **Protective decision making** – a scenario user with low agency in respect of the system takes decisions to protect herself against outcomes considered *possible* or *probable*
- **Proactive decision making** – a scenario user with some degree of agency in respect of the system makes decisions to bring about situations she regards as *preferable*
- **Consensus building** – a group of scenario users perceive their own roles in contributing towards a set of actions which in combination will lead towards outcomes which all users agree as being *preferable*.

By clearly representing system actors, considering their motivations, networks of influence and agency, and, crucially, *by including the scenario user as one such system actor*, scenarios are able to find an appropriate balance between the probable, possible and preferable, in a manner which reflects the realities of the particular system under consideration, and which does not drift into a mere exercise in 'wishful thinking'.

Conclusions – implications for low carbon scenarios

Low carbon scenarios have their own particular challenges, many of which are specific and of a different nature to those faced by the studies discussed in this paper. However, the approaches reviewed in this paper show evidence of scenarios being applied in a wide range of contexts, with successful results. This broad tradition therefore offers insights which could enrich the current practice

of low carbon scenario making. This final section confirms some of these insights.

Cross-disciplinary integration

Although the studies reviewed in this paper do not point to a single reproduceable step by step methodology, several demonstrate the benefits of using a scenarios approach as a canvas on which to creatively integrate cross-disciplinary inputs from a variety of tools, both formal and more intuitive, quantitative and qualitative. A low carbon future will be affected by technology, economics, and behavioural changes, and a scenario approach should offer the flexibility to integrate relevant insights from each of these fields.

Considering long-term futures to improve near-term decisions

The process of undertaking low carbon scenarios is likely to involve learning on the part of participants, about the nature of what is meant by a low carbon future, as well as about the process of cross-disciplinary and cross-societal interactions. However, a central goal of any scenario activity should be to provide insights which help to inform decisions which need to be made in the near term, in respect of a longer term future. Near term decisions can be critical in the light of potential societal and technological lock-in effects (Unruh, 2002), for, 'the future is an emerging landscape with unknown contours… we have to take decisions today that commit us for the future. Even if the information is degraded, we have to place our bets now, to create the future rather than submit to it' (Godet, 1987).

A plausible link from present to future

Because of the criticality of near term decisions in the context of potential lock-in effects, it is also vital that low carbon scenarios do not only describe future 'end-points', but an emerging pathway beginning from the actual present. This structure has the very real benefits of demonstrating the plausiblity of the future as a 'descendant of the present' (de Jouvenel, 1967), and of highlighting which actor actions are required at which points, to deflect 'the course of events in one direction rather than another' (de Jouvenel, 1967, p. 113).

Balancing the possible, probable and preferable through understanding actor motivations and agency

Low carbon scenarios are explicitly concerned with exploring preferable outcomes, defined very particularly in terms of emissions targets and constraints. A key challenge for low carbon scenarios is to explore these futures in a manner which is strategically informative, and not a mere exercise in wishful thinking. The discussion identified that scenarios tread a balance between exploring futures as possible, probable or preferable, and that the crucial way in which clarity about these perspectives is achieved is through the clear identification of system actors, their motivations and agency, and the motivations and comparative agency of the scenario user(s) in relation to these system actors.

This suggests that a key priority for low carbon scenarios is to carefully define the motivations and agency of system actors, in order to deliver scenarios which show plausibility and give strategic insight. However, the review suggested that the clear definition of system actors is much easier for scenario studies focussed on near term, tightly defined sectors, and much harder for scenario studies engaged with a long time frame and cross-societal scope. Evidently, low carbon

scenarios are of the latter kind, and the plausible integration of actor level detail within a panoramic scenario context is perhaps the greatest challenge for low carbon scenarios. This challenge may, in the innovative tradition of scenario methods, call for the creative integration of a range of social science methods, psychology and behavioural sciences, with technical, economic and engineering insights.

References

Aligicia, P.D. (2004) The challenge of the future and the institutionalization of interdisciplinarity: notes on Herman Kahn's legacy, *Futures* 36, 67-83

Amara, A. (1981) The futures field: searching for definitions and boundaries, *The Futurist*, 15 (1) 25-29

Börjeson, L., Höjer, M., Dreborg, K.,Ekvall, T., Finnveden, G. (2006) Scenario types and techniques: Towards a user's guide, *Futures,* 38, 723-739

Berger, G. (1957) Sciences humaines et prévision (Revue des Deux Mondes, 3) in Darcet, J (ed) Étapes de la Prospective, Presse Universitaires de France, Paris

Bradfield, R., Wright, G., Burt, G., Cairns, G., Van Der Heijden, K. (2005) The origins and evolution of scenario techniques in long range business planning, *Futures*, 37, 795-812

Brown, B. and Helmer, O. (1964) *Improving the Reliability of Estimates Obtained from a Consensus of Experts.* The RAND Corporation, P-2986.

Coates, J. (1996) Herman Kahn: an appreciation, *Futures*, 28 (8), 787-789

Dalkey, N.C. (1967) *The Delphi Method: An Experimental Study of Group Opinion*. The RAND Corporation, RM-5888-PR.

Dalkey, J. (1972) An Elementary Cross-Impact Model. *Technological Forecasting and Social Change*, 3, 341-351

de Jouvenel, B. (1967) *The Art of Conjecture* (translated from the French by Nikita Lary), Weidenfeld and Nicolson, London

Dreborg, K.H. (2004) Scenarios and Structural Uncertainty, Department of Infrastructure, Royal Institute of Technology, Stockholm, Sweden

Dresher, M. (1961) *Games of Strategy- Theory and Applications*. Prentice-Hall, New Jersey.

Ducot, C. and Lubben, H.J. (1980) A typology for scenarios, *Futures*, 12 (1) 15-57

Duval, A., Fontela, E., Gabus, A. (1975) *Cross-Impact Analysis, a Handbook on Concepts and Applications in Portraits of Complexity, Applications of Systems Methodologies to Societal Problems*. A Battelle Monograph, no. 9, Colombus, Ohio.

Forrester, J. (1971) *World Dynamics*, Wright-Allen Press, Cambridge, Massachussetts

Freeman, C. (1973) Malthus with a Computer. Chapter 1 in Cole, H.S.D., Freeman, C., Jahoda, M., Pavitt, K.(1973) *Thinking about the Future: A Critique of The Limits to Growth*, Chatto and Windus for Sussex University Press, Sussex

Ghamari-Tabrizi, S. (2005) *The Worlds of Herman Kahn: The Intuitive Science of Thermonuclear War*, Harvard University Press, Cambridge, Massachusets, US

Godet, M. (1987) *Scenarios and Strategic Management* (translated from the French by David Green and Alan Rodney), Butterworths, London

Godet, M. and Roubelat, F. (1996) Creating the future: the use and misuse of scenarios, *Long Range Planning*, 29 (2), 164-171

Gomi, K., Shimada, K. And Matsuoka, Y. (2010) A low-carbon scenario creation method for a local-scale economy and its application in Kyoto city, *Energy Policy*, 38, 4783 – 4796

Gordon, T.J. and Hayward, H. (1968) Initial experiments with the cross impact matrix method of forecasting, *Futures*, 1 (2), 100-116

Helmer, O. (1972) Cross-Impact Gaming. *Futures*, 4 (2), 149-167

Heugens, P.M.A.R and van Oosterhout, J. (2001) To boldly go where no man has gone before: integrating cognitive and physical features in scenario studies, *Futures*, 33, 861-872

Hughes, N. and Strachan, N. (2010) Methodological review of UK and international low carbon scenarios. *Energy Policy*, 38, 6056-6065

Huss, W.R. and Honton, E.J. (1987) Scenario planning – what style should you use?, Long Range Planning, 20 (4), 21-29

Isaacs, J. and Downing, T. (1998) *Cold War*, Bantam Press, London, UK

Kahn, H. (1960) *On Thermonuclear War*, Princeton University Press, Princeton, NJ

Kahn, H. (1962) *Thinking About the Unthinkable*, Horizon Press, New York

Kahn, H. (1965.) *On escalation. Metaphors and scenarios*, Pall Mall Press, London

Kahn, H. (1982) *The coming boom*, Simon and Schuster, New York

Kahn, H. and Weiner, A. (1967) *The Year 2000: A Framework for Speculation on the Next Thirty-Three Years,* Collier-Macmillan, Toronto, Canada

Kahn, H. Brown, W. Martel, L. (1977) *The Next 200 Years: A Scenario for America and the World*, Associate Business Programmes, London

Kleiner, A. (1996) *The Age of Heretics: Heroes, Outlaws, and the Forerunners of Corporate Change*, Nicholas Brealy, London

le Roux, P. et al. (1992) The Mont Fleur Scenarios. *Deeper News* Volume 7 Number 1. Emeryville: Global Business Network

Linstone, H. (2006) Book Review: The Worlds of Herman Kahn: The intuitive science of Thermonuclear War, *Technological Forecasting and Social Change*, 73, 76-79

Lovins, A. (1977) *Soft Energy Paths: Towards a Durable Peace.* Penguin Books, Harmondsworth, Middlesex.

Mander, S., Bows, A., Anderson, K., Shackley, S., Agnolucci, P. and Ekins, P. (2008) The Tyndall decarbonisation scenarios – Part I: Development of a backcasting methodology with stakeholder participation, *Energy Policy*, 36, 3754 – 3763

Mannermaa, M. (1986) Futures research and social decision making – alternative futures as a case study, *Futures*, October 1986, 658 – 670

Marien, M. (2002) Futures studies in the 21st Century: a reality based view, *Futures*, 34, 261-281

Masini, E.B. (1993) *Why Futures Studies?* Grey Seal Books, London, UK.

Massé, P. (1966) Les attitudes envers l'avenir et leur influence sur le présent, in Darcet, J (ed) Étapes de la Prospective, Presse Universitaires de France, Paris

McDowall, W. and Eames, M. (2006) Forecasts, scenarios, visions, backcasts and roadmaps to the hydrogen economy: a review of the hydrogen futures literature, Energy Policy, 34, 1236 – 1250

Meadows, D.H., Meadows, D.L., Randers, J., Behrens, W.W. (1972) *The Limits to Growth*, Universe Books, New York.

Nakicenovic, N. and Swart, R. (eds) (2000) Special report on Emissions Scenarios. Cambridge University Press, Cambridge, UK.

Oxford University Press (1989) Oxford English Dictionary, Second Edition, Oxford University Press, Oxford.

OST-DTI (2001) Energy for Tomorrow- Powering the 21st Century, Report of the Energy Futures Task Force

Raskin, P., Banuri, T., Gallopin, G., Gutman, P., Hammond, A., Kates, R., Swart, R. (2002) *Great Transition: The Promise and Lure of the Times Ahead. A Report of Global Scenario Group*. Stockholm Environment Institute- Boston.

Robinson, J.B. (1982) Energy backcasting – a proposed method of policy analysis, Energy Policy, 10 (4), 337-344

Robinson, J.B. (1988) Unlearning and backcasting: rethinking some of the questions we ask about the future, *Technological Forecasting and Social Change*, 33, 325-338

Robinson, J. (1990) Futures Under Glass. A recipe for people who hate to predict, *Futures*, October 1990

Scearce, D., Fulton, K. and GBN (2004) *What If? The Art of Scenario Thinking for Non-Profits*. Global Business Network. http://www.gbn.com/consulting/article_details.php?id=27

Schwartz, P. (1991) *The Art of the Long View*. Doubleday Currency, New York.

Schwartz, P. and Ogilvy, J.A (1997) Plotting your scenarios, in Fahey, L. and Randall, R.M. eds, (1997) *Learning from the future: competitive foresight scenarios*, John Wiley & Sons, New York, 57-80

Singer, M. (1996) The big picture of Herman Kahn, *Futures*, 28 (8), 783-785

Turner, R.K., Pearce, D., Bateman, I. (1994) Environmental Economics- An Elementary Introduction. John Hopkins University Press

Unruh, G.C. (2002) Escaping carbon lock-in, Energy Policy, 30, 317-325

van Notten, P.W.F., Rotmans, J., van Asselt, M.B.A., Rothman, D.S. (2003) An updated scenario typology, *Futures*, 35, 423-443

Wack, P. (1985a) Scenarios: unchartered waters ahead, *Harvard Business Review*, September-October 1985, 73-89

Wack, P. (1985b) Scenarios: shooting the rapids, *Harvard Business Review*, November-December 1985, 139-150

Wagar, W. W. (1996) Herman Kahn: Teacher, *Futures*, 28 (8) 791-792

Wohlsetter, R. (1962) *Pearl Harbor: Warning and Decision*, Stanford University Press, Stanford, California, quoted in Wack (1985b) (op. cit.)

Williams, J.D. (1954) *The Compleat Strategyst*. McGraw-Hill, New York