Scenario Planning Process of Energy Companies in Sweden

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Abstract

Scenario Planning as a tool for planning for the future has widespread use in the industry today and enjoys an envious status as the primary tool of futures thinking. However, the development in this field has been mired with confusion on its application and purpose. Since popularized by Shell in its use to anticipate the oil crisis in the 70s, scenario thinking has grown in use to aid public policy making, corporate strategic planning and even in the natural sciences. This paper attempts to study the scenario planning process design from a corporate perspective by studying its use in energy companies in Sweden. Energy companies present an ideal industry for this study as it is embroiled with obvious uncertainties in future power and carbon prices but also with subjective uncertainties tied to the political interest in the industry and the industry being in the centre of the climate change debate. Furthermore, the extremely long term nature of investment projects in this industry further exacerbates the need for deep insights into the future. This paper studies the nature of the scenario planning process based on two past papers; that have identified the key characteristics of scenarios. Firm specific internal factors are used to explain the differences in the process designs found in empirical data. Finally a framework to design a scenario planning process is proposed. This framework takes into account these internal factors to enable companies to leverage their internal resources and make full use of scenario planning as a tool.

Keywords: Scenario Planning, Process Design, Process Adaptation, Internal Factors
Acknowledgements

I take this opportunity to thank both professors Professor Thomas Sandberg & Professor Staffan Laestidius, who have helped guide and tutor myself throughout the process of writing this paper. Also, I wish to convey my heartfelt gratitude to the individuals who have very kindly contributed their knowledge and opinions. This thesis would not have been possible without your instrumental contributions. This paper as my first foray into writing a management related thesis has enabled me to study futures thinking in depth in the field of energy; both areas of keen interest for myself.

Vinod Krishnan

“Markets are constantly in a state of uncertainty and flux and money is made by discounting the obvious and betting on the unexpected”.

George Soros
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1. Introduction

1.1. Background
The last twenty years has been a period of strong market reform of the energy sector in Sweden through liberalization and market coupling in the Nordic region. This lead to significant gains in operational and technological efficiency. Recent years show an overall decline in total energy use in Sweden. Industry uses about the same amount of energy today as it did in 1970 although industrial production is three times higher today (SEA, Swedish Energy Agency 2010). This low volatility in demand is however by no means an indicator of the level of uncertainty faced by the companies in the Swedish energy sector today. With the climate policy at the centre of the energy debate, strong lobbying for increasing interconnectors to Continental Europe and UK, potential adoption of electric vehicles and electrification of offshore petroleum installations into the power system, possible migration of power intensive industries and the uncertainty of future fuel and CO2 prices (Econ Pöyry & THEMA Consulting Group 2010), energy companies have to decide on where to place their bets (investments) for the future. A recent study even contends that the Nordic power sector is entering a new formative period. The occurrence and sequence of occurrence of events related to the above said driving forces in the industry may well lead to very different paths in the future. With the long durations usually tied to energy related investments, companies may well be faced with an unnoticed window of opportunity to strengthen their competitiveness. Developing robust strategies that can exploit these opportunities and mitigate risks in different future possible pathways is essential in the survival of these firms.

Similar period of uncertainty in the global energy markets in the 1970s propelled the scenario planning approach into prominence when a team in Shell foresaw the oil crisis in 1973 leading Shell to successfully navigate through the economic downturn profitably. An argument to explain this phenomenon was advocated by Schnaars who argues that the failure of conventional complex quantitative models used to forecast has disillusioned users (Schnaars 1987, 105). Over the period of the last thirty years, an array of scenario planning approaches and tools have been developed and practiced by industry practitioners and academic researchers alike. However this chaotic development in the field of scenario planning has resulted in little consensus and has led to much debate and even confusion about the process and application of scenario
planning. One study suggests that most practitioners do not even know that there are more than two dozen techniques for developing scenarios (Bishop 2007, 5).

This paper attempts to shed light on this confusion by exploring the use of scenario planning methodologies practiced in the industry. The boundary of this study is limited to the Swedish energy sector and does not claim to infer the findings to the use of scenario planning as a whole. Although the line of reasoning in the choice of scenario planning approaches may well be similar in other sectors or geographical regions.

1.2. Thesis Problem & Limitations

The research questions that have been identified for this paper are;

1. How do different energy utility companies in the Swedish energy sector perform their scenario planning?
2. Which methodologies or category of approaches are predominantly used?
3. What are the underlying reasons for these differences in scenario planning process design choices?

**Limitations**

- Does not attempt to ‘fit’ the scenario planning approach of each company to those available in the market or in literature. The focus is placed on understanding the reasoning behind the choice of approach.
- Limited to a portion the Swedish energy market due to logistical and time limitations; ex. transport sector is a key energy user but is not covered by this paper.
- Interpretation of results will be both geographically and industry specific.

1.3. Outline of Thesis

The structure of this thesis is to first explore the literature available on the scenario planning subject and understand the various types of approaches developed. Concurrently, an overview of the Swedish energy sector is made with references to the Nordic energy sector and the larger European region. This industry overview is mainly to study the factors that cause uncertainty to gain a deeper strategic insight into the market. Following chapters discuss the findings and analysis of the qualitative semi structured interviews and the proposed framework for the adaptation of scenario planning in organizations.
2. Research Methodology

A broad means to classify research methods is to distinguish between quantitative and qualitative research. This study will focus only on a qualitative study of scenario planning. Myers describes the qualitative research design process as follows;

![Qualitative Research Design](image)

**Philosophical Assumptions**
Myers explains that the philosophical assumptions stated here refers to the epistemology or research paradigm used for the research. The author goes on to clarify that there are three distinct philosophical assumptions that can define qualitative research namely positivist, interpretive or critical (Myers 2009, 37).

![Underlying philosophical assumptions](image)

**References**

- Myers (2009, p36)

The most dominant of the three is the positivist research. This type of research assumes that the reality is objectively given and can be measured (independently from the observer). The interpretive research, on the other hand, has only gained ground in the area of business and management in the last 20 years. This type of research assume that reality is dependent on ‘social constructions’ such as language, consciousness, shared meanings and instruments (Myers 2009, 38). An important feature of interpretive research is the concept of ‘double hermeneutic’ as described by Giddens (1976). This feature recognizes that the social researcher is as much a subject as he/she is an observer in the situation when studying people. In other words, it is a prerequisite that the researcher speaks the same language and understands the context of the people or organization being studied to be able to gain any meaningful data at all. Critical research is much less common compared to the previous two types of research. Critical research assumes that social reality is historically embedded and there is a trend that can be observed. Although this trend can change, it is constrained by key social, cultural and political forces. This study will take on an interpretive research approach as its underlying epistemology. As such, significant literature on scenario planning will be analysed and the industry context will be understood prior to data collection will be attempted.

Research Method
Next, the research method will be established. For the purposes of this study the research method selected was based on grounded theory. This method attempts to develop theory based on data systematically collected and analysed. The authors describe this as ‘an inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data’ (Martin 1986).

There are several notable advantages to the use of grounded theory namely;

- Provides ample evidence to back up claims
- Provides a systematic detailed analysis of the data
- Encourages going back and forth between data collection and analysis
- Useful for describing repeating processes
- Has an intuitive appeal for new researchers as it allows for detailed data analysis (Myers 2009, 111)

At the same time, the author does point out the drawbacks of using grounded theory as well. The main disadvantage cited by Myers is that novice researchers in the use of
grounded theory typically get overwhelmed at the data coding level. This refers to the process of ‘open coding’ in grounded theory where data or text is analysed using a code that is description of a phenomenon (Myers 2009, 112). The challenge for the novice researcher is, as Myers claims, to be able to move beyond the detail level of coding to establish categories and theorize with generalizations. In this study, two pieces of literature are used as a basis to assess the results of the interviews conducted, i.e. the open coding with the use of scenarios characteristics as the descriptor of the coding. As this complex iterative form of research is not possible with the limited time available for this thesis, this paper solely uses the grounded theory approach for the purposes of coding. As a grounded theory purist, Myers criticizes this type of use of grounded theory as it does not use grounded theory to its fullest potential (Myers 2009, 112). The author does concede however that if this form of use of grounded theory does result in the generation of original contribution to knowledge with interesting findings, then limiting the use of grounded theory to only coding can be justified.

Data Collection Technique
For the purposes of data collection, this study primarily relies on literature review to build an interview guide followed by a semi structured qualitative interview. As such the primary data gathered in this study relies solely on the interviews with energy utilities in Sweden and the interview of the scenario planning consultant of Kairos Futures in Stockholm. Secondary data used in this study comes from a variety of sources including publications on scenario planning, industry reports, annual reports of the relevant companies and popular publications in the field of scenarios. The interview conducted has been chosen to a semi structured one. Semi structured interviews use some preformulated questions but with no strict adherence to these questions. New questions may emerge as the interview proceeds (Myers 2009, 124). This form of interview was chosen because this study is primarily exploratory to identify the reasoning behind the choice of scenario planning process design, as such all possible reasons for these decisions cannot be anticipated and must be allowed to flourish during the interview process. That being said, every interview is planned to begin with the same set of questions (Appendix 1). Each interviewee is to be given these preformulated questions at least two days prior to the interview to ensure that they are sufficiently prepared and are able to fully contribute to the interviewee process. Most of the interviews are planned to be conducted more than once as the empirical data is compared and analysed against the literature available in the field of scenarios. An
interview with an external scenario planning consulting firm is also conducted to verify the analysis performed on the data collected from these companies. This is used as a form of validation prior to building a framework on how scenario planning is adapted into energy companies.

Data Analysis Approach
The data analysis performed is based on both induction and abduction approach of logical reasoning. Abduction together with deduction and induction is used to make logical inferences about the world. Induction is the research approach that generalizes from a particular set of observations to a broad statement (Given 2008, 429). The abduction approach is closely related to the induction line of reasoning. Whilst inductive inferences is viewed as probable (thus the need to validate or supplement it with probabilistic or statistical assessments), abductive inferences are merely plausible explanations. Although both these lines of inferences are easily refuted with contradictory cases to the generalizations made, it is nevertheless an important method of discovery of new theories or hypotheses as it expands the ‘realm of plausible explanations’ (Given 2008, 1).

Ethical Considerations
In order to maintain the ethical integrity of this research, several considerations have been made during the process of data collection; i.e. interviews;

- Each interviewee is given the options of remaining anonymous (both as an individual & the company)
- Each interviewee is given the interview summary for their verification

To maintain the separation and independence of this research from the prerogative of the interviewee, the analysis performed on the data collected (based on the interview summaries available in the Appendix of this paper) is entirely based on the perception of the researcher and has no bearing on the point of view of the companies or the individuals interviewed.
3. Scenario Planning in the literature

This section attempts to introduce the scenario planning approach and explores the different methodologies in terms of the process it is practiced in a corporate environment. The summary section identifies the methodologies that are chosen as a basis for the framework of the data collection method.

3.1. Introduction

How do you make strategic decisions? How do you decide where to place your bets? Shell made a bet on offshore and LNG markets in the 1970s. The remarkable success due to this strategy has been widely attributed to its use of scenario planning. These choices involve significant strategic risk - the risk associated with major investment decisions that involve long time frames and uncertain outcomes (Brummell 2008). Multiple scenario analysis is looked upon favourably as it takes an entirely different perspective on environmental uncertainties. While conventional methods such as trend projection forecasting techniques attempt to eliminate uncertainty by providing managers with one forecast, multiple scenario analysis confronts managers with entirely different outlooks on the future that entails different environmental uncertainties (Bood 1997, 633). The authors go on to outline 6 key functions in the use of scenarios, namely;

1. Evaluation and selection of strategies
2. Integration of various kinds of future-oriented data
3. Exploration of the future and identification of future possibilities
4. Making managers aware of environmental uncertainties
5. Stretching of managers' mental models
6. Triggering and accelerating processes of organizational learning”

(Bood 1997, 635)

Brummel, a current scenarios practitioner, writes that scenario planning is a process undertaken by a company to broaden its thinking about the future as a basis for developing and implementing robust strategies (Brummell 2008). Fink & Schlake describe the effective use of scenarios in its competitive environment is a process that comprises of three fundamental principles; systems thinking, future open thinking and strategic thinking (Fink 2000). One of the more revered scenario guru’s Peter Schwartz clarifies that scenarios are tool to enable us to be able to take a longer term view in a global and uncertain market and to consider perceptions towards alternative future environments (von derGracht 2008). However, despite this clear benefit, the use of
scenarios has been ignored for some time. One study even cites that ‘Practice seems to be leading the literature’. Many different viewpoints on the use of scenarios have been expressed by a number of researchers.

**Definition**

In a recent article on the state of scenario development, Bishop et al claim that there is a clear confusion concerning the use of the term ‘scenario’ as there is widespread use for the term for any description of alternative futures (Bishop 2007). Michel Godet goes even further to propound that the term scenarios today is often abused to describe any set of hypotheses (Godet 2000, 9). Despite this confusion, Bradfield et al makes a vague observation that there are several overlapping opinion camps as the terms planning, thinking, forecasting, analysis and learning are commonly attached to the word scenario in the literature. However the authors go on to claim that there appears to be no area in scenarios in which there is widespread consensus; namely conflicting definitions, characteristics, principles and methodological ideas (Bradfield et al 2005, 796). Bishop et al makes a fundamental clarification by starting with the basic vocabulary used in the scenario literature. The authors highlight that the terms technique, approach, method or tool have all been used loosely with little consensus on its meaning. The paper clarifies the following:

- A ‘technique’ and ‘method’ seem to be used interchangeably in the literature. The authors found that ‘method’ refers to a solid, organized and academic connotation while ‘technique’ defines style more than substance. Both terms however denote the ‘systematic means that is used to generate a product’.
- A ‘tool’ on the other hand refers to a concrete device used to accomplish a task. Scenarios and plans are clearly established as not tools.
- An ‘approach’ is the process one employs to conduct a project.

(Bishop 2007)

This is an important part of the literature review as the reader may well be confused when presented with similar meaning terms from different literature cited throughout the this paper.

3.2. History of Scenario Planning Development

Although modern day scenario planning has gained prominence in the last 30 years, the roots of the scenarios as a strategic planning tool can be evidently employed by military
strategists; usually in the form of war game simulations. However the first documented evidence of such a formulated use of strategic planning principals as a tool can be seen only in the 19th century; in the writing of von Clausewitz and von Moltke (both Prussian military strategists) (Bradfield et al 2005, 797). In the 1950's, Herman Kahn and his associates at the RAND (Research and Development) Corporation demonstrated that different sequence of events could result in a variety of possible outcomes to the US Air Force. (Millet 2009, 62). The author claims that Kahn used mental models similar to imaginary and hypothetical war games. Kahn’s use of scenarios did not make use of numerical or probability based forecasts of the future. Kahn went so far as to say that the military planning was focused more on ‘wishful thinking’ than rational expectation and could result in a nuclear war. (Millett 2003, 17). At this point there were no established scenario planning approaches. Scenarios were more broadly used as a form of preparing for an uncertain future (von der Gracht 2008, 69). This led to Kahn being hailed as the ‘father’ of modern day scenario planning. (Varum 2010, 356). RAND Corporation also developed the use of the Delphi technique and systems analysis. Delphi technique was used to harness and synthesize expert opinion and system analysis was derived from the need for simulation models.

Ian Wilson of General Electric and Pierre Wack of Royal Dutch Shell approached Kahn to explore the possible use of scenarios in corporate planning in the 1970’s. The key difference in the approach adopted by Wack and Wilson is they preferred the focus on ‘alternative future states regardless of the steps by which they were achieved’ as opposed to Kahn’s hypothetical sequence of events from the present to the future. (Millett 2009, 62). Wilson’s team in GE chose to utilize ‘intuitive probabilities’ for their scenarios whilst Wack’s team did not. Wack on the other hand (much like Kahn) opposed the use of probabilities in scenarios as he wanted to ‘encourage flexible rather than deterministic planning. He believed that the use of probabilities stifled senior management’s thinking about the future as probabilities gave rise to forecasts of most likely futures instead.

Wack’s work at Shell catapulted corporate scenario planning into prominence in the 1970’s. In 1969, Shell started the ‘Horizon Planning’ initiative to look ahead to the year 1985 (Bradfield et al 2005, 799). Wack led the initiative and failed in the first attempt aptly called the ‘first generation scenarios’. But the subsequent attempt called ‘Year 2000’ was presented to senior management in 1972 and was a tremendous success
(Bradfield et al 2005) as the study predicted the energy crises of 1973 and 1979, the
growth of energy conservation and the reduction of the demand for oil, the evolution of
the global environment movement and even the breakup of the Soviet Union (de Geus
1997, 67). The success of Shell in the use of scenario planning is evident in literature
today. (Millett 2003) even claims that Shell’s definitions and methods remained as the
‘gold standard’ of corporate scenario generation for the next three decades.

Ian Wilson soon abandoned his use of intuitive probabilities and joined Wack at the
corporate planning consulting group at SRI International to build the foundation of what
is known to be the intuitive logic school. Here the work of Wack was continued by Peter
Schwartz. Schwartz charismatic flair coupled with his experiences at SRI and Shell led
him to write his first book on the subject ‘The Art of the Long View’; is widely regarded
as the bible for scenario practitioners (Millet 2009, 63).

Alongside the developments in the US in the 1950s, the French school of futurist began
to develop as well. Gaston Berger founded an alternative method to long term planning
using scenarios that he termed ‘La Prospective’. The initial aims of this work was
focused on public policy planning and is said to have emerged in response to the
repeated failure of classical forecasting (Bradfield et al 2005, 802). Although Berger’s
work continued, the La Prospective only flourished in the mid 1960s, with the continued
work of Pierre Masse and Betrand de Jouvenel. Whilst Berger used scenario planning
as a tool to develop positive images or ‘normative scenarios’ of the future in the political

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Figure 3. History of Business Scenarios. Adapted from Millett, 2003
context to allow for effective policy making, Masse focused on using scenarios for the building of the French National Plan (1960-1965) and subsequent economic plans. de Jouvenel on the other hand popularized the La Prospective school internationally when he argued that small dominant political groups shaped the direction of national policy could be overcome by promoting futurists to voice their idealistic images of possible futures and those that could be used as a blueprint for national policy making. Michael Godet was the pioneer in bringing the La Prospective school of scenario planning to corporate planning in the mid 1970s when he began to develop scenarios for national energy companies (EdF & Elf). The difference however with Godet’s approach was that he utilized largely mathematical and computer-based probabilistic approach to scenario development. He propounded this focus as it uses a more integrated approach and used a mix of system analysis tools and procedures (Godet 2000). The core difference between the use of scenario planning in the US and France is that the La Prospective still remained largely with a focus on the socio-political foundations of the future of France itself (Bradfield et al 2005).

Early Scenario Techniques
One of the key developments in the early stages of the intuitive logic school is the use of two distinct methodologies in scenario planning namely; Trend Impact Analysis (TIA) and Cross Impact Analysis (CIA). TIA became popular as the traditional forecasting methods depended on extrapolation of historical data and failed to recognize the occurrence of unprecedented future events (Bradfield et al 2005, 801). This was done by building a list of unprecedented future events that could cause deviations from the extrapolated historical trend curve and attaching expert judgement based probabilities to each occurrence based on a function of time and impact of the event. This leads to an adjusted trend curve. The methodological process of CIA is similar to that of the TIA however it incorporates an additional layer of complexity caused by the interdependencies of events to correct the initial probabilities developed. This layer is referred to as the cross impact calculation that attaches conditional or proportional probabilities to sets of events that have or have not occurred (Bradfield et al 2005, 801).

Bradfield et al offers anecdotal evidence that scenarios popularity declined in the 1980s but seems to have undergone a dramatic surge in popularity in references between 1992 to 2000 (Bradfield et al 2005, 804). The development of scenario planning since the early 90s have been predominantly been in the intuitive logic school. Although the
probabilistic modified trends and La Prospective school continue to be developed it does seem to have relatively little exposure from the practitioners perspective. Thus there have been no real standardized procedures that planners can follow. These approaches ‘differ in terms of number of steps, software usage, degree and type of external expert inclusion, usage of probabilities of occurrence, or the form or quantity of the scenarios’ (von derGracht 2008). According to (Ringland 2006, 185-186), there are currently nine well known scenario approaches;

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Scenario Approach</th>
<th>Bradfield et al Categorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battelle Institute</td>
<td>BASICS (Battelle Scenario Inputs to Corporate Strategies)</td>
<td>Probabilistic Modified Trend</td>
</tr>
<tr>
<td>European Commission</td>
<td>“Shaping Factors”, an adaptive form of Delphi consultation</td>
<td>Intuitive Logic</td>
</tr>
<tr>
<td>Global Business Network</td>
<td>Scenario development using Peter Schwartz’s methodology</td>
<td>Intuitive Logic</td>
</tr>
<tr>
<td>Kairos Future</td>
<td>The TAIDA model</td>
<td>Intuitive Logic</td>
</tr>
<tr>
<td>SAMI Consulting</td>
<td>Five-stage approach that concentrates on Insights development and uses knowledge inside the organisation to derive strategy</td>
<td>Intuitive Logic</td>
</tr>
<tr>
<td>ScMI</td>
<td>Scenario Management Approach</td>
<td>Probabilistic Modified Trend</td>
</tr>
<tr>
<td>Stanford Research Institute (SRI)</td>
<td>Stanford Research Institute (SRI) “intuitive-logic”</td>
<td>Intuitive Logic</td>
</tr>
<tr>
<td>The French School</td>
<td>Michael Godet’s approach: MICMAC, an extension of cross-impact techniques</td>
<td>La Prospective</td>
</tr>
<tr>
<td>Wharton Business School</td>
<td>Nine-step heuristic scenario approach</td>
<td>Intuitive Logic</td>
</tr>
</tbody>
</table>

Table 1. List of Established Scenario Approaches. Modified from Ringland, 2006 and Bradfield et al, 2005

3.3. Industry Application of Scenario Planning

Schoemaker’s study in 1997 found that organisations that face the following conditions will especially benefit from scenario planning:
Uncertainty is high relative to managers’ ability to predict or adjust
Too many costly surprises have occurred in the past
The company does not perceive or generate new opportunities
The quality of strategic thinking is low, too routinised, or bureaucratic
The industry has experienced significant change or is about to
The company wants a common language and framework, without stifling diversity
Competitors are using scenario planning.” (von derGracht 2008, 76)

Malaska and Meristo found that scenario planning was not used until after the first oil crises in 1973. Malaska concluded that the increase in usage of scenarios were associated to increased unpredictability of the corporate environment in the 1970s (Bradfield et al 2005, 803). In 1977 and 1981, Linneman and Kahn conducted surveys of scenario planning use among Fortune 1000 US industrial companies found that 22% of respondents use scenario planning. The research found that the level of use varied between industries with technologically sophisticated industries, such as aerospace, being the dominant users. A similar study conducted in Europe found that 36% of respondents used scenario planning in 1981 and a follow up study in 1985 found that the figure increased to 40% of respondents (von derGracht 2008, 70). Both studies of Linneman & Klein and Malaska made a similar discovery that the highest proportion of scenario users were large companies operating in capital intensive industries with long strategic planning horizons (10 years and beyond). The industries cited were oil companies, vehicle manufacturers, electricity suppliers and transport companies (von derGracht 2008, 804). There seems to be a consensus amongst authors that there is limited data on the popularity and proliferation of scenario techniques after this period. A most recent study by Peter Schwarz in 2006 revealed that more than 38% of German companies use scenario techniques frequently and 56% of German companies do so occasionally. The same study however identified that scenario planning methods needs strong improvements to be used in practice (von derGracht 2008, 70). A study by Bain & Company in 2005 of management tools and trends found that of a survey of 960 international executives respondents from all over the world, scenario techniques had a usage rate of 54% and a satisfaction score of 3.9 of 5.0 (von derGracht 2008, 71).
3.4. Approaches Comparison

Now unto the key purpose of this section of the literature review. Scenario projects can be used to focus on different decision fields such as companies and business units, products or technologies. A bibliometric study by Varum & Melo in 2007 of all scientific articles published in the Science Citation Index Expanded (SCI) and the Social Sciences Citation Index (SSCI) yielded 194 results (Varum 2010). Although there are many issues where scenario approaches can differ, all processes follow a common basic structure (von derGracht 2008, 84). One study conducted analysing many of these scenario approaches found that all consist of five to nine steps with differing detailed content however all have similar process sequences (Bood 1997, 634). The authors proposed a generic scenario process in six phases, although the authors do concede that the proposed process bears most resemblance to Schwarz’s model.

![Diagram](image)

Figure 4. The Process of Scenario Development. Adapted from Bood, 1997, p. 634

Recently several authors have attempted to resolve this confusion in practicing scenario planning. Van Notten from the International Centre for Integrative Studies in Maastricht created a typology of scenario types by proposing three major categories based on the “why” (project goal), the how (process design) and the what (content) (van Notten 2003). Van Notten et al distinguishes between normative and descriptive scenarios. Descriptive scenarios explore possible futures based on the current status and normative scenarios describe probable or preferable futures from the point of view of the scenario developer (van Notten 2003, 429). However this study was focused on the overall use and types of scenario projects and not the methodology or approach used in different scenario projects.
Next we will delve deeper into four studies that have significantly contributed to the understanding of the different scenario planning methodological differences.

**Gausemeier et al., 1996**

Gausemeier, Fink & Schlake did a study of the different approaches in 1996 and created an overview of the most established approaches over possible methodological characteristics of scenario projects and a classification scheme of scenarios along nine dimensions (Gausemeier et al 1996, 103-117) as quoted by (von der Gracht 2008, 83-84).

![Figure 5. Nine Dimensions of Scenario Classification. Adapted from Gausemeier, 1996](image)

The first dimension the authors refer to is the *Problem Statement* or the key purpose of the scenario project. The distinction is made between ‘Problems of decision’ and ‘Problems of orientation’. ‘Problem of orientation’ focus on selecting a best course of action has to be chosen between many to achieve a set of predefined goals. ‘Problems of decision’ on the other hand explores the repercussions in scenarios for a set of decision behaviour.

The second dimension, *Controllability*, describes the extent to which influence could be exerted unto the scenarios. External scenario projects are described as projects where the decision maker can’t fully influence the development of the scenarios and conversely for the internal scenario projects. The mix of the two types is termed system scenario projects; where the scenarios are only influenceable in parts.

The third dimension, *Form of organisation*, describes the stakeholders involved in the scenario project and their responsibilities. Here scenario creation and application implementation is identified for different levels of controllability. For external scenario
projects, it is performed by different persons/actors while the same person/actor performs it for internal scenario projects. No clear classification is made for system scenario.

The fourth dimension, Temporal condition, describes if a scenario project falls into the “Situational scenario” category or “Process-related scenario” category. Situational scenarios are projects where a picture of the future is created (similar to a snapshot at a point of time) while process-related scenario projects focus on how the future unfolds or develops. Process scenarios are also referred to as dynamic scenarios while situational scenarios are referred to as static instead.

The fifth dimension, Point of origin, described if the decision maker will take a ‘explorative’ or ‘anticipative’ point of view. The explorative process begins at the status –quo and moves forward to develop scenarios (also known as what-if scenarios) whilst the anticipative process begins at a concrete future projections at a defined point in the future and go back in time (also known as the What-must-be-that scenarios).

The sixth dimension, Goal-orientation, describes if the scenario creation is a “descriptive” or “prescriptive” approach. Descriptive scenarios, referred to as pictures of state, are created based on cause effect relationships between variables and does not include the prerogative of the scenario developer on the state of the future scenario. Prescriptive scenarios focus on how to achieve the desired future and are referred to as sight pictures.

The seventh dimension, Probabilities of occurrence, describes if probabilities are assigned to the key factors or uncertainties. The authors assert that this characteristic is strongly dependent on the eight dimension i.e. Textual orientation. Textual orientation refers to if scenarios are defined using extreme scenarios or trends scenarios. The authors clarify that it is not useful to assign probabilities to extreme scenarios. Trend scenarios, on the other hand, can be evaluated in terms of likelihood based on subjective expert estimations.

The ninth dimension, Planning interval, refers to the time duration of a scenario project. The authors propose that the planning interval is dependent on several factors such as the decision and scenario field, the purpose of the project, or the problem statement.

Börjeson et al., 2006

The following study by Börjeson et al. have created a typology by classifying three different types of futures namely; the probable, possible and preferable futures (Börjeson 2006).
Although the focus of this paper seem to be more into scenario techniques in public policy decision related to the environment, much of the principles here can easily be inferred to scenario planning from a corporate perspective. The futures cited above are based on three fundamental questions; ‘What will happen?’ ‘What can happen?’ and ‘How can a specific target be reached?’ respectively. The first question answers if the scenario is a predictive one. This is then divided based on the type of conditions applied in the predictive scenario. Forecasts are based on the question ‘What will happen on the condition that likely development occurs?’. What-if scenarios are based on the question ‘What will happen on the condition that a specified event occurs?’. These scenarios are ideal when used in conditions where challenges and opportunities are foreseeable and is to make decision makers aware of problems that are likely to arise.

Explorative scenarios are based on the question ‘What can happen?’ The two types distinguished here are external and strategic scenarios. External scenarios are focused on the development of external scenarios (described in previous section) while strategic scenarios are focused on what will happen for a given decision behaviour. The authors clarify that explorative scenarios often are used for long time horizons and are frequently employ a method of backcasting. Normative scenarios are formed based on the question ‘How can a specific target be reached?’. In normative scenarios, the differentiation between preserving and transformation scenarios are made based on how the system structure changes. Preserving scenarios respond to the question ‘How can the target be reached, by adjustments to current situation?’ and transformation scenarios respond to the question ‘How can the target be reached, when the prevailing structure blocks necessary changes?’. The authors suggest that preserving scenarios be used when it seems possible to reach the target within a prevailing structure of the system. Transformation scenarios, often backcasting, are usually used in scenarios for high level and highly prioritized targets but this target seems to be unreachable if the ongoing development continues. The authors point out that a key difference between backcasting and optimising scenarios is
that optimising scenarios serve to find efficient solutions while backcasting scenarios focus on finding options that achieve long-term targets.

The authors also propose techniques that can be used for different levels of scenario development based on the scenario type (See Figure 5). One important technique worth mentioning here is the Delphi method. The main idea of a classical Delphi study is to 'collect and harmonise the opinions of a panel of experts on the issue at stake. It recognises human judgement as a legitimate input to forecasts and also that the judgement of a number of informed people is likely to be better than the judgement of a single individual'. (Börjeson 2006)

<table>
<thead>
<tr>
<th>Scenario types</th>
<th>Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predictive</strong></td>
<td></td>
</tr>
<tr>
<td>Forecasts</td>
<td>Surveys</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
</tr>
<tr>
<td></td>
<td>Original Delphi method</td>
</tr>
<tr>
<td></td>
<td>Time series analysis</td>
</tr>
<tr>
<td></td>
<td>Explanatory modelling</td>
</tr>
<tr>
<td></td>
<td>Optimising modelling</td>
</tr>
<tr>
<td><strong>What-if</strong></td>
<td>Surveys</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
</tr>
<tr>
<td></td>
<td>Delphi methods</td>
</tr>
<tr>
<td></td>
<td>Explanatory modelling</td>
</tr>
<tr>
<td></td>
<td>Optimising modelling</td>
</tr>
<tr>
<td><strong>Explorative</strong></td>
<td>Surveys</td>
</tr>
<tr>
<td>External</td>
<td>Workshops</td>
</tr>
<tr>
<td></td>
<td>Delphi modified</td>
</tr>
<tr>
<td></td>
<td>Explanatory modelling</td>
</tr>
<tr>
<td></td>
<td>Optimising modelling</td>
</tr>
<tr>
<td></td>
<td>Cross impact</td>
</tr>
<tr>
<td><strong>Strategic</strong></td>
<td>Surveys</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
</tr>
<tr>
<td></td>
<td>Delphi methods</td>
</tr>
<tr>
<td></td>
<td>Explanatory modelling</td>
</tr>
<tr>
<td></td>
<td>Optimising modelling</td>
</tr>
<tr>
<td></td>
<td>Morphological field analysis</td>
</tr>
<tr>
<td><strong>Normative</strong></td>
<td>Surveys</td>
</tr>
<tr>
<td>Preserving</td>
<td>Workshops</td>
</tr>
<tr>
<td></td>
<td>Optimising modelling</td>
</tr>
<tr>
<td></td>
<td>Morphological field analysis</td>
</tr>
<tr>
<td><strong>Transforming</strong></td>
<td>Surveys</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
</tr>
<tr>
<td></td>
<td>Backcasting Delphi</td>
</tr>
<tr>
<td></td>
<td>Morphological field analysis</td>
</tr>
</tbody>
</table>

Figure 7. Contribution of techniques in the phases of scenario development. Adapted from Börjeson, 2006

**Bradfield et al., 2005**

Bradfield et al (Bradfield et al 2005) made a more comprehensive study by tracing the evolution of scenario planning in the corporate sector. The authors define three different schools of thought within scenario planning i.e. the 'intuitive logic' school, the 'probabilistic modified trends' (PMT) school and the 'La Prospectiva' school. An important development
here is that the authors have labelled both the use of Cross Impact Analysis and Trend Impact Analysis under the same label ‘probabilistic modified trends’. This is as they claim both techniques share a common foundation that is the ‘mathematical amelioration of extrapolated time series data’ (See Table 1 for categorization of established scenario approaches based on Bradfield et al.) One study by Bishop et al, over viewing scenario techniques after this study, confer that these macro level categories proved very useful to understand the high level difference (Bishop 2007, 10). Bradfield et al also postulate that since PMT school tend to focus on a key set of variable that determine the occurrence of a specific event, the model is limited to the availability of detailed and reliable time series data for a scope of issues. The intuitive logic school however is firmly focused on the learning gained during the process itself thus the process is considered to be more important than the reliability of the content of the end product i.e. scenarios. The intuitive logic approach can be inductive or deductive in nature however all the approaches in this category are largely qualitative based on ‘disciplined intuition’ reasoning. On the other hand the PMT and La Prospective schools are both more outcome oriented. As both are typically used for largely complex mathematical, extrapolative forecasting and computer simulation based scenario development.

The authors also observe the difference in all three methodologies in the role of the external scenario planning expert. The intuitive logic school typically performs the scenario project with a team of individuals from within the organization. Although there is involvement of external scenario planning experts and external industry or technology experts at certain parts of the process, the entire exercise is largely driven from within the organization. In the PMT and La Prospective schools however external consultants play a much more dominant role in both designing and carrying the scenario exercise. This is as the complex and sophisticated mathematical analysis, forecasting and modelling tools utilized by both schools are not available resources within the organization and these approaches also frequently use the proprietary tools of the consulting organization.

The outcome of all three methodologies are evaluated using a common baseline criteria of ‘coherence’, ‘plausibility’, ‘internal consistency’ and ‘logical underpinning’. The PMT and La Prospective schools present the final outcome of scenarios with the most probable scenario (a base case scenario and alternatives with probabilities assigned to each scenario). The intuitive logic school, in comparison, is significantly different as it treats each scenario as equally probable. Finally the authors present a table of comparison between all three methodologies based on the main points of commonality and departure (See Figure 8)
<table>
<thead>
<tr>
<th>Purpose of the scenario work:</th>
<th>Intuitive-Logics Models</th>
<th>La Prospective Models</th>
<th>Probabilistic Modified Trend Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple, from a once-off activity making sense of situations and developing strategy, to an ongoing activity associated with anticipation and adaptive organisational learning.</td>
<td>Usually a once-off activity associated with developing more effective policy and strategic decisions and tactical plans of action.</td>
<td>A once-off activity to enhance extrapolative prediction and policy evaluation.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario perspective:</th>
<th>Descriptive or normative.</th>
<th>Usually descriptive, can be normative.</th>
<th>Descriptive.</th>
</tr>
</thead>
</table>

| Scope of the scenario exercise: | Can be either broad or narrow scope ranging from global, regional, country, industry to an issue specific focus. | Generally a narrow scope but examination of a broad range of factors within the scope. | Narrow scope focused on the probability and impact of specific events on historic trends. |

| Scenario horizon year: | Varies: 3–20 years. | Outcome orientation-directed and objective, quantitative and analytical approaches (with some subjectivity) relying on complex computer-based analysis and mathematical modeling. | Varies: 3–20 years. |
| Methodological orientation: | Process orientation - inductive or deductive, essentially subjective and qualitative in approach relying on disciplined intuition. | Combination of some key individuals from within the organization led by an expert external consultant. | Outcome orientation-directed and objective, quantitative and analytical approaches (with some subjectivity) using computer-based extrapolative forecasting and simulation models. |

| Nature of scenario team participants: | Internal - scenarios developed by a facilitated from within the organization. | External - scenario exercise undertaken by expert external consultants. | Expert external consultants. |

| Role of external Experts: | Experienced scenario practitioner to design and facilitate the process; periodic use of remarkable people as catalysts of new ideas. | Dominant - expert-led process using an array of proprietary tools to undertake comprehensive analysis and expert judgments to determine scenario probabilities. | Dominant - expert-led process using proprietary tools and expert judgments to identify high impact unprecedented future events and their probability of occurrence. |


| Scenario starting point: | A particular management decision, issue or area of general concern. | A specific phenomenon of concern. | Decisions/Issues for which detailed and reliable time series data exists. |
| Identification/selection of key driving forces: | Intuition - brainstorming techniques, analysis of STEEP factors, research, and discussion with remarkable people. | Interviews with actors involved in the phenomenon being studied and comprehensive structural analysis using sophisticated computer tools. | Fitting curves to historical time series data to identify trends and use of expert judgment to create database of potential high impact unprecedented future events. |
| Establishing the scenario set: | Defining the scenario logics as organizing themes or principles (often in the form of matrices). | Matrices of sets of probable assumptions based on key variables for the future. | Monte Carlo simulations to create an envelope of uncertainty around base forecasts of key indicators. |
| Scenario Exercise Output: | Qualitative - set of equally plausible scenarios in discursive narrative form supported by graphics, some limited quantification. Implications, strategic options and early warning signals increasingly a part of scenario output. | Quantitative and qualitative - multiple scenarios of alternative futures supported by comprehensive analysis incorporating possible actions and their consequences. | Quantitative - baseline case plus upper and lower quartiles of adjusted time series forecasts, may be embellished by short storylines. |
| Probabilities attached to scenarios: | No, all scenarios must be equally probable. | Yes, probability of the evolution of variables under assumption sets of actors' behaviour. Multiple. | Yes, conditional probability of occurrence of unprecedented and disruptive future events. Usually 3–6 dependent on the number of simulations. |
| Number of Scenarios generated: | Generally 2–4. | Coherence, comprehensiveness, internal consistency - underpinned by rigorous structural analysis and logics. All scenarios equally plausible. | Plausible and verifiable in retrospect. |
| Scenario evaluation criteria: | Coherence, comprehensiveness, internal consistency, novelty - underpinned by rigorous structural analysis and logics. All scenarios equally plausible. | Coherence, comprehensiveness, internal consistency - underpinned by rigorous structural and mathematical analysis; plausible and verifiable in retrospect. |

Figure 8. Comparison of Three Schools of Scenario Approaches. Adapted from Bradfield et al, 2005

**Bishop et al., 2007**

Bishop et al builds on this and discovered eight general categories (types) of scenario techniques with two to three variations for each type, resulting in more than two dozen techniques. In this study, the author compares the starting points, process and products of each of the general and sub categories of scenario techniques (Bishop 2007). The fundamental difference in this study is that it focuses on the various different tools available for the different scenario planning techniques. See Appendix 6 for the list of these techniques categorized by Bishop et al.
3.5. Summary

Despite the large number of scenario approaches, tools and varying definitions amongst scenario practitioners and academicians, we have a greater understanding of the differences in recent years with several studies on categorization and application of approaches. For the purpose of this thesis, two typologies will be used as a basis for evaluating the methodologies in practice amongst energy companies in Sweden; i.e. Gausemeier et al, 1996 and Bradfield et al, 2005. Ideally the underlying reason for the choice of approach would be accessible (if confidentially issues don't prevent it) and can be used to compare it against literature. Although Van Notten et al and Börjeson et al's proposed scenario typologies have contributed significantly to the development of the classification of scenarios, it has taken a largely public policy as its main application. Bishop et al's overview of techniques on the other hand has taken a much larger sample of approaches and techniques. However the paper's main contribution has been in the tools that can be used effectively for a given scenario technique and doesn't delve deeply into the choice of scenario technique itself. For the purposes of the interview, the guideline of the semi structured interview will aim to score each interview against Gausemeier's nine dimensions and Bradfield's observation of features among the main schools of scenario approaches. The exploratory interview aims to understand why the other options (features and dimensions) were not selected. These results will then be compared against all the literature cited above and not just those used to conduct the interview. Although one of the considerations within the Swedish market could be that a prominent consulting experts in scenario planning such as Kairos Futures (TAIDA approach) could have successfully promoted their own approach thus swaying the market development with the success of their intuitive logic approach. However as scenario planning has been widely used in the Swedish industry for some time (several scenario based literature has been published in the fields of urban planning, biology, automotive etc.), the Swedish market is assumed to have been exposed to a variety of approaches and not influenced as a whole by this bias. The following section attempts to understand the driving forces and uncertainties in the Swedish energy market. This will lead to a deeper understanding of not only the perspective of the scenario developers but also to understand the presence of factors that are not easily measurable or do not have reliable historical data to be represented with. Furthermore, one of the preconditions of using an interpretive approach is that the researcher has to understand the context and language of the interviewee to gain any meaningful data (See Philosophical Assumptions, Chapter 2).
4. Overview of Swedish Energy Market

The purpose of this section is to provide a brief overview of the Swedish energy market from the perspective of the uncertainties. This is mainly to ensure that the reader understands the context of the scenario planning application. This section does not attempt to rank the significance of these uncertainties or identify the most important driving forces; it merely provides a discussion to have an overview of these issues.

4.1 Introduction

The energy balance in Sweden’s energy market is comprised of three main users i.e. industry, transport and residential. In 2009, the total energy supplied was 568TWh. A large portion of this (34%) was losses mainly due to conversion and distribution losses, international transport & non energy use and losses in cooling of nuclear power stations (SEA, Swedish Energy Agency 2010). The following is the breakdown of the energy supplied in 2009;

![Breakdown of Total Energy Supplied in Sweden, 2009](image)

Electricity and oil make up the largest energy carriers in Sweden. Nuclear energy, hydro energy, biomass and wind energy make up the main sources of energy in Sweden. Oil products are primarily used in the transport sector and makes up approximately 30% of the final energy use in Sweden in 2009. Coal and coke is used as reducing agents in blast furnaces and makes up less than 3% of final energy use. Final use of electricity in 2009 amounted to 125 TWh. In 2009, the industry used 39% of this and residential and services sector use another 58% (SEA, Swedish Energy Agency 2010). The following is the proportion of energy sources for electricity generation by installed capacity in Sweden in 2009;
Biomass is a key energy source in Sweden. In 2009, the use of biofuels, peat and waste amounted to 127 TWh (approximately 22% of total final energy use). The bulk of the biomass is used for heating purposes. In 2009, 90% of heating were used in the residential and services sector and 10% were used in the industry.

Recent years show an overall decline in total energy use in Sweden. Industry uses about the same amount of energy today as it did in 1970, despite the fact that industrial production is three times higher today. (SEA, Swedish Energy Agency 2010) However, recent economic downturn has had an impact on the energy demand as well; use of energy by industry in 2009 fell by 11%. One report also claims that this drop was due to the reduced energy consumption during the recession by the large power intensive industries (Svensk Energi AB 2010). Two sectors account for the bulk of the energy use in industry in Sweden. Pulp and paper consumes approximately 50% and the iron and steel industry consumes approximately 15%. Total electricity use has remained constant since the mid 1990s. Sweden is the country with the highest proportion of renewable energy in the European Union, with 44.7% of total energy demand covered by renewable sources in 2009, up from 33.9% in 1990 (GWEC 2010), (SEA, Swedish Energy Agency 2010). The supply of energy in Sweden is increasing more rapidly than the demand for it, but this is due to certain losses having been moved from the user side to the supply side. Despite the
growth in supply, Sweden still had a net import of 4.7 TWh of electricity in 2009 (SEA, Swedish Energy Agency 2010).

4.2 Policy Development
Up till the early 1970s, the energy supply in Sweden was primarily from oil. 80% of energy supply came from oil products and domestic heating was also based on oil (Johansson 2002). After the oil crisis, the importance to move towards less dependence on oil products became critical. The first energy tax (high taxes on oil products) was introduced in the 1970s to spur the move away from oil. Together with the development of nuclear power, to support the industry and boost energy security, energy efficiency in buildings became an important development. Large energy intensive industries are a major contributor to the value added in the Swedish industry and have strong lobby group in support of low cost energy. Despite this, the social consciousness of the Swedish public has also made a tremendous impact on the development of the Swedish energy policy. After the Three Mile Incident in the 70s, the political resistance towards nuclear power emerged and even triggered a referendum on the matter. Likewise in the 1990s, strong environmental movement pushed for a direction towards lower CO2 emissions and a phase out of nuclear energy. In parallel, strong market reform was reshaping the structure of the Swedish energy industry. The reforms in the 90s were mainly through liberalization and to some extent privatization. NordPool, the Nordic power exchange, was set up in the year 1991. The key argument in favour of liberalization was that monopoly institutions were said to lack incentives to invest and operate efficiently. One report claims that the evolution of the market reform in Nordic countries was based on four factors; efficiency, industrial policy, environmental concerns and energy security. During this same period saw a new direction amongst Nordic countries to move away from the old system of self sufficiency of electricity supply. The increasing interconnections between Nordic countries and to some extent continental Europe saw the reduced need of overcapacity (at the expense of national energy security) and gains in efficiency through power trade (Econ Pöyry & THEMA Consulting Group 2010). This market coupling and market based pricing led to a need for new regulation to manage the grid operations. Ironically, the energy market deregulation increased the extent of regulation. Through this period the core challenge faced by companies in the market was the move from institutional monopolies to commercial entities with the new risks that were introduced in the market. At the same time, the introduction of a carbon tax in 1991 as a form of internalization of environmental
costs targeted at industrial polluters has been a key milestone to the shift towards a low carbon footprint society.

The Swedish energy market today is a complex market to understand. The Swedish Energy Agency claims that the current energy strategy is focused towards the;

• Improving the efficiency of energy use.

• Favour the use of biofuels.

• Create incentives to reduce companies’ environmental impact.

• Create conditions supporting indigenous production of electricity (SEA, Swedish Energy Agency 2010)

The Swedish government recognizes the current electricity production is primarily based on nuclear power and hydropower. With climate change playing a key role in the energy agenda, the direction of the current policy measures is to retain nuclear energy and develop renewable energy as a third key source of energy. This is seen to reduce vulnerability and increase the security of electricity supply (Svensk Energi AB 2010). The new climate and energy policy passed in the Swedish parliament (Government’s Bills No. 2008/09:162 and 2008/09:163) sets a target of developing a proportion of energy supplied by renewable sources to be at least 49% of the country’s total energy use by 2020. Alongside this, another target of 10% of the energy use of the transport sector is to be from renewable sources by 2020 and an overall reduction of 20% in energy intensity between 2008 and 2020 is also to be met. In terms of emissions, the target is to reduce greenhouse gas emissions by 40% by 2020 in comparison to the levels of 1990. This greater emphasis on renewables has resulted in some significant changes;

• A 90% drop in oil fuels in 2009 in comparison to that of 1970

• Between 1970 and 2009 the proportion of biofuels, peat etc. has increased from 21% to 38% of total energy use by industry.

• Electricity use has increased from 21% to 36% of total energy use by industry since 1970

• Between 1970 and 2009, the specific energy use (energy used per unit of added value) fell by 66% showing a trend towards less energy-intensive products and production processes.

(SEA, Swedish Energy Agency 2010)
These targets are strongly influenced by the EU climate policy directives (EU Directive No. 2009/28/EC) and other international agreements that are in place such as the Kyoto Protocol, etc. The EU climate policies will certainly play a significant role in the shaping of the Swedish energy market in the years to come. There are a number of policy proposals currently being considered concerning energy efficiency improvement programs, energy infrastructure investment planning, land use & forestry (biomass supply) etc.

Energy taxes are a loose term that comprises of fuel and electricity taxes. Fuel taxes are based on the energy content of the type of fuel. While the electricity taxes are based on the relevant environmental impact (based on Carbon, SOx, NOx emissions). However the electricity generation companies in Sweden are exempted from energy and carbon dioxide tax. Heat production however is not exempt from such taxes except when biofuels and peat are used. As an EU state, Sweden is part of the EU Emissions Trading System (ETS) and it also practices the use of its own Green Certificates. Some variations do occur when companies are subject to multiple regulations; for an example, peat is not considered a renewable fuel in EU directives but qualifies in the Swedish Green Certificate. Another important note here is that the Emission ETS covers only energy-intensive industries and electricity and heat producers, although other companies, individuals and organisations may also participate. Green Certificates on the other hand exempts the electricity intensive companies. Companies trade using emission right unit corresponding to one tonne of carbon dioxide in the ETS or gain credits reduction through the CDM or JI mechanisms. As these emission rights or certificates are freely traded in the market thus there is a strong element of uncertainty in the extent of the future support of renewables by the state. This is as the current phase EU ETS system will expire in 2012. Another important consideration of the value of the emission rights is that it is strongly correlated to the fossil fuel prices. The allowance of carrying forward of rights however has somewhat allowed companies to hedge against future risks in emission rights price volatility.

4.3 Market Structure
The five largest electricity producers in Sweden made up 85% of the total output in Sweden and over 50% in the entire Nordic region in 2009 (Svensk Energi AB 2010). This was a result of consolidation of ownership in power assets creating the oligopolistic structure to the Swedish electricity market it is today. The following are five key players in this market;

- Vattenfall
- Fortum
Statkraft
E.ON
Skellefteå Kraft

An important point to note here is that over 52% of the ownership in electricity generation capacity in 2009 belonged to the state and municipalities. The growing scarcity of electricity (Sweden has been a net importer of electricity since year 2000, low hydro (less precipitation) and nuclear output in 2009) due to the steady demand increase for electricity in the Nordic region & other interconnected countries has also promoted a conducive investment climate. Svensk Energi claims that there are ambitious investment plans by energy companies between 2009 and 2018. The study estimates that 300 million SEK has been planned; with half allocated to transmission networks, district heating and natural gas operations and the bulk of the remainder going to wind power (Svensk Energi AB 2010). The following diagram shows the transmission capacity of interconnectors to the Nordic region;

![Diagram showing transmission capacity](image)

Figure 11. Transmission Capacity in Nordic region and other countries, MW. Adapted from SvenskEnergi 2010

District heating on the other hand remain largely fragmented. 130 companies make up 98% of the district heating supply. Most district heating and cooling companies are run as local authority-owned limited companies. A study to deregulate the industry is currently underway. This is intended to strengthen the position of district heating customer, reduce the price variation in heating for different regions and increase market transparency.
District cooling is similar in structure with 29 commercial suppliers (some operating more than one system) existing in 2009 (SEA, Swedish Energy Agency 2010).

4.4 Factors Affecting the Swedish Energy Market

The purpose of this section is to explore the driving forces and uncertainty faced by the Swedish energy market based on literature. It does not however attempt to understanding the potential impact of each issue. Econ Pöyry & THEMA Consulting published a report in November 2010 studying the challenges in the Nordic power market for the addition of renewable energy. This study is particularly useful as it uses a scenario approach to understand the various driving forces and uncertainties relevant to the Nordic Power market. (Econ Pöyry & THEMA Consulting Group 2010). In this report, six drivers of the Nordic Power market were identified for building four distinct scenarios;

- Climate Policy measures (Targets vs. Reality)
- Global & Regional Macroeconomic Development
- Power Intensive Industry (Demand Growth & Industry Migration)
- Fuel prices and CO₂ prices (in relation to investment costs)
- Market Integration (Future interconnectors and utilization)
- Technology Development in Power Generation (Availability and costs)

The following table (Table 2) is the compilation of the driving forces and its related uncertainties that the authors propose. It is evident that the levels of interconnection between variables within the scenarios are strong and have to be treated in a system analysis perspective.
<table>
<thead>
<tr>
<th>No.</th>
<th>Driving Force</th>
<th>Relevant region</th>
<th>Uncertainties</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Climate Policy measures</td>
<td>Global &amp; Regional (EU &amp; Nordic)</td>
<td>Will there be a second wave of the recent recession?</td>
<td>Economic development impacts both fuel prices as well as demand for industrial products thus is an important factor. Large state budget deficits are risks for longer term economic stagnation.</td>
</tr>
<tr>
<td>2</td>
<td>Climate Policy measures</td>
<td>Global &amp; Regional (EU &amp; Nordic)</td>
<td>How strong will the long term growth be?</td>
<td>Historically, GDP growth has had a strong correlation to energy demand. Economic development at both the global and regional level must be considered.</td>
</tr>
<tr>
<td>3</td>
<td>Power Intensive Industry Outlook</td>
<td>Nordic</td>
<td>How will the global demand for products from the power intensive industries in the Nordic area develop?</td>
<td>Strong global economic growth will impact both the demand for products from the power industry and also the cost of other inputs to the industry.</td>
</tr>
<tr>
<td>4</td>
<td>Fuel prices and CO2 prices</td>
<td>Global</td>
<td>What is the future fuel price level?</td>
<td>Fuel and CO2 prices are key elements in power price. Growth and stagnation of economic development also strongly impact fuel prices. These price levels will also determine the portfolio of future energy generation sources.</td>
</tr>
<tr>
<td>5</td>
<td>Market Integration</td>
<td>EU</td>
<td>Which cable projects will be implemented in the development of the EU Internal Energy Market?</td>
<td>The choice of projects implemented will have a bearing on the electricity price volatility and price formation. The level of integration with the rest of Europe and within the Nordic region will also determine the strength of the energy price correlation between national markets.</td>
</tr>
<tr>
<td>6</td>
<td>Technology Development in Power Generation</td>
<td>EU</td>
<td>Will there be delays or bottlenecks in the interconnector projects?</td>
<td>The current strong global demand for transmission cables (ex. Connection of offshore wind farms) could delay these large scale projects.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EU</td>
<td>Will large scale smart grids or carbon capture and storage become commercially available?</td>
<td>Both these technologies will have a strong impact on price formation &amp; structures and generation costs across Europe thus will impact the integrated Nordic market.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EU</td>
<td>Will there be a steep cost reduction in renewable energy generation?</td>
<td>If such a steep learning curve is achieved, support mechanisms may no longer be needed for commercial availability of these technologies.</td>
</tr>
</tbody>
</table>
Although most of the factors cited in this report apply to the bulk of the different types of energy generation in Sweden, it however doesn’t consider the specific factors affecting heat generation, large scale hydro power generation and nuclear power generation. This is as this report is focused on the outlook for renewable electricity generation.

The most surprising aspect of this report is that it does not consider other factors that seem to be equally important such as availability of skilled manpower for the implementation of energy projects, impact of climate change of generation capacity (wind index, level of precipitation for hydropower), availability of (public or private) financing for future energy investments and sustained availability of biomass. The reason for this is unclear. It is possible these factors were either omitted as they are considered to be less significant (or impactful) or the historical trends related to these factors reflect a low level of uncertainty (low probability of occurrence). Another point of debate within the report is the issue of price elasticity of electricity generation in the Nordic region. Other studies claim that electricity generation in the Nordic region is completely inelastic (Nordic Competition Authorities 2007, 11) or has low elasticity in the longer term (Hope 2008, 5). Thus arguing against the report’s claims of possible industry migration or the impact of additional generation capacity. However considering that even the EU is considering carbon compensation and number of other factors that could induce price elasticity, there is an inclination to support the argument of the report.

Historical data shows that the price of Nordic electricity is also determined by the level of precipitation (access to cheap hydropower) (Svensk Energi AB 2010, 13). Increasing demand due to lower mean temperatures coupled with low precipitation has resulted in the necessity of increased operations of coal fired condensing power plants in Denmark and Finland. The increased integration with Europe has caused the Nordic electricity price to be also affected by the power balance in the rest of Europe. The paper goes on to argue that years with high run offs result in hydro producers being forced to either produce electricity or spill excess water; this also affects the spot price with the change in the power balance. If the proposed deregulation of the heat generation goes ahead, this will make an enormous change in price of heating; as was experienced by the Nordic electricity market after the market reform in the 1990s.

In comparison, a study in the US in 2006 of the key drivers or external variables that influence the US electric power industry was done for the purposes of scenario planning
Over 100 variables were defined and grouped into the following overarching categories:

- The evolution of primary fuel markets
- Changes in social values regarding energy externalities (e.g., climate change)
- The direction and structure of world economic growth
- Changes in political values that influence regulations (e.g., priority of environmental issues)
- Lifestyle and value shifts influencing consumer demand for energy services
- The shape of the structure of the electric power industry (i.e., business models)
- The course of natural events related to climate change
- The course of price changes for electricity and consumer responses
- The evolution of the power industry infrastructure (decentralized or centralized)

The report highlights the first two from the list above as the most critical (and uncertain) and was used to initiate the scenario development process. It is clear that one of the most critical factors (evolution of the primary fuel market) in the US electricity market does not really apply to the Swedish context as electricity generation in Sweden is approximately 97% fossil fuel free. However, this study considers a host of other variables that may have been overlooked in the Econ Poyry & THEMA consulting study.

The proposed move towards further deregulation of district heating will also make a large impact in the Swedish energy market. One proposed deregulation format is to allow Third Party Access (TPA) by separating generation and distribution of heating. One study distinguishes between three types of TPAs: single buyer model, regulated TPA and negotiated TPA (Wårell 2009). The paper claims that two pricing mechanisms currently exist in the Swedish district heating market; fair return above marginal cost and profit maximization. The paper also warns that pricing in district heating is very elastic as consumers are very price sensitive. Reduced production in heating will also impact reduced revenue from electricity sales. In essence, the paper propounds that the end price to the customer will primarily depend on how extensive the level of competition is at the point of heat generation. A higher level of competition will drive the price towards the marginal cost of heat production. It is suffice to say that the profitability of district heating companies today will be significantly impacted by the choice of TPA or the overall market design adapted.
Another important trend currently occurring in heat generation in Sweden is the use of waste heat from pulp and paper industries for district heating purposes. This not only drives down the marginal cost of production due to low cost of ‘raw material’ (in this case waste from the industry) but also exploits a larger economy of scale for heat generation for the heat generation in the industry (Johansson 2002). As the feedstock for biomass based district heating is primarily residual waste from the forest and agricultural industries, the future outlook for both these industries will have a strong impact for the security of fuel supply and cost of fuel for the district heating companies.

To classify the various types of uncertainty, one study proposes a classification scheme as shown in the table below (Waller 2003, 100);

<table>
<thead>
<tr>
<th>General Environmental Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Political:</td>
</tr>
<tr>
<td>Government policy:</td>
</tr>
<tr>
<td>Macroeconomic:</td>
</tr>
<tr>
<td>Social:</td>
</tr>
<tr>
<td>Natural:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input market:</td>
</tr>
<tr>
<td>Product market:</td>
</tr>
<tr>
<td>Competition:</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Company Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations:</td>
</tr>
<tr>
<td>Liability:</td>
</tr>
<tr>
<td>R&amp;D:</td>
</tr>
<tr>
<td>Credit:</td>
</tr>
<tr>
<td>Behavioural:</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Figure 5. Table of Environment Uncertainties (Adapted from Waller, 2003, 100)
5. Analysis of Scenario Planning Processes of Energy Companies in Sweden

5.1. Brief Company Profiles

This section attempts to give a brief overview of the interview respondents of this study. Most interviews were conducted in person however due to logistical constraints some interviews were on the phone. One of the respondents also chose to remain anonymous, thus referred to as Company X.

**Vattenfall AB**, headquartered in Stockholm, Sweden is one of the largest energy utilities (generation, distribution & sales) in Europe with core markets in Sweden, Germany and the Netherlands. Vattenfall is entirely owned by the Swedish state and is the largest energy utility in Sweden (in terms of electricity generation and sales). It is also active in heating, however is not active in gas sales. In Sweden, Vattenfall’s electricity generation mix comes primarily from nuclear and hydropower (approximately 89%) and the remainder comes from wind, biomass & waste, natural gas & oil and coal (Vattenfall AB 2011). Apart from these activities, Vattenfall is also active in energy trading activities and lignite mining (Germany).

**E.ON Sverige** is entirely owned by E.ON AG headquartered in Düsseldorf, Germany and is one of the largest energy utilities (generation, distribution & sales) in Europe with core markets in Germany, United Kingdom and Sweden (E.ON AG 2011). As of the end of 2008, E.ON Sverige is the second largest Swedish energy utility (on the basis of power sales and production capacity) and is the regional unit overseeing operations throughout the Nordic region (including Finland, Denmark & Norway). The bulk of the energy generation for E.ON Sverige is derived from nuclear and hydro power (approximately 88%) and the remainder is generated using fuel oil, natural gas, biomass, wind power and waste. The unit is also active in gas heating supply and trading activities.

**Company X** is European energy utility (generation & trading only) with a strong focus in hydro power and core markets in Norway, Sweden and Germany. It is a relatively smaller player in terms of heat and electricity generation with a total annual generation at about 57 TWh. The electricity generation comes from a combination of hydropower,
gas, bioenergy and wind power. It also has a relatively smaller presence outside of Europe in hydro power projects.

**Dong Energy** is a European energy utility (generation, distribution and sales) wholly owned by the Danish state with a strong focus in Northern Europe. Dong Energy’s product range includes oil, gas, electricity and heating. The largest portion of Dong Energy profits are derived from oil and gas production and energy trading (Dong Energy 2011). Power and heat generation comes from oil, gas, wind (offshore & onshore), biomass and coal sources. In Sweden, Dong Energy’s only presence is part ownership of a hydropower plant in Indalsälven, Sweden (Dong Energy 2011).

Apart from the four above said energy utilities, the findings of these interviews were discussed with an external consultant from **Kairos Futures**. Kairos Futures are specialists in the area of scenario planning and have practiced their own form of the intuitive logic model that is known as the TAIDA model.

### 5.2. Summary of Results

Several overarching similarities in the general context of these companies were found whilst conducting these interviews that may be relevant to the scenario planning approach adopted. Firstly, all the energy utilities interviewed used complex and large forecasting models for power and other market fundamental prices. Secondly, almost all the interviewed companies have made strong investments to diversify their technology portfolio. One can interpret this in a number of ways but it is safe to assume that due to the extremely uncertain conditions that make it impossible to predict the dominant technology of the long term future, these companies choose to keep diverse portfolios to ensure that they will be able to compete in the long run by remaining present in different generation technologies. At the same time, most companies have a stronger focus on certain technologies than others.

Two studies by Gausemeier et al and Bradfield et al that were discussed in the literature review section will be used to understand the more specific similarities and differences of each company’s approach to scenario planning. These two studies were used to perform the open coding as described in Grounded Theory (Martin 1986). Vattenfall, E.ON Sverige and Company X use scenario planning to different extents but essentially develop scenarios to be structurally different. Dong Energy on the other hand has a crucial difference where the use of scenarios is essentially a variation of sensitivity analysis based on key variables. As this aspect is such a crucial aspect of scenario planning, it can be
argued that Dong Energy does not fall into the category of scenario ‘thinking’. However when all four company’s use of scenarios was scored against Gausemeier et al and Bradfield et al scenario dimensions, Dong Energy’s approach to scenarios does seem to inherit many characteristics that are similar to scenario planning thus it has been included in the data analysis. On the other hand, Vattenfall no longer explicitly considers scenarios as a management tool it uses, however since it has used scenario planning for a long period, scenario thinking has become embedded in the project evaluation process, thus Vattenfall has been considered appropriate for this analysis.

The nine scenario dimensions as proposed by Gausemeier et al.

<table>
<thead>
<tr>
<th>No.</th>
<th>Characteristics</th>
<th>Vattenfall</th>
<th>E.ON Sverige</th>
<th>Company X</th>
<th>Dong Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Problem Statement</td>
<td>Problems of orientation</td>
<td>Problem of orientation</td>
<td>Problem of decision</td>
<td>Problems of Orientation &amp; decision</td>
</tr>
<tr>
<td>2</td>
<td>Controllability</td>
<td>System scenario</td>
<td>System scenario</td>
<td>System scenario</td>
<td>System scenario</td>
</tr>
<tr>
<td>3</td>
<td>Form of Organization</td>
<td>No external actors considered</td>
<td>No external actors considered</td>
<td>No external actors considered</td>
<td>No external actors considered</td>
</tr>
<tr>
<td>4</td>
<td>Temporal Condition</td>
<td>Mainly Process related with key milestones &amp; internal targets</td>
<td>Mainly Process related with key milestones</td>
<td>Mainly Process related with key milestones &amp; internal vision</td>
<td>Process related</td>
</tr>
<tr>
<td>5</td>
<td>Point of Origin</td>
<td>Explorative. Anticipative views incorporated to small extent</td>
<td>Explorative. Anticipative views incorporated to small extent</td>
<td>Explorative</td>
<td>Explorative</td>
</tr>
<tr>
<td>6</td>
<td>Goal Orientation</td>
<td>Descriptive</td>
<td>Descriptive</td>
<td>Descriptive</td>
<td>Descriptive</td>
</tr>
<tr>
<td>7</td>
<td>Probability of Occurrence</td>
<td>Probabilities considered implicitly</td>
<td>Scenarios developed to be equally probable. Final decision considers probabilities implicitly</td>
<td>Scenarios developed to be equally probable. Final decision considers probabilities implicitly</td>
<td>Scenarios developed to be equally probable.</td>
</tr>
<tr>
<td>8</td>
<td>Textual Orientation</td>
<td>Combination of trend and extreme scenarios</td>
<td>Combination of trend and extreme scenarios</td>
<td>Combination of trend and extreme scenarios</td>
<td>Trend scenarios</td>
</tr>
<tr>
<td>9</td>
<td>Planning Interval</td>
<td>Not defined. Ranges from 20-40 years</td>
<td>25 years</td>
<td>10-40 years</td>
<td>Typically 40 years</td>
</tr>
</tbody>
</table>

Table 3. Interview Data summarized based on the nine scenario dimensions of Gausemeier et al.
The 14 features of scenario categories as proposed by Bradfield et al.

<table>
<thead>
<tr>
<th>No.</th>
<th>Characteristics</th>
<th>Vattenfall</th>
<th>E.ON Sverige</th>
<th>Company X</th>
<th>Dong Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Purpose of the Scenario Work</td>
<td>Anticipation</td>
<td>Adaptive Organization Learning</td>
<td>Developing Strategy</td>
<td>Adaptive Organization Learning</td>
</tr>
<tr>
<td>2</td>
<td>Scenario Perspectives</td>
<td>Descriptive</td>
<td>Descriptive</td>
<td>Descriptive</td>
<td>Descriptive</td>
</tr>
<tr>
<td>3</td>
<td>Scope of the Scenario Exercise</td>
<td>Broad</td>
<td>Broad</td>
<td>Broad</td>
<td>Narrow</td>
</tr>
<tr>
<td>4</td>
<td>Horizon year</td>
<td>Not defined. Ranges from 20-40 years</td>
<td>25 years</td>
<td>10-40 years</td>
<td>Typically 40 years</td>
</tr>
<tr>
<td>5</td>
<td>Methodological Orientation</td>
<td>Process Orientation</td>
<td>Process Orientation</td>
<td>Process Orientation</td>
<td>Outcome Orientation</td>
</tr>
<tr>
<td>6</td>
<td>Nature of the scenario team participants</td>
<td>Internal</td>
<td>Internal</td>
<td>Internal</td>
<td>Internal</td>
</tr>
<tr>
<td>7</td>
<td>Role of external experts</td>
<td>None</td>
<td>None</td>
<td>Limited</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>Establishing Scenario Sets</td>
<td>Scenario Logic based on themes</td>
<td>Scenario Logic based on themes</td>
<td>Defined Matrix with 2 key driving forces</td>
<td>Based on assumptions on key variables. Monte Carlo simulations NOT used</td>
</tr>
<tr>
<td>11</td>
<td>Scenario Exercise Output</td>
<td>Qualitative and Quantitative</td>
<td>Qualitative and Quantitative</td>
<td>Qualitative and Quantitative</td>
<td>Quantitative</td>
</tr>
<tr>
<td>12</td>
<td>Probabilities Attached to Scenarios</td>
<td>Probabilities considered implicitly</td>
<td>Scenarios developed to be equally probable. Final decision considers probabilities implicitly</td>
<td>Scenarios developed to be equally probable. Final decision considers probabilities implicitly</td>
<td>Scenarios developed to be equally probable.</td>
</tr>
<tr>
<td>13</td>
<td>Number of Scenarios generated</td>
<td>Not defined. Varies from one project to another</td>
<td>Three to Five</td>
<td>Four</td>
<td>Three to Five</td>
</tr>
</tbody>
</table>

Table 4. Interview Data summarized based on the scenario features of Bradfield et al.

1 Based on the book ‘The Sixth Sense’ (van der Heijden 2002, 233), refer to next page for explanation
Note:

1. Tools/Techniques used were not explored as it is beyond the scope of this thesis to study the Job profiles and the associated tools used for each department relevant to the scenarios planning process.

Purpose/Problem Statement

The problem statement is by far the most crucial characteristic as it defines options that are relevant for the remaining design. In fact, one literature cites that the level of success of a scenario project depends on the degree of purpose of the project (van der Heijden 2002, 232). In this context Vattenfall and E.ON Sverige both use scenarios for the evaluation of specific investment projects (i.e. problems of orientation). Company X on the other hand uses scenarios specifically for the purposes of strategy development (i.e. problems of decision). Dong Energy practices ‘scenario thinking’ in both types of problems. These different applications of scenarios changes how these companies choose to utilize their complex forecasting methods as a basis to build scenarios and consequently the decision making process. The authors Bradfield et al, uses the characteristic ‘Purpose of the scenario work’ by a definition of a previous work. In this work, the authors describes that the purpose can be defined by four main areas of purpose as shown in the matrix below (van der Heijden 2002, 233). The authors go on to explain that the choice of purpose of the scenario work will define the scenario process design.

<table>
<thead>
<tr>
<th>Purpose of Scenario Projects</th>
<th>Once Only Problem Solving</th>
<th>Ongoing Survival/Thriving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening up to exploration</td>
<td>Making sense</td>
<td>Anticipation</td>
</tr>
<tr>
<td>Closure Decisions</td>
<td>Developing Strategy</td>
<td>Adaptive Organization Learning</td>
</tr>
</tbody>
</table>

Figure 12. Purpose of Scenario Projects. Adapted from van der Heijden (2002, p233)

Interestingly, apart from Dong Energy, the remaining three companies had already begun experimentation with scenario planning for a number of years and the decision on the extent of use of scenario planning was strongly dependent on the organization’s perception of the value of scenarios as a tool and where it can be effectively applied. This perception is strongly influenced by the organizational learning experienced during the
initial experimentation and use of scenarios. In Vattenfall, the experience was a negative one as the team believed that the scenario project failed to deliver an actionable outcome for strategy development. Thus scenarios are merely ‘used’ for periodical evaluations of investments. Similarly in E.ON Sverige, scenarios are used only for investment evaluation. However the perspective gained from this exercise is used when strategy development activities are done. As E.ON Sverige has a relatively small team, it is easier to engage the different participants to gain a consensus on their view of the future. Scenarios provide a useful means of beginning this conversation. Thus in a direct sense, the purpose of scenarios in E.ON cannot be construed as it is for strategy development but at the same time it is evident that it plays an important role in it. As the scenario purposes are observed to be varied across the sampled companies, it is difficult to observe the characteristic (based on both bodies of literatures selected) trends and it’s correlation to the scenario process design amongst companies; even if these characteristics are categorized by the purpose of the scenario process. Evidently the relatively small sample of companies in this study also makes this trend analysis especially difficult.

**Perspective & Orientation**

However, several characteristics are identical across all companies. All the companies interviewed practice system scenarios and descriptive scenarios. All companies also view the nature of the scenario team participants as internal with little or no contribution of external consultants; especially with regards to the process design. These similarities are clearly in line with Bradfield et al’s description of Intuitive Logic scenario model. These strong similarities may be due to the strong influence of the Global Business Network (GBN)/ Peter Schwarz’s Intuitive Logic Model in the industry (Schwartz 1991). The use of system scenarios and descriptive scenarios resound with the highly uncertain long term future of the industry (thus the need to use a combination of internal and external scenarios) and the inability of each company to influence the overall direction of the industry (thus the aversion to the use of narrative scenarios). The organic nature of the scenario project work (internally led with little external contribution) is far more effective according to Kairos Futures. This is as the level of effectiveness of scenario projects are strongly related to the level of ‘buy in’ of the various parts of the organization. Similar to any change management project, accurate analysis needs to be balanced with strong engagement of the different stakeholders to ensure that decision taken as a product of the scenario exercises are not only carried out as planned but also to ensure that the entire
organization is strategically aligned. Another key variable in this context is the level of decentralization of the business units in question. This topic is further discussed in the next section (Section 5.3). There are however some differentiation in certain characteristics. Dong Energy takes on a more outcome oriented perspective and quantitative results as an output. This approach bears more similarity to the La Prospectiva and PMT scenario models. Apart from Dong Energy, the rest of the companies are vehemently against a purely quantitative outcome of the scenario project as it is not only grossly inaccurate with the large number of assumptions needed to be made over a long period (sometimes up to 40 years) but it is also an extremely time consuming endeavour. Vattenfall, E.ON Sverige and Company X choose to incorporate a large qualitative component to the scenario projects to discuss the ‘strategic fit’ of each of the evaluation in question and the non quantifiable nature of uncertainties such as changes in regulatory framework and the competitor analysis. Although Dong Energy is relatively more reliant on quantitative analysis, it is however against the use of Monte Carlo simulations as a tool within scenario based evaluation for the same reasons mentioned above. Evidently as there are so many tools and approaches that can be used to quantify the scenario project outcomes, the adaptation of scenario process can vary significantly depending on the specific choices made on the approach and tools utilized.

**Exploratory vs anticipative view**

This open attitude towards different possible futures is also reflected in the prominence of the exploratory view in scenario development. Backcasting is not used in any of the companies interviewed. However the level of anticipative views incorporated does vary. Companies such as Vattenfall and E.ON Sverige do incorporate anticipative views to a small extent for key milestones such as the market view in the 2020 due to the strong political leadership towards the EU 2020 strategy. In line with the GBN’s method of key driver identification (Schwartz 1991, 107), E.ON Sverige and Company X have predefined key drivers that are considered for all scenario projects. Vattenfall used to practice predefined key drivers as well till the decision to move away from scenario planning as a tool was made. The system currently employed is based on ‘What If’ analysis requested by the Top Management. This method is more reliant on the intuition of the Top Management and seems to be more appropriate for the less formalized culture within Vattenfall. In summation, this type of explorative view can easily be categorized as an ‘External scenario’ based on the Börjeson et al study as the scenarios do not take a strategic view
as described as Börjeson et al; i.e. considerations of how the environment will evolve based on a given set of behaviour.

**Scenario Set**

The study of how scenario sets were developed was a much more subjective observation as detailed nature of scenario development is not privy to the public. E.ON Sverige and Vattenfall clearly use themes such as ‘Green Scenario’ to signify scenarios with a strong contribution of renewable energy or ‘Nuclear Scenario’ to signify scenarios with a strong nuclear energy contribution to their energy mix. Dong Energy does not use such an approach as it focuses more on the possible variations on key variables such as power prices, carbon prices, etc. Company X takes on a more structured approach as it follows the four quadrant approach based on the two predefined key driving forces.

**Textual Orientation & Probabilities**

The choice of textual orientation is largely influenced by a number of other factors. As all the energy companies have developed large and complex economic modelling of future market fundamentals, the use of trend based scenario development has become the starting point for scenario development. Theme based scenarios and GBN’s approach of equally probable scenarios also are key factors in the textual orientation of how scenarios are developed. Equally probable scenarios inherently do not allow for extreme scenarios to be considered. However recent events such the Fukushima nuclear incident usually find the way into the scenarios by the request of senior management. E.ON Sverige attempts to consider these extreme scenarios by performing sensitivity analysis on the scenarios developed. Vattenfall on the other hand is open to considering extreme scenarios thus the probability consideration is left to the prerogative of Top Management. As a crucial aspect of scenario development, Vattenfall, E.ON Sverige and Company X treat the balance of developing equally probable scenarios and extreme scenarios as an important consideration and deal with this by manipulating the number of scenarios considered and time frame considered for the scenario project. Dong Energy, on the other hand, almost does not consider extreme scenarios (at least in an explicit sense) as the key variables considered are not manipulated based on extreme events. Furthermore the need for comprehensive structurally different scenario development in extreme scenarios is not part of the scenario design from Dong Energy’s perspective.
Scenario horizon & number of scenarios

The scenario projects amongst energy companies are clearly from mid (10 years) to long term (40 years) horizons. Only E.ON Sverige works to a fixed time horizon (2035), all the other companies treat each scenario project differently; dependent on the technology in focus and the purpose of the project (investment evaluation vs strategy development). In general, all four companies practice between three to five scenarios. However the reasoning behind the selection of the number of scenarios is not clear and difficult to establish as it seems to be extremely context specific and is strongly influenced by the intuition of the Top Management and the business unit (when driven by the business unit).

5.3. Additional Factors Considered Relevant

During the course of interviews, it became apparent that a number of internal factors play a significant role in the adaptation of the scenario planning process in different companies. This section explores the possible internal factors that could explain these different scenario design choices based on abductive reasoning. To understand these differences, a comparative table has been developed to consider firm specific internal characteristics (Table 5). A key aspect to bear in mind is that these characteristics are solely in relation to the scenario planning process. At the same time, an important consideration here is also that these observations are very subjective and may carry a bias in the part of the interviewer and the interviewee. As such the reasoning for selection of each characteristic is described below.

<table>
<thead>
<tr>
<th>No.</th>
<th>Characteristic</th>
<th>Vattenfall</th>
<th>E.ON Sverige</th>
<th>Company X</th>
<th>Dong Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Strategic Purpose</td>
<td>Investment evaluation</td>
<td>Investment evaluation</td>
<td>Strategy development</td>
<td>Investment evaluation &amp; Strategy development</td>
</tr>
<tr>
<td>2.</td>
<td>Initiator &amp; Driver for Investment evaluation</td>
<td>Any (Can be initiated from any Business Unit)</td>
<td>Relevant Operational Business Unit</td>
<td>Top Management</td>
<td>Relevant Operational Business Unit</td>
</tr>
<tr>
<td>3.</td>
<td>Organization Complexity (Horizontal differentiation specific to the scenario planning process)</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>4.</td>
<td>Organization Formalization</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>5.</td>
<td>Standardization in Scenario Planning Process</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>6.</td>
<td>Level of Involvement of Business Units in Scenario Development</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 5. Firm specific factors considered relevant for scenario planning based on purpose of scenario project
Initiator & Driver for Investment Evaluation

A key difference in all four companies analyzed is the role the business unit plays in the evaluation of the investments. A significant difference is in terms of the level of centralization (or more accurately decentralization). In E.ON Sverige and Dong Energy, the relevant business unit is seen as the driver for the investment project. For an example, if the gas power business unit is interested to build a power plant, it leads the process of making the investment plan based on the framework supplied by the strategy division and delivers the plans to the top management for evaluation. The process after this point is an iterative one mainly between the top management and the gas power business unit, with the support of the corporate strategy and market analysis departments. This provides a significant room for the business unit to choose the investment projects (consequently the type of scenarios) that it feels to be suitable and how to develop the scenarios for testing the robustness of the investment evaluation in multiple future conditions. On the other hand, Vattenfall receives ideas for investment projects that are initiated from any part of the organization. As a relatively significant number of departments are usually involved in the Vattenfall scenario based investment evaluation project. These include the relevant business unit, strategy & development and investor relations & communications (regulatory changes input, etc.). These departments work closely to consolidate the scenarios that the top management chooses to use to evaluate the project (i.e. ‘What If’ analysis). This centralized structure with a significant dependency on intuition of top management eliminates the need for a structured scenario design as it is treated on a more case by case basis. Similarly Company X uses scenario planning in a very centralized form. Investment decisions are triggered from the top, thus the involvement of the relevant business unit is relatively low. A key difference here is that scenarios are primarily used for strategy development. Thus the need for numerical analysis is relatively low compared to when a specific investment is evaluated. In effect, the ‘initiator & driver for Investment Evaluation’ characteristic in this table is treated as a proxy for the decentralization level of the largest stakeholder in the context of the scenario planning process.

Organizational theory defines organizational design in three structural components i.e. complexity, formalization and centralization (Robbins 1990, 112). This clear relationship between the level of centralization and scenario process design has catalyzed this study to delve deeper into the other aspects of organizational design that may impact the scenario process design.
Organizational Complexity

The organizational complexity here can be divided to the horizontal, vertical and spatial complexity in relation to the departments relevant to scenario planning process (Robbins 1990, 83). There is a significant variation in terms of organization complexity between the selected companies. Firstly, one of the four companies (E.ON Sverige) is a subsidiary of a large multinational; E.ON AG. This additional complexity requires the Group level Top Management to evaluate projects that are beyond a certain size. The E.ON example is a case of high spatial complexity. This type of complexity may well be the reason why there is a higher level of standardization in the scenario planning process to streamline all subsidiaries' scenario based evaluation functions to facilitate or ease decision making on a large global scale. However, E.ON Sverige on its own is a relatively small unit with little vertical and horizontal complexity. Secondly, the size between these companies also varies significantly. Obviously for the context of scenario process design, the complexity attributed to the number and size of departments involved is far more important than the overall size of these companies. Vertical differentiation, defined as the depth of the organizational hierarchy (Robbins 1990, 83), has not been considered a relevant factor here as all organizations interviewed display similar vertical depth for the purposes of the scenario planning process. Vattenfall has numerous departments involved in the scenario planning project i.e. various sub-departments within the strategy and development department (market, technology and commercial units), various sub-departments within...
the Investor Relations & Communications (regulatory change monitoring), the relevant operational business unit and Top Management. This involves a relatively high degree of horizontal differentiation of organizational complexity. Vattenfall chooses to deal with this complexity not by increasing the standardization in the scenario process but by reducing it. Here organizational complexity is superseded by the organizational culture that is comfortable with multiple reporting lines and low uncertainty avoidance (a characteristic of cultural difference proposed by Geert Hosftede). This form of organizational design bears many similarities to the ‘adhocracy’ organizational design (Robbins 1990, 298). According to the author, ‘adhocracy’ is characterized by high horizontal differentiation, low vertical differentiation, low formalization, decentralization and greater flexibility and responsiveness. The difference between the adhocracy design and the example of Vattenfall seems to be the level of decentralization in the context of scenario planning process. Thus the level of flexibility and responsiveness may not be as high as in a true ‘adhocracy’. Meanwhile, Company X and Dong Energy have a similar level of horizontal complexity.

Organization Formalization

Formalization can be defined as the ‘degree to which the jobs within the organization are standardized’. This can be observed both in written and unwritten forms (Robbins 1990, 94). This is a far more difficult characteristic to observe without having access to the job profiles of all the individuals involved in the scenario planning process. This is especially important as the degree of formalization typically varies even within the organization depending on the job function (Robbins 1990, 94). This has been one of the limitations of this study. A general observation, based on Vattenfall, is that the organizations that perform scenario planning in the same physical location as the headquarters of the parent company inherently display a marginally lower organizational formalization in the context of scenarios. This is because the specialists in these offices are used over multiple projects that are not confined to their own departments or sub departments. This is done to essentially to maximize the use of their expertise. Conversely companies such as Dong Energy and Company X, although within the same physical location as the parent company, do seem to display a slightly higher degree of formalization. An obvious reason for this may be due to the impact of the company size. As Vattenfall is a much larger organization, the potential to create synergies across competences and thus creating savings on specialists needed may be much easier and even necessary.
Standardization in Scenario Planning

Standardization here refers to the level of standardization used in the scenario development process. E.ON Sverige, for example, uses a set framework of assumptions and themed scenarios as a baseline for scenario development. This is also influenced by other decisions such as if key driving forces are predefined, how probabilities are treated, the scenario horizon, anticipative views incorporated and if extreme scenarios are considered. E.ON Sverige does not standardize all these factors but displays a higher level of standardization in comparison to the remaining companies. Clearly, in the case of E.ON, increased spatial complexity increases the level of standardization. Meanwhile horizontal complexity can be dealt with higher levels of standardization or the reliance on organizational culture; as in the case of Vattenfall. To a relatively lesser extent, two other aspects also affect the level of standardization. These are the frequency of the scenario project and the time period allocated for the scenario project. Relatively infrequent scenario planning projects, as in Company X (every two years), requires little standardization as it can be easily adapted in the situational context. A time constrained project can be completed more rapidly with a high level of standardization in the scenario planning project.

Organization Culture

This was determined as an important factor purely based on abductive inference. However as the scenario planning consultant (Kairos Futures) agreed that organizational culture is a key factor, hence this opinion has been considered significant as they have a broad exposure to a variety of scenario planning processes in different companies. Past literature defines organizational culture as ‘the dominant values espoused by an organization’ or ‘a system of shared meaning based on patterns of beliefs, symbols, rituals, myths and practices that have evolved over time’ (Robbins 1990, 438). The author also identifies ten characteristics of organizational culture that are both structural and behavioural dimensions. Of these ten, two characteristics are particularly relevant for understanding the impact of organizational culture on the different adaptations of scenario process design. These two are ‘Integration’ and ‘Communication patterns’. Robbins defines Integration as ‘the degree to which units within the organization are encouraged to operate in a coordinated manner’ and Communication patterns as ‘the degree to which organizational communications are restricted to the formal hierarchy of authority’. It is also important to consider the difference of the dominant overall organization culture and the
subcultures (Robbins 1990, 440). Subcultures can occur vertically or horizontally. In the context of multinational corporations as being discussed, there is also a key difference between the organizational culture and the national culture (van der Heijden 2002, 101). van der Heijden warns that often organizational cultures may not reflect the national culture that it stems from. A study on national culture difference, by Geert Hofstede, cites uncertainty avoidance as one of the main categories of differentiation. Thus, the key to understanding how differences in organizational culture impacts scenario design is to first understand the tacit nature of each organization’s culture. Due to the difficulty in data collection on organizational culture in the companies interviewed, this study has been severely limited to postulate how this impacts the scenario design. A recently written paper however does study this further. Mason propounds that there are three different cultures in the use of scenario planning and this corresponds to three purposes these cultures use scenario planning (Mason 2003). The cultural differences however explore the risk taking behaviour and the need for learning and innovation for different levels of dynamic and fast moving market conditions. This study does not delve into how the organizational culture impacts the scenario process design specifically.

Organizational Learning
In past literature, there seems to be a consensus that one of the main benefits of scenario planning is organizational learning (van der Heijden 2002). A key contribution towards organizational learning in the context of scenario planning is by Bood & Postma. The following figure is an illustration of how multiple scenario analysis impacts the organizational learning.
The authors argue that the mental models of the managers based on their own perceptions and interpretations are the key to their differences in opinions amongst them. Scenario planning as a tool assists the organization as a collective to tap into their managerial knowledge and challenge their convictions and assumptions that have been taken for granted (Bood 1997, 644). The authors go on to postulate that ‘A large part of our knowledge is tacit and for that reason knowledge is difficult if not impossible to communicate verbally’.

Clearly how an organization learns also defines how scenario planning is used. van der Heijden terms the ‘process of building connections between isolated observations and insights’ as scaffolding (van der Heijden 2002, 166). This connection between codified and intuitive knowledge is strongly linked to how decision making is done in the scenario planning process. The author goes on to explain that organizations do not just vary in whether they practice single and double loop learning but also in terms of how far they are along the learning cycle (as shown below).
To put it simply, van der Heijden explains that organizational learning occurs only when performed collectively in an organization. When different individuals share their experiences, the team collectively develops new theories and finally acts together on it; it is a clear indicator of organizational learning. Thus companies with a higher emphasis on organizational learning would probably require a significant involvement from the relevant business unit and may even slightly resent the process standardization. Finally, the authors refer to this type of collective learning, continuous experimentation and feedback as adaptive organizational learning.

The findings of Kolb were the foundation of works by Crossan et al. The authors observe that there has been no consensus in literature on a general theory for organizational learning. They go on to postulate a framework referred to as the 4I framework. This framework proposes that four related processes occur in organizational learning (i.e. Intuiting, Interpreting, Integrating and Institutionalizing) over three levels (i.e. Individual, Group and Organization) (Crossan 1999, 524).
Although the demarcation between each level and each process is clear in the diagram, the authors explain that the process of intuiting can easily spill over into the group level as can the process of integrating occur at the organizational level. For the purposes of scenarios, this paper is mainly concerned with the group (scenario team) and the organization levels. The authors then go on to present a visual representation of the dynamics of these processes.
The feedforward relationship, that is the move from intuiting to integrating, is a challenge as this is a shift from individual learning to collective learning. The feedback relationship, that is the move from institutionalizing to intuiting, is equally problematic as a high level of institutionalizing suppresses the intuiting ability of individuals. Both of these relationships are of vital importance to how scenarios are used in organizations. Scenario process designs need to allow and build environments that promote the growth of feedforward relationships and at the same time do not create too much institutionalizing, that is process standardization in the context of scenario process, which inhibits creative thinking and the ability of individuals to challenge conventional wisdom. This further supports the inference made from the contributions of van der Heijden; as discussed earlier.

Based on earlier discussions, it is clear that internal factors within the organization impact the scenario planning process in organizations. At the same time, the choice of the scenario process design is also based on the benefits the firm seek to gain from scenario planning as a tool. The benefits to be gained are a product of not just the strategic purpose of scenario planning as a tool but also the other design choices made in relation to the scenario planning process. The interview with the Kairos Futures’s scenario planning consultant also clarified that certain qualifiers must be met prior to embarking on any scenario planning project. In order to help shed light on how an adaptation of scenario process design can be made to firm specific characteristics; a framework is proposed to visually represent these four broad categories (benefits, internal factors, qualifiers and scenario process design options).

Figure 18. Proposed Framework for the Adaptation of a Scenario Planning Process Design
An important point to be pointed out here is the omission of the impact of the external environment on the scenario process design. External environment refers to type of external data monitored, type of analysis done, etc. This is as all the companies interviewed track very similar external data such as market power & fundamental prices, competitor analysis, changes in regulatory framework, macroeconomic indicators etc. The reason for its omission is that there was no observable correlation between the external environment information for the firm and the choice of scenario process design.

In the model above, the qualifiers or prerequisites for the effective use scenarios is Top Management leadership in the use of scenarios and adequate Knowledge management tools. Knowledge Management tools are essential to be able to deal with the tremendous volume of data required to enable a consolidated scenario development in the energy industry. Within the energy industry, firms monitor various sources of data to supplement their economic forecasting models. At the same time more qualitative information such as changes in the regulatory framework and competitor related intelligence is also compiled. As these companies are present in more than one region, the volume of this data is enormous even on a daily basis. Thus there is a strong reliance on information systems to process this information. To be able to incorporate scenarios into these information systems based economic models is indeed a challenge on its own. All the companies interviewed did not use a dedicated tool to build scenarios (e.g. Crystal Ball, etc.) but developed their own economic models to be able to incorporate the assumptions and scenario logics for each scenario theme. The importance of the information system here is not merely to transform this data and assumptions into a scenario output but to also make this analysis available to all the relevant parties involved in the scenario planning process in a form that is understandable. Easy access to results of the analysis and the underlying scenario logic is typically equally important for the scenario planning process.

As the decisions made based on the output of the scenario planning project are typically high level and key strategic decisions that can entail a significant risk exposure, the involvement and sponsorship of top management for scenario planning is crucial. One literature even cites that the main target of scenario projects is the ‘support of entrepreneurial decisions’ (Gausemeier 1998, 6). In essence, a scenario planning project like any other corporate initiative requires firms resources, thus run the
risk of being shelved for more immediate operational issues to be tackled. Scenario planning is inherently an exercise for mid to long term decisions thus can easily be discarded in place of matters that require the more immediate attention of the senior members of the firm. In an interview with Kairos Futures, the scenarios consultant reflected that the most effective scenario planning processes that he has facilitated have always had a strong stewardship of the top management. One means of dealing with this issue, as suggested by the Kairos Futures, is to carefully select the team members of a scenario project such that it includes both specialists/top management individuals as required and combining them with individuals that do not hold high positions of responsibility; thus able to dedicate more time to the scenario development work. The crucial aspect however is that the entire process is overseen by the top management leadership.

Benefits
It has become clear during the course of the data collection that each organization uses scenarios for different purposes. The purpose is also deeply intertwined with the benefits an organization seeks to achieve by the use of the scenario planning process. The five benefits proposed in this model are based on the work of van der Heijden et al (van der Heijden 2002, 142-144). These benefits are broad categorizations and do not imply that different organizations select between these options of benefits. Organizations typically place a stronger emphasis on certain benefits compared to others.

Enhanced Perception
The scenario process allows the managers to step away from the business as usual perspective and provide a framework for managers to analyse and understand the trends and events occurring. The process of challenging the conventional wisdom and explicitly making assumptions of the future reduces the likelihood that the organization as a collective be caught unaware and subsequently make mistakes.

Corporate Planning Integration
van der Heiden et al postulate that scenario projects allow firms to move away from total reliance on intuitive planning approaches to an approach that is based on concrete logical constraints of the scenario framework. The authors go on to explain that this framework becomes the platform that allows a wider participation across the
firm and consequently a wider variety of information that can be incorporated into the strategic planning process. This across the board involvement frequently drives the input of seemingly unconnected environmental factors into the scenario framework for the decision making process.

**Strategic Conversation**

Scenario planning process can be used as a politically safe platform where managers can challenge their ‘mental models’ in a rich learning environment that stimulates creativity. This ‘arena’ allow managers to articulate their own assumptions in the scenario exercise thus managers can identify inconsistencies in their own thinking (related to environmental trends and analysis of causal relationships) and their counterparts as a collective. This form of an adaptive learning organization leads to higher manager motivation in the thinking and planning process.

**Dealing with Complexity**

Scenarios provide a structure to deal with the changes in multiple variables when considering major structural changes. When managers openly and explicitly deal with various levels of uncertainties, it promotes the analysis of uncertainties by examining patterns based on cause and effect in a disciplined and systematic approach. This reduces bias for underestimating uncertainty.

**Communications tool**

Without the use of scenario based thinking, individuals typically promote and advocate their own (usually singular) view of the future. Scenario planning as a tool on the other hand allows open minded rational discussions based on alternative viewpoints. Shell pioneered the use of scenarios as a driver to influence decision making across the organization. Top management can utilize scenarios as a communications tool to influence decisions at lower levels of the organization without directly becoming involved; i.e. strategic alignment. This ‘scenario culture’ becomes the basis of any key strategic decision proposed to top management.
Internal Factors

Organizational Design
The organizational design choice of firms reflects different purposes depending on the strategy it wishes to pursue. These choices are based on needs such as creating cost savings synergies across the organization, streamlining business processes or decision making and the control the top management wishes to exert unto lower levels of the organization. These needs are reflected in terms of level of decentralization, job formalizations and complexity of the organizational structure. These design conditions impact how scenario planning can be used as a tool. A higher level of decentralization reflects a stronger need for transparency and communication in the scenario process to ensure that the relevant operational business participates and learns throughout the process and that the entire organization is aligned. Higher centralization on the other hand does not require such a high level of participation on the part of the relevant operational business unit. Higher formalization, be it written or otherwise, facilitates standardization of the scenario planning process. This standardization however can be argued that it restricts the flexibility of the process, to question conventional wisdom and to think of the future in a creative manner. This is fundamentally dependent on the complexity level of the organization as a whole; e.g. the complexity of E.ON Sverige within the E.ON AG group as a whole. Such a large organization has to place a strong emphasis on the standardization of the scenario planning process to streamline the data being presented for decision making. This is as the time available for the top management at the group level is relativity limited and this type of standardization facilitates the decision making process. A high horizontal complexity naturally reduces the ability to initiate the strategic conversation in the process as there is a seemingly larger distance between the individuals involved.

Organizational Culture
Organizations such as Vattenfall utilize their organization culture to their advantage. The organization culture and sub culture that displays conducive ‘integration’ and ‘communication patterns’ (Section 5.3) have an inherent advantage as these organizations can rely on this culture to overcome their horizontal complexity. One severe form of limitation of this research has been the inability to truly take into account all the aspects of organizational culture into this study. One can certainly argue that
whether organizational culture of a firm be it strong or weak, conducive or disadvantageous to the scenario process, or localized in a subculture, there is little that can be done to manage or transform this culture/subculture. However as this study is primarily concerned with how the scenario planning process can be adapted into organizations, this is indeed an important consideration. Organizations that have the departments involved in the scenario planning process that typically work as isolated business units with little interaction between the specialists should institute stronger standardization of the process or build virtual teams to work on the scenario projects.

Levels of Learning Organization

One could argue that organizational learning is in fact deeply interconnected to the organizational culture itself. However this relationship cannot be explored at this point as there is insufficient data to validate it. The real challenge in fact is to identify the ‘level of the organizational learning’. This is especially difficult as it is not only a dynamic process and that there is no consensus on how to measure (yet), but it may also vary across the organization. This may mean that the level of organization learning perceived may differ depending on the individuals involved in the scenario planning process. However, the positive aspect here is that we now know the conditions we need to create to allow for effective organizational learning. Based on Crossan et al’s work, the scenario process design should strive to allow both the feedback and feedforward relationships (Section 5.3) to flourish. To summarize, organizational learning directly impacts three factors in the scenario design; strategic purpose, involvement of the business unit and the process standardization.

**Designing a Scenario Process Adaptation**

Four overarching scenario planning process design choices have been identified to determine an effective scenario planning process adaptation. These choices are the strategic purpose, process standardization, need for quantitative analysis and business unit involvement. In order to use this framework, a disciplined and systematic approach is required. The point of departure should always be the strategic purpose. Defining the strategic purpose would depend on the focal questions the organizations need answers for. In broad terms, this could be if the scenario process would be used for evaluating investment or for strategy development or a combination of both. As pointed out by van der Heijden, a clear purpose is paramount to executing a successful scenario planning project. Upon agreement of the purpose, the benefits expected of the project should
also be identified. This can be done by simply deciding on a priority level for the five defined benefits. It is essential that the reasoning behind these choices be made explicit to the scenario team members to ensure that the expectations are clear. The next step is to explore the internal factors that are relevant to the use of scenarios. Unfortunately, this study has not adequately studied three aspects of the organizations interviewed to be able to make a comprehensive model of how these internal factors are to be evaluated. These three factors are the organizational formalization, organizational culture and the level of the organizational learning. Once the organization’s internal factors have been evaluated in the context of scenarios, scenario planning process design can begin. The need for quantitative analysis hinges mainly on if the purpose of the process is to evaluate an investment. Typically investment evaluations require strong numerical evaluations. Another benefit of numerical output from scenarios is that it increases transparency and the ability to communicate results to the rest of the organization. However the downside of heavy reliance on quantitative analysis is that it is resource intensive (thus significantly increasing the time needed to produce these scenarios) and it creates a superficial basis of certainty in future scenarios. The level of involvement of business units depends on several factors. A highly decentralized business unit that drives the evaluation of future investments should be given a high level of participation. This is not only to allow for the business unit to communicate the complexity of the information but also to allow for it to learn during the course of the process. A high level of participation of business units for a more centralized organizational design is not as imperative. However having this participation enhances the organization learning as a whole and the ability to communicate the strategy from top management to lower levels more rapidly. The level of standardization should be the final decision to be made in this framework but it is also the most arduous as it has many dimensions. The key aspects are if key drivers of the scenarios are defined (e.g. macroeconomic development, etc.), how probabilities are treated, the scenario time horizon, if anticipative views will be incorporated and if extreme scenarios are going to be considered. Finally, decisions on the time period allocated for the scenario project, number of scenarios to be used and the responsibilities in information supply and team composition must be made. This is a crucial aspect of the entire design of the process. An important point to note here are that several aspects of these scenarios have been omitted as they have been noted to be accepted as the norm amongst the interviewees. These characteristics omitted are
purely quantitative scenarios, normative scenarios and external consultant driven scenarios.

7. Summary

Conclusions

This paper set out to analyse the differences in practice in the scenario planning process among energy companies in Sweden and attempts to understand the underlying factors that cause this difference. Although this paper has identified the main differentiator as internal company specific factors, there still much room left to understand how these factors impact the choice of the scenario planning process design. These differences were structured to be understood based on two prior studies (i.e. Bradfield et al & Gausemeier et al). The interview guide used (Appendix 1) has tried to bridge the difference between past literature and the empirical data collected. This collection of scenario dimensions and characteristics has served as an instrument to categorize data observed during the data collection phase. Thus this study can be considered a continuation of previous attempts to resolve the confusion in the practice of scenario planning as a tool. One concrete evidence uncovered in this analysis is the predominance of one category of scenario planning approach; namely the Intuitive Logic model. Although variations have been observed amongst the companies interviewed, most of the features of the Intuitive Logic model have been used as a basis to develop the scenario planning process in these companies.

An interesting observation made during the course of this study is that the purpose of scenario planning as a tool has evolved from just for strategy development to include investment evaluation as well. This is reflected in newer literature such as Crundwell (2008) and Miller (2003). A large part of the inferential reasoning of this study has been abductive in nature. Most significantly, the framework proposed for the adaptation of scenario process design has included internal factors that have been main abductively inference. Although these inferences have been validated either through prior literature or verification from scenario specialists, abductive reasoning by nature are easily refuted based on the generalizations made. As three of the factors considered (impact of formalization, organizational culture and organizational learning) were not directly observable during the course of the data collection, one of the main drawbacks of this study has been its inability to completely verify its results. However the results of this study is hoped to stimulate further study into the effective adaptation of scenario planning into energy companies.
The key learning however from this study is that companies need to adapt their scenario planning design to suit changes in their internal firm specific factors and the benefits they seek from scenarios as a tool. The choices available when establishing a scenario process design can be leveraged to enhance the organization’s ability to use scenario planning as a tool. Having said that, this study only postulates that these design choices would lead to an increase performance of using scenarios as a tool, it does not however attempt to predict what form of organizational design and choice of scenario design yields the most effective results. In summary, the research questions that were initially identified have been answered, albeit to a limited extent. As such, a number of future research ideas have been identified to further add to the ‘body of knowledge’ on scenario planning process design. The following section describes the limitations of this study that have been found during the course of this study and expands on these ideas.

Limitations and Proposed Future Research

As mentioned earlier, this study has been limited by the inability to uncover the impact of organization culture, organizational learning and organization formalization on the scenario planning process and how it can be enhanced; although several propositions have been made in this paper. This study was also not able to study the various specific techniques and tools used by the companies for the scenario planning process. This was as the number of individuals involved in the scenario projects were too large and the tools practiced were also in use for other applications in the organization. Thus it was not possible to distinguish the tools that were practiced for the purpose of scenarios and others that were not primarily used for this purpose but nonetheless contributed to the process indirectly. How the scenarios developed within these companies were evaluated for its coherence and cohesiveness was also not studied. This was as there was too much subjectivity embedded in the responses of the interviewees that it was decided to omit this scenario characteristic. Another important aspect of this interview has been the largely interpretive nature of this study. As the researcher was not an active or passive participant of the scenario planning process in these companies, there may have been factors that have overlooked or the significance of some factors considered to be understated as well. As such, the following are several suggestions on how future research in the study of adaptation of scenario planning into companies can enrich the ‘body of knowledge’ on scenario planning process design;
• The use of an ethnographical research method to study the impact of organizational culture on the scenario planning process. This study could also be furthered to include how organizational culture improves the effectiveness of scenario planning as a tool for decision making.

• As this study has been a cross section study of the energy industry, it is conceivable that it lacks the practical considerations in the use of scenario planning as a tool. As such, a case study approach that is limited to a smaller sample of companies where the researcher is an active (or passive) participant may well uncover these overlooked practical factors and verify the interpretive bias that may have been present in this study. At this level of detail, it may also be possible to study how companies can choose to evaluate the scenarios that they have developed and even the level of effectiveness or the performance of scenario planning as a tool.

• A significant of the companies interviewed used virtual teams to work on these scenario projects. This is due mainly to the limited number of specialists for certain field who are used across departmental and geographical boundaries. This study has not fully studied the impact of the use of ‘adhocratic’ organizational designs or virtual teams on the scenario planning process.

• This study has been confined to the study of scenario planning both in a specific industry and specific geographic region. Thus its results may not apply in other contexts. Horizontal studies to verify the validity of this framework may be useful to challenge the inferences made here.

• Any future studies could also include how the various scenario techniques, based on past literature on the development of scenario techniques (Bishop 2007), have been chosen to be used for different purposes. Ideally, future studies could focus on identifying the most effective scenario technique for a given scenario process design.

• Finally it may also prove valuable to explore the governance, power and knowledge structures within energy companies based on ‘Decision Network Analysis’. This method is a derivative of Social Network Analysis and explores the impact of the dimensions above within the social structure of the energy company as a whole. This method is applicable as energy companies, such as interviewees in this study, are very large with business units that operate within a hierarchy and social conditions. The understanding of dimensions such as governance, power and knowledge can lead to a deeper understanding of how the scenario design options can chosen to maximize the use of scenarios as a tool.
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Appendix

1. Interview Guideline

As the interview was conducted in a semi structured format, the questions devised were used solely as a guide and not in a strict sense of sequence. The following were the key questions used.

1. Describe how scenario planning is used in your company? What is the role of your Business Unit in Scenario Planning process?
2. Problem statement/purpose of scenario planning. Are scenarios used for choosing between alternatives for a predefined goal or used to build decision behaviour?
3. Are non influencable factors considered in the scenarios? What is the scope (Region, sub industry) and time horizon used?
4. Are process related scenarios or situational scenarios practiced?
   Situational scenarios are snapshots into the future whilst process related scenarios focus on how the future unfolds.
   Point of departure - Is the perspective taken a explorative or anticipative one? Are descriptive or prescriptive/normative approaches used?
5. Are probabilities of occurrence assigned to key factors in the scenario development? If they are not, then are extreme scenarios used as the options?
6. Is there a particular methodology of scenario planning adopted from external consultants (Kairos Futures, GBN, etc.)? Was there a reason why this approach was chosen?
7. What tools or techniques are used to facilitate the scenario planning (Delphi method, Cross Impact Analysis, STEEP, stakeholder analysis)?
8. What are the challenges faced in data collection or identification of key factors to be considered?
9. How do you think the scenario planning process in your company can be improved? Describe the drawbacks and advantages of the current process.
Vattenfall AB headquartered in Stockholm, Sweden is one of the largest energy utilities (generation, distribution & sales) in Europe with core markets in Sweden, Germany and the Netherlands. Vattenfall is entirely owned by the Swedish state and is the largest energy utility in Sweden (in terms of electricity generation and sales). It is also active in heating, however not in gas sales. In Sweden, Vattenfall’s electricity generation mix comes primarily from nuclear and hydropower (approximately 89%) and the remainder comes from wind, biomass & waste, natural gas & oil and coal (Vattenfall AB 2011)). Apart from these activities, Vattenfall is also active in energy trading activities and lignite mining (Germany).

Vattenfall has embarked on large scale reorganization in early 2011 to achieve a stronger top down control over the organization’s activities. The main change in this restructuring is the reorientation of business divisions from a geographical focus to a functionally focused one. The 2010 annual report cites the purpose of this restructuring to ‘streamline decision making and to create substantial cost, personnel and knowledge synergies’. A number of departments and sub divisions are part of the strategy function within Vattenfall. The two main departments involved are the ‘Strategy & Environment’ department and the ‘External Relations & Communications’ department. There is a significant overlap between these two departments. Scenario Planning as such is not used in Vattenfall however a number of concepts from scenarios have been adapted into the strategy execution perspective. Vattenfall attempted to implement Scenario Planning, based on the Global Business Network model, a number of years ago however the formal use of scenarios was disbanded a year and a half ago. The key reason for this change was although the scenarios developed assisted in the organizational learning, it did not assist in strategy development. In essence, the experience was the output of the scenario planning process was not actionable for the strategy development activities. This however did not hinder the use of scenarios based thinking in the evaluation of projects.
The evaluation of projects within Vattenfall is an open process that can be triggered from any division within the organization (Top management, Business divisions, support divisions etc.). The Strategy & Environment consolidates a base case scenario for each project under evaluation. Market data is supplied by the relevant business division for the project in question and data related to the external environment (public policy etc.) is supplied by the relevant sub divisions within the External Relations and Communications department that are categorized by specific regions. Competitor Intelligence is a function performed within the Strategy & Environment department. The use of scenario thinking is primarily by the request of Top Management (Executive Group Management). As different ‘What If’ scenarios are typically requested off the Strategy & Environment department. These scenario are process related to a large extent but always fully take into account of the long term targets of Vattenfall (ex. being CO₂ neutral in the Nordic region by 2030). Thus Vattenfall incorporates various milestones in the scenarios used to assess these projects. Usually the scenario development process and the selection of scenarios is an iterative process with Top management heading the evaluation process and the Strategy & Environment department and the relevant business division working closely for the scenario building. At the same time the Strategy & Environment department also its own technology and finance specialists at its disposal for the building of scenarios as well.
3. E.ON Sverige Interview Summary

Interviewee: Dr. Jan Andera,
Position: Head of Market Analysis
Date: 26th April 2011

**E.ON Sverige** is entirely owned by E.ON AG headquartered in Düsseldorf, Germany and is one of the largest energy utilities (generation, distribution & sales) in Europe with core markets in Germany, United Kingdom and Sweden (E.ON AG 2011). As of the end of 2008, E.ON Sverige is the second largest Swedish energy utility (on the basis of power sales and production capacity) and is the regional unit overseeing operations throughout the Nordic region (including Finland, Denmark & Norway). The bulk of the energy generation for E.ON Sverige is derived from nuclear and hydro power (approximately 88%) and the remainder is generated using fuel oil, natural gas, biomass, wind power and waste. The unit is also active in gas heating supply and trading activities.

Scenario Planning is deeply embedded in the activities of E.ON and plays a key role in the strategy and market analysis process of the group. Strategy & Analysis unit in E.ON Sverige focuses on short term and long term planning for E.ON’s activities in the Nordic region. In the long term, the unit focuses on projections for the fundamentals (such as electricity and heat) markets till the year 2035. In the short term, the unit analyzes the changes amongst its competitors and in the market.

*The scenario planning process*

For the purposes of scenario planning, the Strategy and Analysis unit provides the advisory framework for the evaluation of proposed projects from business units. In E.ON Sverige, the proposed investments are lead by the responsible business units and final decisions on investments are typically made by the top management in the Nordic region. The basic framework for the scenario based assessment was developed 3 years ago in the group headquarters as a regional collaboration between different E.ON subsidiaries. The basic framework assesses each scenario based on two predefined key drivers.

This standardized framework promotes the decentralized freedom for the Strategy & Analysis unit in the Nordic region to adapt their analysis into each scenario to assess investment projects. The relevant Business Unit for an investment project owns and drives
the investment evaluation. The investment plan is then evaluated by the top management. The evaluation of this investment is evaluated based on two perspectives; i.e. the project’s strategic fit against the strategic direction of the organization and economic feasibility (against value creation for shareholders). A power price model is used as a guide to develop quantifiable scenarios. This model functions as a guide to determine key input variables to develop these scenarios. The model and the strategic direction of the organization as a whole is revised annually to take into account the new reality of the environment. However the key emphasis of this process is that each scenario is in principle treated with equal probability of occurrence. This does not mean that the final decision making does not consider the probability of each scenario. The probability is considered to be taken into account whilst the final decision is made by the top management (thus wildcard/extreme scenarios are implicitly considered). To balance this, scenarios can be subjected to sensitivity analysis thus gaining some insight into extreme scenario conditions. The pathway of scenario development is considered to be a process related scenario (explorative based on how the future will unfold). At the same time each scenario is broken down into phases where certain milestones are explicitly taken into account. One example of this milestone is the 202020 EU Strategy. Thus it can be considered that the scenarios practiced are a mixture of anticipative and explorative although there is a stronger emphasis on explorative reasoning. Essentially, scenarios serve as a platform to build a consensus on their view of the future. This view is then used to evaluate investments. As the Strategy & Analysis team within E.ON Sverige is relatively small, conversations on future outlooks occur frequently thus facilitating the consensus building process.
4. Company X Interview Summary

Interviewee: XXX

Position: Senior Advisor, Corporate Strategy and M&A

Interviewer: Vinod Krishnan

Date: 4th May 2011

Company X is European energy utility (generation & trading only) with a strong focus in hydro power and core markets in Norway, Sweden and Germany. It is a relatively smaller player in terms of heat and electricity generation with a total annual generation at about 57 TWh. The electricity generation comes from a combination of hydropower, gas, bioenergy and wind power. It also has a relatively smaller presence outside of Europe in hydro power projects.

The use of scenario planning in Company X has been primarily for the purposes of strategy development. Company X does not use scenarios to evaluate projects or investments. A key difference in Company X however is that investment decision making is a largely top down process; where top management identifies and drives new strategic investments. There are two main departments that are involved in this process that are the Corporate Strategy department and the Market Analysis department. Both departments work closely for the scenario development. The Market Analysis department collects and feeds the market data into the models developed. Models used are similar to other competitors in the sense that it is forecasting models for market fundamentals and for market power prices. The Market Analysis department also monitors the early warning signs identified in the scenario planning project. The Corporate Strategy department, on the other hand, monitors changes in the regulatory framework and the competitor analysis. Corporate Strategy department also performs and incorporates the stakeholder analysis in the scenarios being developed.

Company X began using scenario planning as a tool 5 years ago. In the initial period, the use of scenarios was purely qualitative and descriptive. However in the last scenario planning exercise, there has been a stronger emphasis to incorporate market data with quantitative projections. This initiative has been largely driven by the Market Analysis department. Having said this, the current model is based on the intuitive logic model with 4 quadrants. In other words, each scenario is developed to be equally likely and probabilities of occurrence are considered implicitly. The 2 key drivers used for the scenario planning are;
1. Macroeconomic developments

2. Political leadership towards Climate Change

As scenarios are mainly developed to test the robustness of newly developed long term strategies, the scenario planning projects are typically not done more frequently than every 2 years. This would largely depend on the level of turbulence or changes in the general operating environment. The time horizon also varies in each scenario planning project from 10 (2020) to 40 (2050) years. As Company X is mainly active in European markets, the strategy development initiatives and thus the scenario projects are focused on the European context. The Market Analysis department does monitor market and the general environment for projects and markets outside Europe but this done on a period basis and to a smaller extent. The scenarios developed are all process related scenarios but incorporating key milestones such the Euro 202020 strategy and the longer term vision of Company X (i.e. being the leader of renewable energy generation, etc.). Thus scenario building is a combination of exploratory and anticipative. A key aspect of the scenario development is that all underlying assumptions and cause and effect relationship logics are built into the modelling thus eliminating the need for a separate scenario planning tool. The scenario planning process and modelling has been developed internally within company X. External consultants are engaged from time to time for scenario projects however the consultant’s participation is for specific knowledge in the scenario development and not to develop the scenario planning process itself. The key challenge in the strategy development point of view is translating the learning gained in the scenario planning process is to make actionable decisions. This is as equally probable scenarios model typically requires management to decide between different futures. Furthermore decisions can be made at three levels in regards to future direction; Geographical presence, Technological presence & Presence in different parts of the value chain.

Two areas have been identified as potential improvement areas in regards to the scenario planning process;

1. To increase the involvement and participation of people in the business area in the scenario development.

2. To translate the long term strategy decisions made from the scenario planning process into short and mid term execution strategies. This admittedly is a far more complex endeavour.
5. Dong Energy Interview Summary

Interviewee: Federico Castelli

Position: Head of Corporate Strategy

Interviewer: Vinod Krishnan

Date: 4th of May 2011

Dong Energy is a European energy utility (generation, distribution and sales) wholly owned by the Danish state with a strong focus in Northern Europe. Dong Energy’s product range includes oil, gas, electricity and heating. The largest portion of Dong Energy profits are derived from oil and gas production and energy trading. Power and heat generation comes from oil, gas, wind (offshore & onshore), biomass and coal sources. In Sweden, Dong Energy partly owns a hydropower plant in Indalsälven.

Dong Energy uses a tool called High Level Model (HLM) for the purposes of long term strategic planning. HLM is an Excel based tool that is owned by the Corporate Finance department. The Corporate Strategy department uses HLM to consider future possible market conditions. The robustness of strategies developed are tested against different uncertainties using this tool. HLM incorporates market future prices for the initially 3 years and uses complex models developed internally to simulate market conditions after that period. There is currently 3 different models used for market forecasting purposes. Each model comprises of differences in time horizons, geographical coverage and market considered by means of monitoring capacity based forecasting or market tightness. There is an initiative currently underway to homogenize these three models. Each of the five business units (Exploration & Production, Power Generation, Renewables, Energy markets & Sales & Distribution) uses a different Excel based model to simulate these conditions. As there is a significant level of uncertainty on forecasts in the period after the initial three years, an internal Market Price Committee, composed of finance and economics experts, standardizes forecasts for the key input variables (power price, carbon price, commodity prices, etc.) to be used by all the business units; the price curves for different regions and market fundamentals. The models from all five business units are aggregated to form a holistic view of Dong Energy, and thus termed the HLM. HLM is used for both strategy evaluation and investment/project evaluation. Downside risk and financial value added such as Value at Risk, Price at Risk, NPV or ROCE based on the groupwide cost of capital (WACC) is the model’s output used for decision making.
To a large extent, a formalized scenario planning process is not employed by Dong Energy. This is as no predefined key drivers are identified to be tracked and the bulk of the scenarios generated approximate a sensitivity analysis. The organizational culture is seen to have a key reason why a formal scenario approach has not been adopted. However, scenario thinking is part of the evaluation process. Scenarios are generated based on the four quadrant model of equal probability of occurrence. This is done by changing future variables such as commodity and power prices. The model does not explicitly consider changes in the regulatory framework and the competitor analysis done through market intelligence gathered. Most of the scenarios generated are based on anticipated changes over market prices. Thus extreme scenarios or wild cards are not seen as the primary use of the HLM model.

The HLM also plays a key role in investment decisions. In Dong Energy, each business unit drives new investment initiatives. For an example, the decision to invest in an asset is done based on three evaluation criterions. The first is based on pre approved market price input variables provided by the Market Price Committee. This is typically done using 3-5 different price curves of different future conditions yielding different financial results. Secondly, the business unit creates hypothetical static scenarios in the future if the investment were to be made and included in the business unit’s portfolio. This simulates the value of potential synergies created by adding the asset into the business unit’s portfolio. These scenarios are plugged into the HLM and the overall financial value is then evaluated. Finally, the strategic fit of the investment in the asset is compared against the long term strategy of the group. This is done by the corporate strategy department. The value of the scenario based approach is seen to have two main benefits;

1. At the transaction level for investment decision making, the scenario based approach use of the HLM provides financial value estimates in different anticipated market conditions.
2. The results of the scenarios in the HLM assist to be able to communicate the evaluation of each investment to the different stakeholders involved. This is especially important as it simplifies the evaluation criteria used to one that is easily understood by all parties.

Probabilistic approach towards scenarios with the use of applications such as the Crystal Ball is not looked upon favourably as the level of detailed assumptions required renders the results unreliable. The key challenge faced by the Corporate Strategy department in the use of the HLM model for the purposes of scenario based evaluations is that the large
and complex HLM model takes a long time to compute each of the scenarios considered. At the same time, as the system is owned by the Corporate Finance department and updated by each individual business unit, the response time required for strategic decision making has become long. To counter this, the future direction is to simplify the HLM into a quicker and more responsive application that can provide quick insights even if it comes at a cost of slightly reduced accuracy.
## 6. Comparison of scenario techniques (Bishop et al.)

<table>
<thead>
<tr>
<th>Technique</th>
<th>Starting point</th>
<th>Process</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Incasting</td>
<td>Personal information, personal, team information, unconscious, ideas, values</td>
<td>Thinking, imagining</td>
<td>One or more scenarios</td>
</tr>
<tr>
<td>2. Baseline Mentoal</td>
<td>Dominant trends</td>
<td>Implications, cross-impacts, elaboration</td>
<td>Elaborated baseline scenario</td>
</tr>
<tr>
<td>3. Elaboration of fixed scenarios</td>
<td>Multiple scenario logics</td>
<td>Elaboration on specific domains</td>
<td>Elaboration of multiple scenarios</td>
</tr>
<tr>
<td>4. Event sequences Probability trees Sociovision Divergence mapping</td>
<td>Branching uncertainty or choice points Cluster similar alternatives into macro themes Multiple potential events</td>
<td>Sequence, assign probabilities Place on one of four time horizons, link events in sequence</td>
<td>Probability of end states Multiple scenarios Multiple future histories</td>
</tr>
<tr>
<td>5. Backcasting, horizon mission methodology Impact of future technologies</td>
<td>One or more end states, can even be fantastical Technology themes</td>
<td>Steps that could lead to that end-state Highly capable scenarios, signposts leading to scenario, cost/benefit</td>
<td>Ideas for near-term work or investment Contingent strategies to pursue given the occurrence of signposts</td>
</tr>
<tr>
<td>6. Dimensions of uncertainty</td>
<td>Dimensions of uncertainty</td>
<td>Multiple alternatives for each dimension, link one alternative from each dimension</td>
<td>Multiple end states as combinations of one alternative from each dimension Four mutually exclusive scenarios</td>
</tr>
<tr>
<td>GSN Option development and evaluation</td>
<td>Driving forces, two dimensions of uncertainty</td>
<td>Select two most important and most uncertain, create 2 x 2 matrix, title and elaborate</td>
<td>Ranking of combinations of alternatives from most to least consistent</td>
</tr>
<tr>
<td>MORPHOL</td>
<td>Dimensions of uncertainty</td>
<td>Multiple alternatives for each dimension, rate consistency of every alternative against every other alternative, perform nearest neighbour calculation</td>
<td>Multiple end states as combinations of one alternative from each dimension, based on evaluations and likelihood of pairs of alternatives; can calculate probability of combination of probabilities of alternatives are known</td>
</tr>
</tbody>
</table>

Figure 19. Comparison of Scenario techniques. Adopted from Bishop et al. (2007, p 18)
<table>
<thead>
<tr>
<th>Technique</th>
<th>Starting point</th>
<th>Process</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-impact analysis</td>
<td>Potential future events or end states</td>
<td>Initial probability of each, contingent probabilities of each given the occurrence of each other, Monte Carlo simulation</td>
<td>Final probabilities of each event or end state</td>
</tr>
<tr>
<td>IFS</td>
<td>Variables of future ends states</td>
<td>High, medium, low values of the variables, initial probability of each range, cross-impact of ranges from different variables on each other, Monte Carlo simulation</td>
<td>Final probabilities of each range of each variable</td>
</tr>
<tr>
<td>SMIC PROB-EXPERT</td>
<td>Potential future events or end states</td>
<td>Initial probability of each, contingent probabilities of each given the occurrence of each other, correction of contingent probabilities for consistency, Monte Carlo simulation</td>
<td>Final probabilities of each event or end state</td>
</tr>
<tr>
<td>Trend impact analysis</td>
<td>Trend, one or more potential future events</td>
<td>Estimate impact of event on trend – time of initial impact, max impact, time of final impact</td>
<td>Adjusted trend values</td>
</tr>
<tr>
<td>Sensitivity analysis</td>
<td>Systems model with boundary conditions</td>
<td>Enter multiple plausible values for each uncertain boundary condition, possibly Monte Carlo simulation</td>
<td>Range of plausible outcome variable</td>
</tr>
<tr>
<td>Dynamic scenarios</td>
<td>Dimensions of uncertainty</td>
<td>Build system model for each dimension, combine into one overall model</td>
<td>Dynamic behavior associated with each scenario</td>
</tr>
</tbody>
</table>