Using Scenarios to Balance Future Requirements and Capability Development

Erik Jacobsson

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Division of Production Management

Faculty of Engineering at Lund University

Abstract

Title: Using scenarios to balance future requirements and capability development

Author: Erik Jacobsson

Division: Production Management

Supervisors: Bertil Nilsson at the Technical Faculty of Lund University, Innovation Advisor at the case company

Keywords: Scenarios, Corporate development, Energy Sector, Capabilities, Technology

Background: The speed of change in the world is ever increasing. In the business world, one of the sectors that are changing the fastest is the energy sector. One way to cope with change is to use scenarios and scenario analysis. There are many scenarios published every year. Which scenarios should one use, how should they be interpreted and what should be done about their implications? A case company which is a supplier to the energy sector, needs to understand the best way to handle the current development.

Purpose: The purpose of the project and this report is to determine/collect the potential new requirements and developments in the energy sector and create a framework to balance these requirements against technology/capabilities for a supplier.

Method: This research has a pragmatic worldview and uses an overall qualitative approach to understand the scenarios, their implications and what should be done about them. The research objectives are achieved through a literature study, a case study and a gap analysis.

Conclusion: Through constructing a framework for finding the highest quality scenarios, the WEC Energy Scenarios from 2016 deemed the best candidate to understand and evaluate future requirements. Six different capability areas were found, Real-time data measurement, Real-time control with data, Optimising products, processes and services with data, Continuous connectivity, Systems integration and Internet of things. These six areas represent capabilities/expertise that will be needed in the future for a qualified supplier to the energy sector. They are all connected to each other to some degree, and in some cases are actually different levels of the same underlying theory. The six areas are all heavy in understanding- and use of data, witnessing that success for a qualified supplier in the future will to a large extent be how well one handles data. Through mapping the status of the six areas at the case company, it could be seen that the company has at least started development and discussions, but has a lot to do before being set for the future, especially in the last three of the six areas. It was found that the main reasons the case company lacks in some of the areas are historic tech, market preferences and organisation. It was further found that handling the gaps and becoming capable in these six areas would require several things. First, set a Common Agenda that the entire company can get behind, that sets the official direction and commitment to becoming capable in these data-related areas. Second, create a new entity/department which can bear the costs of the data equipment on the products and solutions, turn data into valuable information, as well as enjoy the revenues of the value created through the data and information. Lastly, acquire a mid- to large-sized company/department that is already capable in these six areas.

From this project, it can be concluded that the work process of constructing a scenario framework and a capability framework is well functioning and a solid method to develop strategic input.

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Erik Jacobsson

Definitions and abbreviations

% – percent

Δ – Delta/ Change

°C – Degree Celsius

APAC – Asia-Pacific

bn – Billion

CC(U)S – Carbon Capture, Use and Storage

CO_2 – Carbon Dioxide

EU31 – European Union + Switzerland, Iceland and Norway

EUR – All of Europe and Russia

EV – Electric Vehicles

GDP – Gross Domestic Product

GtCO2 – Giga Tonnes (of CO_2)

GW – Giga Watts

HVAC – Heating, Ventilation and Air Conditioning

INDC – Intended Nationally Determined Contributions

IoT – Internet of Things

IPCC – Intergovernmental Panel on Climate Change

IT – Information Technology

LAC – Latin America and Caribbean

LNG – Liquefied Natural Gas

MENA – Middle East and North Africa

Mn – Million

MTOE – Million Tonnes of Oil Equivalent

NAM – North America

NOX – Nitrogen Oxides

OECD – Organization for Economic Cooperation and Development

p.a. – Per Annum

PV – Photovoltaic

RD&D – Research, Development and Deployment

SOX – Sulphur Oxides

SSA – Sub-Saharan Africa

TFC – Total Final Consumption

TPES – Total Primary Energy Supply

UN – United Nations

UNFCCC – United Nations Framework Convention on Climate Change

USA/The US – United States of America

yr. – year

1. Introduction

The first chapter explains what the author have intended to do. It starts with a background description and is followed by problem definition, purpose, project objectives, target groups, contributions and focus and delimitations. Last, the structure of the report is explained.

1.1 Background

The corporate and research interest in coping with change has increased rapidly during the last century. The world and business landscapes are ever changing, and the relative speed of change is increasing as well. Ability to handle and prepare for change can be the difference between survival and death of companies and organisations. Thus, some have started to study and use techniques and methods to be better prepared for changing environments. One such technique is the use of scenario analysis.

Using scenarios as a means of preparing was, for organisational strategic use, first introduced by Shell (Schoemaker, 1995). Scenario analysis involves constructing and/or using plausible future states as means of preparing for the future. Scenarios can be built on both quantitative and qualitative data and are used as a way to create an understanding of what may be needed from a company, offers, capabilities or otherwise, in the future. Thus, the company or organisation can get an understanding of what is needed to do today to fit in the future scenarios. This is especially important in long periods of time and long cycles, where decisions made today has impact for many years to come.

As mentioned, the world is from many perspectives changing faster than ever before. Change in demographics, lifestyles, regulatory pressure and so on creates changes in supply and demand in almost any sector. A sector that is experiencing large change is the energy sector, more specifically, the production, distribution and consumption (and recirculation) of energy. Not only is the sector directly affected by change in lifestyle and demographics, but also heavily influenced by policies, especially related to sustainability. This due to sustainability policies' ability to push agendas that forces entirely new energy systems.

A case company, dealing in production of specialized products and solutions for heavy industry, has three business divisions. As a major part of the company is related to the energy division and the energy sector, preparing for the coming future and changes in the sector, and making correct decisions for the future, is crucial to the company's overall performance.

1.2 Problem

The overall project problem, derived from the background, regards how one can **understand** future states and its today not experienced requirements and **balance** these with existing and potential new capabilities/technologies. This is considered within the energy sector in global groups related to production, distribution and consumption/recirculation. Within these groups, the problem concerns understanding what a qualified supplier must be able to offer in the future.

1.3 Purpose

The purpose of the project and this report is to determine/collect the potential new requirements and developments in energy and create a framework to balance the requirements against technology/capabilities for a supplier.

1.4 Project objectives

To ensure project success, a set of goals and objectives were set up. In addition, these also guided the project, the process and the contents and thus bear the role that research questions normally would.

The overall project **objective** is to develop frameworks and work processes for strategic planning in energy industry where potential future requirements and needs, identified through scenarios, can be balanced by supplier´s capabilities, technology and offers. These frameworks and work processes should also be verified, or rejected, that they work. This is done through four **targets/phases**:

1. Understand and map how high-quality scenarios are constructed
2. Map development of the world and its energy sector until 2030 using plausible future scenarios. Understand what will be required of a future supplier in terms of capabilities, technologies, expertise and know-how
3. Map current state of the case company in these requirements
4. Understand and map the gaps between 2. and 3. and define/develop strategy to develop the capabilities/expertise needed in the future in the case company.

The **first phase** considers understanding how quality scenarios are constructed. The target is to create a framework that can be used to determine which scenarios are of high quality. The **second phase** will use scenarios to map how the world and the energy sector currently develops and what the developing tendencies are. Furthermore, this development will be interpreted to understand what it means for a qualified supplier. In other words, what challenges will have to be surmounted, what offerings will be required and what capabilities and expertise will be necessary. *Where* these will be needed will be investigated as well. The **third phase** will consider what the case company currently has in terms of major technologies and offers to markets, furthermore what current capabilities and expertise that the case company can leverage to match future needs and developments. The **fourth phase** considers the gaps and discrepancy between the second and third step and will analyse what the case company needs to develop in terms of capabilities, expertise and technologies to be a qualified supplier in the future.

Lastly, the suggested process and frameworks **functionality should be verified**. If all four phases are followed, and the results of the work process and the frameworks are adequate, then it can be verified that the suggested process and its frameworks are a solid method to use for developing strategic input.

1.5 Target groups

The target group for this master thesis is the Corporate development department of the case company, the rest of the company, other companies in energy industries, other companies looking to lay their strategy and prepare for future changes in energy and researchers within similar areas.

The project and report contributes to the target groups in different ways:

- To academy: Consolidation of scenario literature
- To research/society/companies: Frameworks and work processes for evaluating scenarios, creating capability maps and developing strategic input

1.6 Focus and delimitations

The project, study and report is first and foremost limited by the time length of the thesis, more specifically 20 weeks.

Furthermore, the project is delimited to the energy sector, in other words production/distribution/consumption of energy. The development, scenarios, needed- and actual capabilities at the case company will all concern the energy sector.

The third delimitation relates to the fact that the project aims to help the case company. Results and recommendations may be more or less applicable for other companies depending on their similarities to the case company.

1.7 Report structure

The report consists of 10 chapters, Introduction, Method, Case company background, Frame of reference, Empirical findings in scenarios, Empirical findings in company capabilities, Analysis, Discussion, Conclusion and Contributions and further suggestions, as described in Figure 1 below.

1. **Introduction** – explains what the author have intended to do
2. **Method** – describes the methods used in the project, as well as motivates why the specific methods were chosen
3. **Case company background** – describes the case company which the project was conducted with, at and for
4. **Frame of reference** – describes the theory used to assess the project and its objectives/goals
5. **Empirical findings – Scenarios** – explains which scenarios that have been used to analyse the future and what they mean for a supplier to the energy sector
6. **Empirical findings – Company capabilities** – explains and shows the results from the investigation and research at the case company to verify the functionality of the framework
7. **Analysis** – analyses the results
8. **Discussion** – discusses the results and methods of the project, first in general terms and then in specifics for the four respective objectives/phases
9. **Conclusion** – shortly summarises results and implications of the project as well as conclude what the case company should do to become/remain a qualified supplier in the future
10. **Contributions and further research** – shortly describes the contributions and value created for the academia/theory as well as for the case company, furthermore suggests further research areas

Appendices

Figure 1 – Explanation of report structure, (Author)

2. Method

This chapter describes the methods used in the project, as well as motivates why the specific methods were chosen. The first section describes the chosen research approach, the second describes the research process, the third the data collection, the fourth the data analysis, the fifth the quality of the study, and finally, the sixth and last section describes criticism on sources used.

2.1 Research approach

The research approach was chosen in line with the project's purpose and character. According to Höst (2006) and Robson (2002), a research project can have different purposes, these generally fall within either *descriptive, exploratory, explanatory or problem solving*. Earlier, the purpose of the project was stated to be to "… determine/collect the potential new requirements and developments in energy and create a framework to balance the requirements against technology/capabilities for a supplier." Thus, the projects main purpose is *exploratory,* with a hint of *problem solving.* In line with theses purposes, the chosen research approach is case study.

2.1.1 Case study

When a project aims at describing a phenomenon thoroughly, case study is a suitable approach. The approach suits describing contemporary phenomenon's, especially those which are difficult to distinguish from their environment (Höst, et al., 2006, p. 33) (Runeson & Höst, 2008). Furthermore, the case study approach is suitable when answering "how" and "why" questions (Yin, 1994). Conclusions in a case study are seldom generalisable to other cases, even though the conclusions are likely to be similar when the conditions are the same. (Höst, et al., 2006, p. 34)

The structure of a case study is often flexible, questions as well as purpose and direction can change under the course of the project. The studied or interviewed persons in a case study should be as different from each other as possible to cover as many variations as possible in the phenomena which are observed. Data that are collected is usually qualitative, and interviews, observations and archive analysis are common techniques for data collection. (Höst, et al., 2006, p. 34) These techniques are more thoroughly described under 2.3 Data collection.

2.1.2 Abductive method

Due to using mostly qualitative data, as well as iterating between theory and practice, the project used an abductive approach, which is a combination of induction and deduction. The idea of the abductive research approach is to use prior theoretical knowledge and try to, through empirical studies, to observe real-life situations which deviate from the theory. The process is iterative, going between finding new matching theory and conducting more empirical studies. The iterative process closes the gap between prior theoretical knowledge and real-life observations. The process often results in new theory or new hypotheses (Kovacs & Spens, 2005).

2.2 Research process

The overall project, its purpose, objective and targets were jointly set by the author, LTH and the case company. It was unanimously agreed that the project should, to the greatest extent possible, try to work on one target at a time before proceeding to the next, to ensure that the created frameworks and research would not become biased. Thus, the project research process followed the projects four targets from 1.4. The targets are re-stated below for clarity, and form the projects four phases:

1. Understand and map how high-quality scenarios are constructed
2. Map development of the world and its energy sector until 2030 using plausible future scenarios. Understand what will be required of a future supplier in terms of capabilities, technologies, expertise and know-how
3. Map current state of the case company in these requirements
4. Understand and map the gaps between 2. and 3. and define/develop strategy to develop the capabilities/expertise needed in the future in the case company.

To achieve the first target, a thorough literature review on scenarios, scenario analysis, scenario planning and scenario thinking was conducted. The literature search was made in LubSearch and Google Scholar. Keywords used was scenarios, scenario analysis, scenario planning, scenario thinking and forecasting. Every keyword was also searched for with ”energy” added to it due to the projects nature and purpose. In addition, the citation pearl growing (Rowley & Slack, 2004) was used as a search strategy as well. The citation pearl growing approach uses references within initially used literature to find other relevant literature. This was considered a suitable approach since there is a very large number of articles and books on the subject of scenarios, but many stems from the same original sources. The citation pearl growing approach was used to find these original sources. The literature review provided a thorough view on the subject of scenarios. Furthermore, it also allowed the creation of a framework to find external scenarios of good quality.

To achieve the second target, the framework for finding good external scenarios (the result from objective one) was used. The framework allowed for ranking and evaluation of external scenarios. The external scenarios were found through an archival analysis. Archival analysis is using data collected for other use than the current research. It is important to know and remember the original purpose of the data from the archival analysis to avoid misinterpretation (Höst, et al., 2006). The scenarios were found through searches in LubSearch, Google Scholar and Google. The keywords for the archival analysis and finding the actual scenarios were energy scenarios, future/evolving energy technologies, future/evolving energy scenarios and energy forecasts. When seemingly all relevant scenarios had been found, they were evaluated using the framework from objective one. The scenarios which were selected were thoroughly analysed to develop a speculative set of future requirements for suppliers to the energy sector. The set of requirements was structured into a framework for comparison with objective three, during objective four.

The framework of requirements from objective two was used to construct an interview guide for target three. In objective three, interviews were conducted with key personnel in the case company to understand where the company was in relation to the future requirements. The interviews resulted in a set of finished, on-going and started activities in developing capabilities for future requirements. The set of capabilities and their status was set into a framework to compare with the results of objective two, during objective four.

Target four involved analysing and comparing the future requirements from objective two with the developed and developing capabilities of objective three. Before comparing and analysing, objective four started with a literature review to find best practice in gap analysis and strategy development. The literature review was conducted in LubSearch and Google Scholar, and used the keywords gap analysis.

Figure 2 below summarises the research and project process.

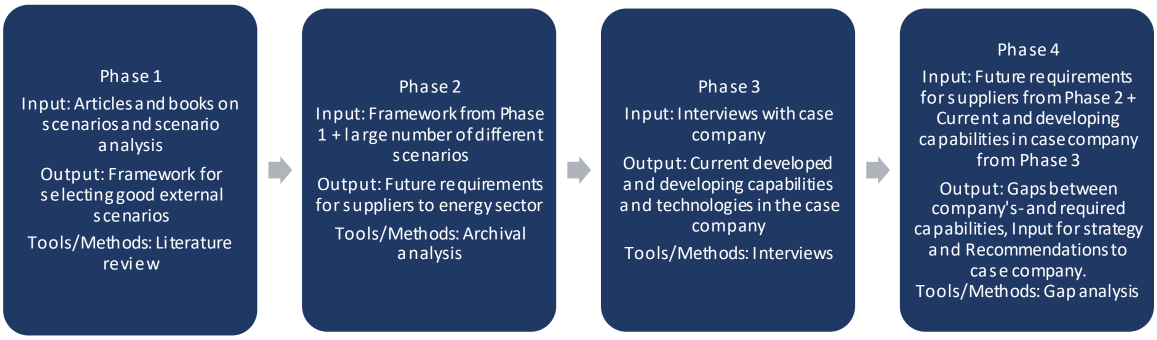

Figure 2 – Summary of the research process, (Author)

From conducting the research process described above, all phases produced results. From analysing the outputs from the phases both separately, conjunctively and overall, the work process and its frameworks functionality could be verified, achieving the projects overall objective. This verification of the work process and frameworks was made as a fifth phase. The verification is reported in 7.4.

2.3 Data collection

2.3.1 Literature study

Various literature sources were found through databases, internet searches, and through suggestions from the supervisors at LTH and the case company. The most relevant in each phase were chosen. Different kinds of sources were used: academic articles, business reports, technical descriptions and scenarios. The scenarios were of varying origin/kind, some developed by consulting firms, some by energy companies, some by scholars and some by institutions. A desk study of these sources was conducted to achieve a general understanding.

As an abductive process was used, there were many iterations between literature and analysis within each phase. The conclusions of each phase are the results of many iterations of ways to fit the observations within the existing theoretical frameworks and the frameworks created in the project.

2.3.2 Interviews

Semi-structured interviews (see appendix A) were conducted with key personnel in the case company. The interviews were semi-structured in order to cover a number of specific areas, as well as to allow the participants to voice their own opinions and thoughts. Participants were chosen by the project supervisor at the case company.

The interview guides and questions (see appendix A) were initially developed based on the framework of requirements from phase two and adjusted when new observations were made. For instance, an opinion or idea raised in one interview could base a question in another interview.

2.3.3 Archival analysis

Archival analysis was used during phase two to find appropriate scenarios to evaluate using the framework from phase one, and later to establish future requirements in the energy sector. A full list of scenarios found and evaluated can be found in Chapter 5.1.

2.4 Data analysis

Analysis of different kinds have been made throughout phase two and four. According to Runesson (2008), quantitative data is analysed using statistics, while qualitative data is analysed using categorisation and sorting. These types of analysis were used in phase two, while qualitative analysis as well as gap analysis was used in phase four. Gap analysis is explained in chapter 4.2.1.

2.5 Quality of the study

In this section, the quality of this project and research is discussed in terms of validity, reliability and generalisability.

2.5.1 Validity

Validity concerns whether the project has been able to achieve its purpose and fulfil the objectives or not, or if it fulfils some other objectives (Höst, et al., 2006). Overall the validity is judged to be good. A full discussion on the project in general, as well as results and methods in each phase can be found in chapter 8.

2.5.2 Reliability

Reliability is the extent to which results can be replicated, i.e. that the same results would be achieved if repeated under the same conditions (Höst, et al., 2006). Due to nature of the project, using specific scenarios and a specific case company, replicating the results depends on using the same scenarios and case company. The author believes that a project conducted at the same time and in the same way as this one would indeed produce similar results. The main objection is that different researchers/authors have different levels of knowledge as well as different skillsets in analysis and these differences could theoretically produce different results. In order to deal with this, it has been stated as clearly as possible when something is strict results and when something is speculative analysis.

2.5.3 Generalisability

Generalisability concerns to what extent the results of the project can be generalised to the whole population (Höst, et al., 2006).

The results from phase one, in other words the scenario evaluation framework, were made to be used on any scenario, not just energy scenarios. Thus, the results from phase one should be generalisable.

The results from phase two, in other words the future requirements in terms of capability for suppliers, is generalisable to some degree. The analysis and results hold for suppliers or players that are connected to the energy sector. There are likely many other sectors and areas where the results hold to some degree as well, but nothing can be said for sure without further specifying which area.

The results from phase three and four, in other words the status of capability in the case company and the gap analysis, can not be directly generalised without caution. Since the case company is the global leader in their field, it is likely that many other players are at the same level or worse in terms of capabilities, this can however not be said without specifying which companies, as well as conducting some sort of analysis.

2.6 Criticism of the sources

The sources for this project consist mostly of well-known academics and companies and can be considered reliable. However, the energy sector is currently moving and changing at a fast pace. Thus, although the information at the time of writing may be correct, it could quickly become dated. The reader should therefore be aware of this and verify that no major change has occurred before using this project and/or report to guide decision making. One way to ensure this could be to check the updated version of the scenarios used and make sure that they still point in the same direction. The used scenarios are updated by the same organisation every three years. Some recent, fairly radical, events have happened since the creation of the scenarios (Trump election and Brexit etc.). These are still covered within the scenarios.

3. Case company background

This chapter describes the case company which the project was conducted with, at and for. Due to secrecy and sensitive information throughout the report, the company is described to the smallest extent possible.

3.1 Introduction, business concept, divisions, new strategies

The case company is a leading, global provider of specialty products and process engineering solutions and mechanical engineering industry.

The company helps customers become more productive and competitive by delivering high-quality products and solutions within a number of key technologies.

The company is divided in three sales divisions. This project is conducted within the Energy division. The three divisions make up 12 business units.

Recently, the company went through a re-structuring process with new strategies. The new strategic approach is purposed to increase organic growth and focuses on three key areas. This is also connected to the need to find a long-term path towards R&D, M&As and JVs.

Many of the company's major customers are in the energy area. They can be found all over the sector, including engineering of energy prospecting plants, engineering of crude oil production plants, energy production plants, energy distributors, energy consumers/re-circulators.

4. Frame of reference

The study and project lies in the intersection of scenario analysis and strategy analysis. This chapter will describe the theory used to assess the project and its objectives/goals. The chapter and thus the theory will be divided in two parts, one focusing on scenario analysis and one focusing on strategy analysis. Within these parts, smaller sections of theory and references that are relevant to the project will be described. The covered topics can be seen in Figure 3 below.

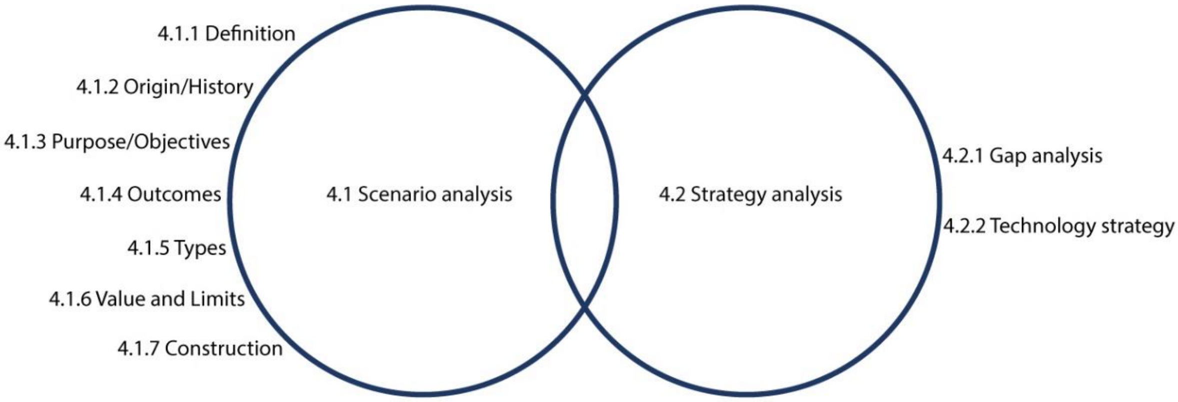

Figure 3 – Frame of reference contents, (Author)

According to Karlsson, Hakkarainen and Larsson (1983), there are in principle three different decision basis's that can be used to prepare for decision situations about the future in energy.

The first entails studying what happens if one acts in different ways. One tries, to the best of their ability, to study probable links of causation. From these one can create models of expected results from different efforts or inputs. By developing and quantifying different ways of acting and letting models calculate what will happen one can get an understanding about the best way to act. Long-time investigations are often dominated by this view (Kalsson, et al., 1983).

The second method to creating decision basis is to describe different principal future situations, in other words what *can* happen. This is suited especially for situations that can only be manipulated to a small extent by a single (or multiple) actor. From the described scenarios of the future, one can try to assess how to act if the development is in line with the different scenarios (Kalsson, et al., 1983).

The third method to prepare is to study properties in the own situation, context and surrounding world to make conclusions about which direction one should put their efforts to achieve best possible results between the own situation and surrounding world (Kalsson, et al., 1983).

The methods are summarised in Figure 4 below.

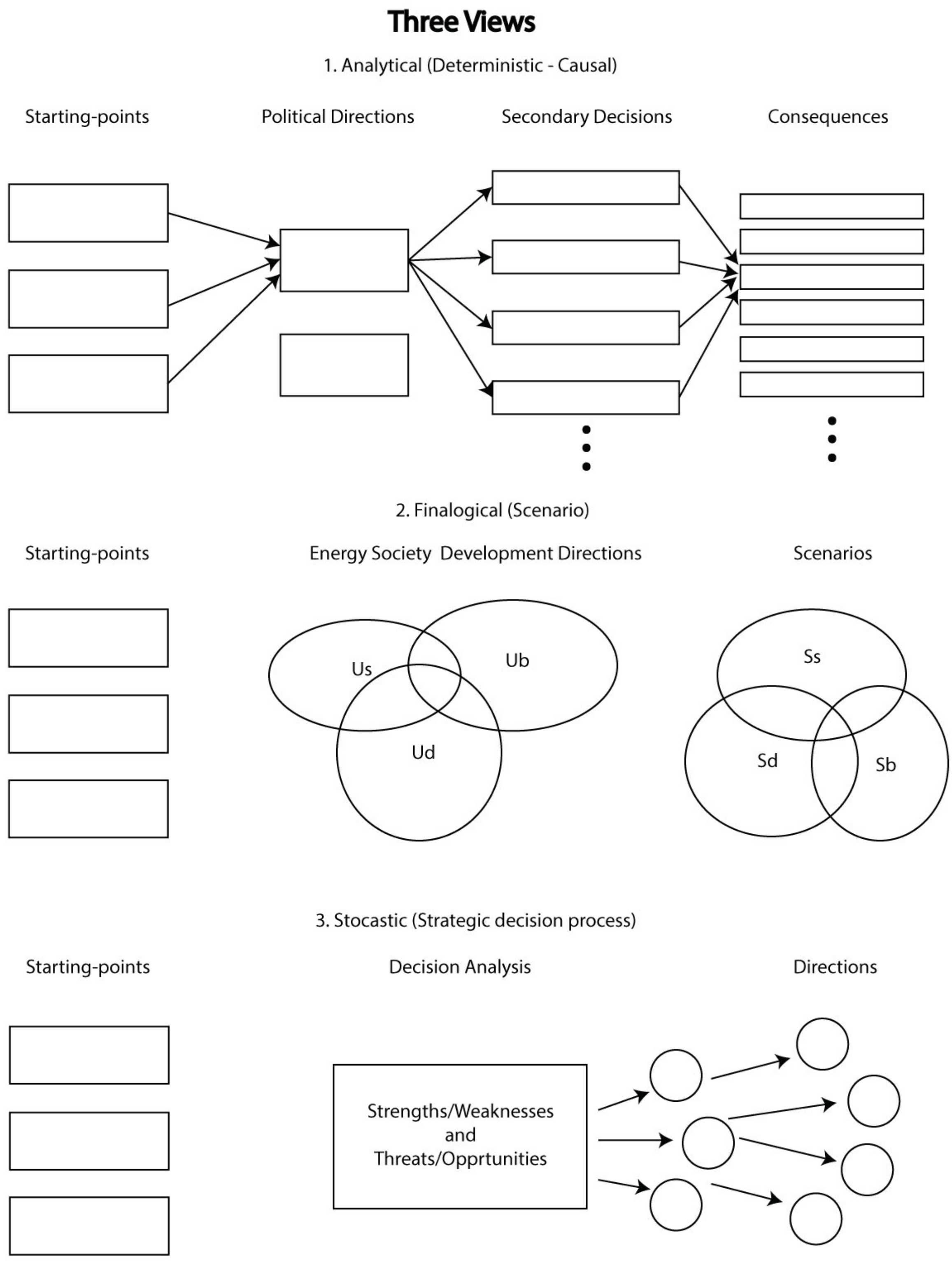

Figure 4 – Three principal methods of developing decision bases, recreated from (Kalsson, et al., 1983)

The second method, scenarios and scenario analysis, is the method this project and report uses and will be thoroughly described below.

4.1 Scenario analysis

4.1.1 Intro and definition of scenarios

Scenarios often carry different definitions, but in essence they are descriptions of possible futures, (Heijden, 2005, p. 27) or actions and events in the future (Cambridge, 2018). Scenario analysis is the process of analysing the scenarios and their future possible realities by considering their alternative possible outcomes (Aaker, 2001, p. 108) (Bea & Haas, 2005, pp. 279, 287). Scenarios and scenario analysis, generally, does not try to find or show the exact picture of the future. Instead, multiple alternate future developments are pictured side by side (Heijden, 2005, p. 114). The alternate futures are generally not considered to be more or less probable in relation to each other. They are framed to all be plausible (Heijden, 2005, p. 4), and thus aimed at broadening perspectives rather than aspiring to be a crystal ball for the future (Heijden, 2005, p. 61).

Scenarios, and scenario planning, allow the (strategic) conversation in an organisation to reflect different perceptions of a situation. Scenarios, when bringing different views and outcomes to the table, makes a discussion or situation aware of the ambiguity and uncertainty. They force people think in terms of multiple, different but equally plausible interpretations of what will happen. That in turn creates room for people consider alternate viewpoints which first broadens perspectives, and in turn aligns what needs to be done and implemented (Heijden, 2005, p. xiv).

Scenarios are frequently used in strategy development. Strategy, in order to be successful, needs uniqueness or "an original invention". Creating an original invention requires the ability to see the world in a new way (Heijden, 2005, p. xiv). Good scenarios are thinking and perception devices. They are not about forecasting highs and lows but about making a new reframed perspective visible (Heijden, 2005, p. 61). Thus, scenarios are well suited to be such a reframing tool to see the world in a new way (Heijden, 2005, p. xiv).

Scenarios are often discussed in connection to scenario analysis, scenario thinking and scenario planning. According to Ron Bradfield, they are basically different notation on the same concept (Bradfield, 2005). However, some differences can be seen in terms of scenario planning being more focused on strategy and strategic decisions, while scenario thinking may have slighter broader use cases.

Beyond scenario- analysis, thinking and planning, the words scenario, projection, prediction, forecast and outlook are sometimes used as synonyms. They are, however, slightly distinguished from each other in their meanings. *Prediction* is a probabilistic statement that something will happen in the future, *projection* is a probabilistic statement that something could happen under some conditions, *scenarios* are simply descriptions of what could possibly happen, and *outlook* is a fair synonym to scenario (Paltsev, 2016). *Forecasts* are "most likely"-pictures of the future, often based on the assumption that the past can be extended in to the future (Heijden, 2005, p. 25).

In terms of comparing scenarios and forecasting, forecasting is about providing answers, scenarios on the other hand are about asking the right questions (Heijden, 2005, p. 6).

4.1.2 Origin/History of scenarios

Scenarios in its modern sense sprung from two different perspectives, the US perspective and the French perspective. Although developed around the same time periods in the 1950s, the perspectives focused on different things. The French perspective had a *normative* focus, developing future states to pursue. The US perspective was more aligned with the modern focus described above, that is, to improve perception and widen perspectives (Heijden, et al., 2002, pp. 124-131). Below, a brief description of the development and evolution of the US perspective will be given.

Before scenario use developed in organisations, scenarios were first used in the military in war games. The first time it moved into the civil domain was through the activities of the RAND Corporation during and after World War Two. The concepts were furthermore developed by the Hudson institute. The institute was created by Herman Khan who used "scenario" with a Hollywood association, that were not accurate predictions, but rather stories to explore (Heijden, 2005, pp. 3-4). Many have experimented with them since then and during 1960s and 1970s, however, Shell and more specifically Pierre Wack are generally seen as the founders of scenario use in strategy and in organisational use (Heijden, 2005, p. xviii).

Shell started using scenarios due to planning based on forecasts increasingly failed. Thus, scenarios arose at a conceptual level and were initially introduced as a way to plan without having to predict things that were difficult or impossible to predict. Shell started to separate predictable elements, *predetermineds*, from unpredictable elements, *uncertainties*. The idea was that predetermineds would be reflected the same way through scenarios in the same way, while uncertainties would play out differently through a set of scenarios. The plausible futures (scenarios) that were developed served as testing ground for policies, plans and ideas (Heijden, 2005, pp. 4-6).

Four different objectives for using scenarios at Shell was developed. Under equally plausible futures, the **first objective** of scenario-based planning became the generation of projects and decisions that are more robust under a variety of alternative futures. Stretching mental models and producing the right questions rather than answers, better quality thinking about the future became the **second objective** of scenario-based planning. Using scenario analysis made people interpret information from the environment differently, the **third objective** was to enable Shell's manufacturing people to be more perceptive, appreciate events as part of a pattern they recognised, and so appreciate their implications. When top management started using scenarios, setting the context within which decisions are made down the line became the **fourth objective** (Heijden, 2005, pp. 4-10).

The four objectives for using scenarios at Shell are still relevant today, although, scenarios are used in even more situations and to satisfy even more objectives now, which will be clear in the following section.

4.1.3 Purpose and objectives of scenarios

Overall, as mentioned, scenarios describe what *could* happen. Thus, their overall purpose is to widen perspectives. Furthermore, in the extension, the ultimate purpose is to create a more adaptable organisation and adaptive organisational learning skills (Heijden, 2005, p. 1) (Heijden, et al., 2002, p. 3). Essentially, the scenario process is about developing knowledge of the contextual environment, by scaffolding elements of knowledge in the zone of proximal development into codified knowledge within the organization (Heijden, et al., 2002, p. 167).

Stemming from the overall purposes, scenarios tend to be used for specific contributory tasks (Heijden, 2005, p. 17). These may include:

- Open up minds
- Address a specific problem or question
- Install a permanent capability
- Create closure around strategy
- Make sense of a puzzling situation
- Produce ideas for action
- Develop anticipatory skills
- Turn participants into experiential leaders

In terms of strategy, according to Heijden (2005, pp. 15-16), good strategy needs to be based on the following elements:

1. Acknowledgement of aims, either through an external mandate, or the organic purpose of survival and self-development.
2. Assessment of the organisation's characteristics, including its capability to change.
3. Assessment of the environment, current and future.
4. Assessment of the fit between the two.
5. Invention and development of policies to improve the fit.
6. Decisions and action to implement the strategy.

Scenarios and scenario-based planning is a method and approach which deals with all six steps (Heijden, 2005, pp. 15-16).

Regarding futures and strategy, uncertainty is a key factor. Scenarios help in dealing with uncertainty in three specific ways (Heijden, 2005, p. 111):

- They help the organisation in understanding the environment better
- Scenarios put structural uncertainty on the agenda
- Scenarios help the organisation to become more adaptable

According to Heidjen (2002, p. 233), the purpose of scenario projects can be expressed along two main dimensions:

- Projects can either serve specific aims or more general process aims
- Projects can either be undertaken to open up a closed organizational mind for exploration or to achieve closure on decisions and actions

Combining these dimensions provides four combinations, which show the four main areas of purpose that can be distinguished, see Figure 5 below.

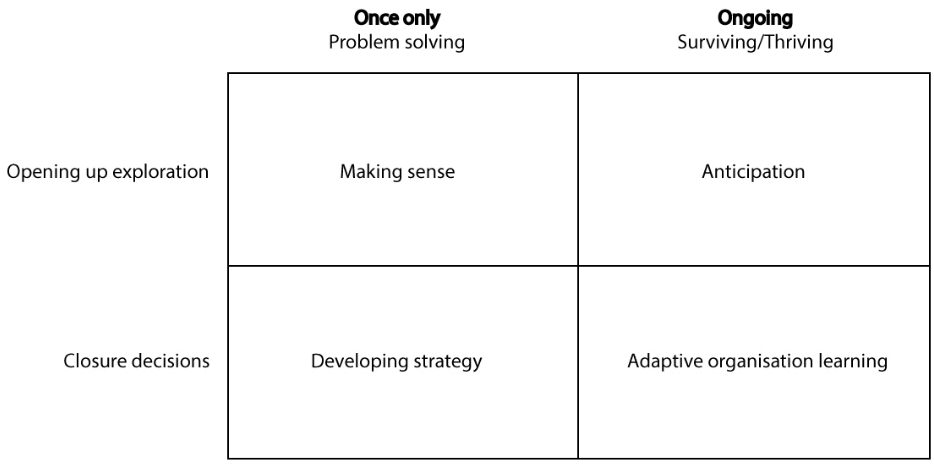

Figure 5 – Purposes of scenario projects, recreated from (Heijden, et al., 2002)

According to Lindgren and Bandhold (2003), scenario projects tend to fall within two dimensions, focus and purpose. These dimensions cover a wide array of objectives and use cases for scenarios, seen in Figure 6 below (Lindgren & Bandhold, 2003, p. 26).

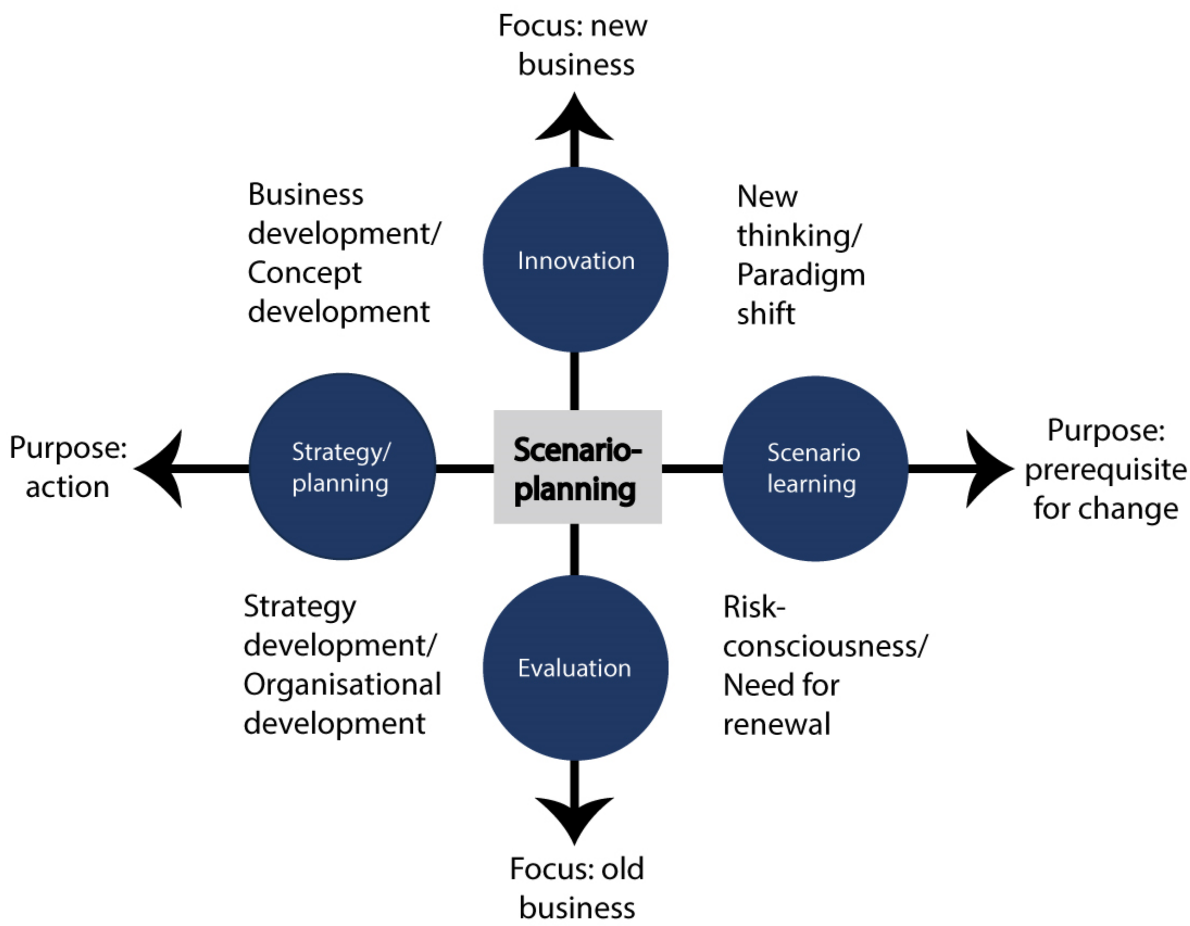

Figure 6 – Scenario projects along different purposes and focuses, recreated from (Lindgren & Bandhold, 2003)

Furthermore, scenarios and scenario thinking can promote (Cairns, 2011, p. 12):

- Early contingency action
- Early recognition of opportunities

As can be seen, there are many reasons why organisations decide to engage in scenarios and scenario-based planning. But these are (or should be) all sub-goals of the one ultimate objective, to gain a new and unique insight. Success in an organisation, especially in strategy, implies uniqueness, uniqueness implies new perspective and insight (Heijden, 2005, pp. 52, 75).

4.1.4 Outcomes

The outcomes of a scenario-project are of course (if all goes well), in line with the decided purpose and objectives described above. However, the contributions of scenarios and scenario-based planning is different at different levels:

At the individual level, scenarios can contribute as (Heijden, 2005, p. 49):

- a cognitive device: scenarios are highly efficient in data organising
- a perception device: scenarios expand mental models
- a reflection tool: helps people think through ideas and brings in new perspectives

At the group level, scenarios can contribute as (Heijden, 2005, p. 49):

- a ready-made language provider, assisting the strategic conversation
- a conversational facilitation vehicle, organising discussion of relevant aspects
- a vehicle for mental model alignment, puts all above in a suitable form for corporate strategic conversation and consideration

When used in strategy and strategic decisions, according to Cairns and Wright (2011), typical outcomes of the scenario process include (Cairns, 2011, p. 12):

- Confirmation that the overall strategy of a business is sound
- Confirmation that lower-level business choices are sound
- Recognition that none of the business options are robust
- Sensitivity to the 'early warning' elements that are precursors of both desirable and unfavourable futures.

The outcome of the scenarios may be, for example, closure around strategy choices. Whatever the final "product" of the scenarios and their discussions are, it is not the emerging stories that matter. Rather, it is the process (Heijden, et al., 2002, p. 141). This is tightly connected to the overall purpose of gaining insights and input, as well as creating organisational learning. To gain these insights and inputs, the outcome of scenarios should be *questions* rather than *answers* (Heijden, 2005, p. 6). In line with the outcome being insights, input and learning, the outcomes and their analysis are usually at a high level with broad brush strokes (Heijden, 2005, p. 93).

4.1.5 Types of scenarios

To achieve the objectives and purposes of a scenario project, a large variety of different scenarios can be used. Scenarios are, as mentioned, a wide concept. However, most fall into a few major categories.

Exploratory and normative

Exploratory and Normative groups scenarios in their general purpose, if they have a target end-state to reach.

Exploratory scenarios are those which are aligned to the traditional purpose of scenarios, they widen perspectives. They achieve this by exploring multiple pathways and treating all of them as plausible (World Energy Council, 2016, p. 29) (Lindgren & Bandhold, 2003, p. 33).

Normative scenarios are those which are developed as a vision of what to achieve or designed to meet a future goal. They act a lot as guidelines. Furthermore, they are generally broken down into plans to achieve the goals and targets, rather than to develop a more adaptive organisation (World Energy Council, 2016, p. 29) (Heijden, 2005, p. 260) (Lindgren & Bandhold, 2003, p. 33).

Top-down and bottom-up

Bottom-up and Top-down refers to how the scenarios are built, which in turn affect their results. Bottom-up scenarios are built, as the name suggests, from the bottom up. That means that the scenarios are built and constructed by looking at aspects from small scale, consolidating in an iterative process to construct the final outcome. Bottom-up scenarios are often rich in technological detail while they lack economic details and feedback from other sectors (Paltsev, 2016, pp. 4-5).

Top-down scenarios are built, also as the name suggests, from top-down. These are usually made with economic models that represent microeconomic principles. Thus, they are rich in economic detail, however, they often lack in technological detail, such as physical engineering constraints (Paltsev, 2016, pp. 4-5).

First- and second generation scenarios

First- and second-generation scenarios relate, as the name suggest, in which order they are developed. However, the essence of first and second-generation scenarios are not when they are created, but rather with which purpose they are created. First generation scenarios are developed to create a basic general understanding, to then provide the ability to create even better (second generation) scenarios. A first-generation scenario is not always created before the second-generation scenario, if the understanding is adequate enough the "decision scenario" can be developed right away (Wack, 1985, pp. 4-5).

Differences in details

Beyond the above described groups of scenarios, scenarios differ a lot in details and focus. This includes, but not limited to, geographic coverage, sectoral coverage, time horizon, basis of method (model-based, expert-based), developed by (public institutions, government agencies, academic researchers, private companies) and update frequency (Paltsev, 2016, p. 3).

4.1.6 Value and limits of scenario analysis

The actual usage of scenarios in organisations over long time indicates their usefulness and their value. The value of scenarios and scenario analysis is connected to using them correctly. Paltsev (2016) recognises that scenarios, and other future looking tools, are often unsuccessful in producing precise and definitive estimates. However, they can be used as qualitative analysis of decision-making and their risks associated with different pathways. He further concludes that the value of (energy) scenarios is not their decision-making capabilities, but rather their decision-support capabilities. Scenarios are limited however, in that they tend to overestimate the extent to which the future will look like the recent past. This point further amplifies the idea to ask questions rather than search for answers, and to use scenarios which widens the perspective of what is possible. Scenarios that does this, even though they and their input tend to be described with a broad brush, provides the most value (Paltsev, 2016).

4.1.7 Construction of scenarios

Construction and development of scenarios have developed and improved since the originals in the Shell corporation. Many researchers and consultants, more or less specialised in scenario analysis, recommend their own specific method or approach. This section will describe some of the major important points in creating scenarios which are represented in most methods and approaches.

Scenarios are constructed through combining *predetermineds* (which are constant through each scenario) and *uncertainties* (which varies through each scenario). There are usually a great range of predetermineds and uncertainties that will affect the future. To make sense and to focus resources, groups of predetermineds or uncertainties are often clustered. The different clusters are then prioritised according to importance or purpose of scenario (Heijden, 2005, pp. 92, 101-102). Figure 7 below shows how scenarios, at a general and high level, are constructed.

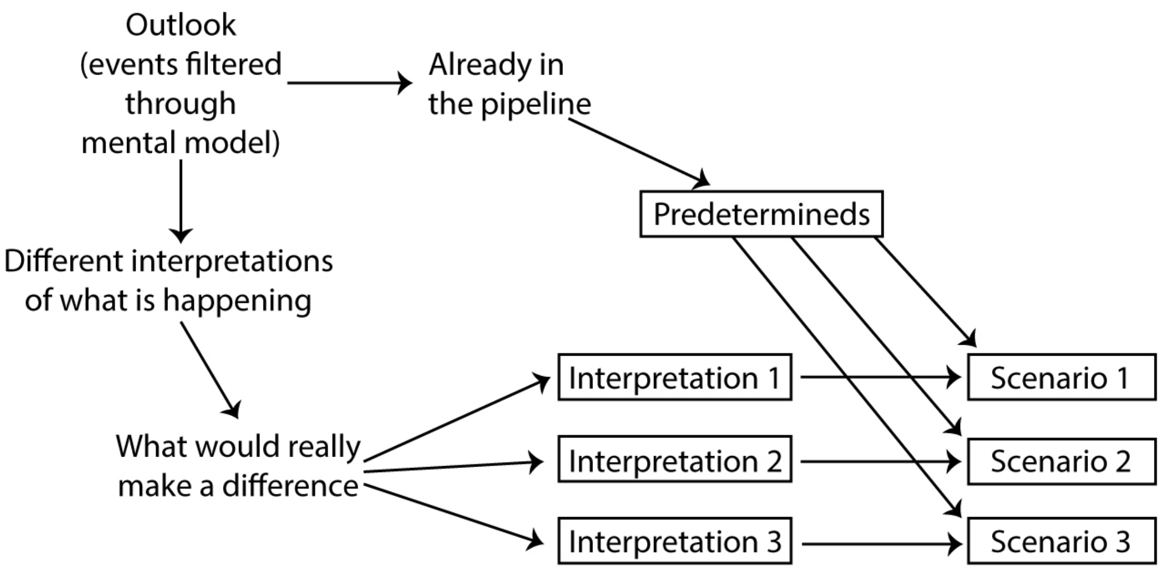

Figure 7 – Principle of scenario building, recreated from (Heijden, 2005, p. 92)

Examples of predetermineds include demography, population, growth rate of production and application of *existing* inventions. The time frame generally affects whether a factor is predetermined or uncertain (Heijden, 2005, pp. 101-102).

According to Lindgren and Bandhold (2003), there are seven criteria for a good scenario (for strategy purposes), these are (Lindgren & Bandhold, 2003, pp. 32-33):

1. Decision making power: the set of scenarios must provide insights useful for the question being considered
2. Plausibility: the scenarios must be realistically possible
3. Alternatives: the scenarios should cover the widest range of uncertainty
4. Consistency: each scenario in the set must be internally consistent
5. Differentiation: the scenarios should be structurally or qualitatively different
6. Memorability: the scenarios should be easy to remember
7. Challenge: the scenarios should challenge the organisations received/perceived wisdom of the future

4.2 Strategy analysis

4.2.1 Gap analysis

Gap analysis relates comparison of actual performance with potential or desired performance. It is connected to optimal resource allocation, from the premise that an organisation has to make the best use of resources, and not miss out investment in capital or technology, to avoid performing below its potential.

Gap analysis should identify gaps between optimised allocation and integration of resources and current allocation level. This often reveals areas that can or need to be improved. The concept involves determining, documenting, and improving the difference between business requirements and current capabilities. Gap analysis can be conducted after benchmarking or other assessments. When a general performance expectation in an industry is mapped and understood, it is possible to make direct comparison of the expectation with the company's current performance. The comparison becomes the gap analysis. The analysis can be performed in many areas, and on both strategic and operational level.

This project will not discuss gap analysis in terms of exact, quantitative, allocation of resources, but rather if certain areas have gotten adequate recognition.

4.2.2 Technology strategy

Technology strategy is a debated subject (Davenport, et al., 2003). According to Ford (1988), technology strategy relates to the core of what the company knows and can do, it is about knowledge and ability. It further relates to policies, plans and procedures to acquire, manage and exploit knowledge and abilities. According to Davenport (2003), technology strategy is acquisition, management and exploitation of technological knowledge and resources, to achieve the organisations business and technological goals.

This project will relate to technology and technology strategy with the broad interpretations above. In other words, technology, capabilities, expertise and know-how will be used synonymously and relate to what a company knows and can do.

5. Empirical - Scenario analysis

This chapter will explain which scenarios that have been used to analyse the future and what they mean for a supplier to the energy sector, such as the case company. The chapter will first construct a framework in line with the frame of reference to evaluate and select the best external scenarios. After, the chapter will explain how the chosen scenarios have been constructed, what the scenarios entail and what they mean for companies that supply the energy sector. Finally, the chapter will construct a framework of capabilities and technologies that will be of high importance in the future, given these scenarios.

5.1 Selection of scenarios

To select the best external scenarios to evaluate the future requirements for suppliers, a framework was created. The framework was created in line with the frame of reference (chapter 4.1) as well as the project problem and is purposed to ensure selection of scenarios which are of high quality and of academic rigor. The framework is made up of 17 factors which should, to as large extent as possible, be present in the scenarios. The first six factors are universal for any scenario, the second nine factors are mostly universal but especially important for this project, the last two factors are important for this project, but not necessarily for others. The framework can be seen in Table 1 below.

Table 1 – Scenario Selection Framework, (Author)

What	Why
Theory based construction (predetermineds and uncertainties etc.)	Academic rigor
Insights to project question (challenging)	Academic rigor, strategic insight
Plausible (possible) scenarios	Academic rigor, strategic insight
Alternatives (cover a wide range)	Academic rigor, strategic insight
Consistency (internally consistent)	Academic rigor, strategic insight
Differentiation (structurally or qualitatively different)	Academic rigor, strategic insight
Exploratory (not Normative)	Create new insight, challenge understanding
Bottom-up (not Top-down)	Project circling around technology
Mainly qualitative	Focus is insight, input and challenge
Created by large organisation	Quality scenarios are demanding
Preferably made by institution (and not a company)	Avoid bias and secret agendas
Preferably experienced creators ("second generation")	Scenario creation requires experience
Many points of feedback	Consistency and plausibility
Many involved actors/people	Consistency and Plausibility
Collectively exaustive in terms of data and info	Quality of analysis and strategic insight
Preferably Global	Case company is global
Relatively new (2013-2018)	Energy sector is a fast changing area

When evaluating a scenario with the framework, the scenario is investigated and evaluated on the set of factors in the framework. Every factor that is fulfilled/achieved by the scenario awards one point. The scenario that is of highest quality is the one with the most points. Should there be a tie, it can be solved by counting which scenario has the most points from the first eight factors, which are arguably more important than the other six plus two.

With the framework in place, a great number of scenarios were evaluated, see chapter 2.2 for the process of finding the scenarios. The scenarios that were found and evaluated to be the main scenarios for the project can be seen in no particular order in Table 2 below.

Table 2 – Scenario candidates evaluated to be used in the project, (Author)

Institution/Organisation	Scenarios, name
World Energy Council	World Energy Scenario 2013, World Energy Scenarios 2016
Shell	New Lenses
IVL Swedish Environmental Research Institute	Energy Scenarios for Sweden 2050
Energinet DK	Energy scenarios for 2030
EnerData	EnerFuture 2017
E3M-Lab of the Institute of Communication and Computer Systems	EU Reference Scenario 2016
National Grid	Future Energy Scenarios
Chair of Energy Economics, Institute for Industrial Production, Karlsruhe Institute of Technology	The development of the German energy market until 2030
Entso-e	TYNDP 2018 Scenario Report
Eirgrid	Tomorrow's Energy Scenarios 2017 Planning our Energy Future
Epri	A Perspective on the Future of Energy: Scenarios, Trends, and Global Points of View
International Energy Agency	World Energy Outlook

In line with the framework for selecting scenarios, created in line with the frame of reference, the selected scenarios to use were the **World Energy Scenarios 2016 created by The World Energy Council**. They were by far, according to the theory and the framework, the best scenarios. They were the only scenarios which not only fulfilled but also exceeded the full framework. The other scenarios scored on a range from three to nine points.

The selected scenarios will be described in terms of construction/design process, data/information, meaning for suppliers and future requirements.

5.2 Creation of the scenarios

5.2.1 World Energy Council

The World Energy Council was formed in 1923 and is an impartial network of leaders and practitioners with the purpose of promoting and affordable, stable and environmentally sensitive energy system for the benefit of all. The Council is UN-accredited and represents the entire energy spectrum of stakeholders. The organisation has more than 3000 member organisations and are located in over 90 countries. Members include governments, private and state corporations, academia, NGOs and other energy-related stakeholders (World Energy Council A, 2018).

The World Energy Council helps stakeholders create global, regional and national energy strategies by hosting events, publishing studies and developing dialogue between the stakeholders (World Energy Council A, 2018).

5.2.2 World Energy Scenarios

The World Energy Council has developed scenarios (although earlier called Futures, Perspectives and Cases) since 1983 to allow policy makers and energy leaders to test key assumptions that they decide to make to shape the energy of tomorrow. The latest instalment is the 2016s version 'The Grand Transition' (World Energy Council B, 2018) (World Energy Council C, 2018) (Jefferson, 2000).

5.2.3 Creating the scenarios, process and method

The scenarios have been created with the purpose to explore the future ahead to 2060. On the way to 2060, there are many indicators on the way, especially at 2030. The scenarios are of great use to many. To name a few, they can be used by policy makers, energy leaders and companies. Use cases includes creating efficient policies, developing strategy and understanding future demands and requirements (World Energy Council, 2016, pp. 14, 29-30).

There are an infinite number of pathways through the future. The scenarios have thus been created to be exploratory routes, rather than extremes. They are neither utopias or dystopias, furthermore more, they are not normative (designed to meet a future goal). Rather, they are designed to be a range of plausible pathways (World Energy Council, 2016, pp. 14, 29-30).

Finally, they are built bottom-up, using a quantifying model paired with expert insights from a huge network of experts (described below) (World Energy Council, 2016, pp. 14, 29-30).

Main actors behind the scenarios

The scenarios were created jointly by three main actors, the World Energy Council, Accenture and PSI (World Energy Council, 2016, p. 2). Accenture is the world's fifth largest consulting firm (Consultancy United Kingdom, 2015), renowned for strategic projects, especially with technological- and digital relation (Accenture, 2018). PSI, also known as the Paul Scherrer Institute, is the largest research institute for natural and engineering sciences in Switzerland. PSI conducts research within three main fields, Matter and materials, Energy and environment, and Human health (Paul Scherrer Institute, 2018).

Method and process

The scenarios were developed through gaining insight and knowledge through six steps. First, to find and agree on *critical trends*, 20 executive interviews, three exploratory workshops as well as text analytics were conducted. Second, to define *alternative dynamics*, scenario framing workshops supported by expert insights from more than 100 global experts were held. Third, to develop *distinct scenarios*, two scenario building workshops and eight regional workshops were made. Fourth, to develop a *dynamic model*, refinement of trends and mapping to energy drivers were done. Fifth, to define *model inputs*, historical analysis and benchmarking to quantify key input drivers were conducted. Finally, sixth, *running the model and analysing outputs*, were done using the GMM MARKAL (described below) model supported by a robust quality control process (World Energy Council, 2016, p. 131). The method and process are summarised in Figure 8 below.

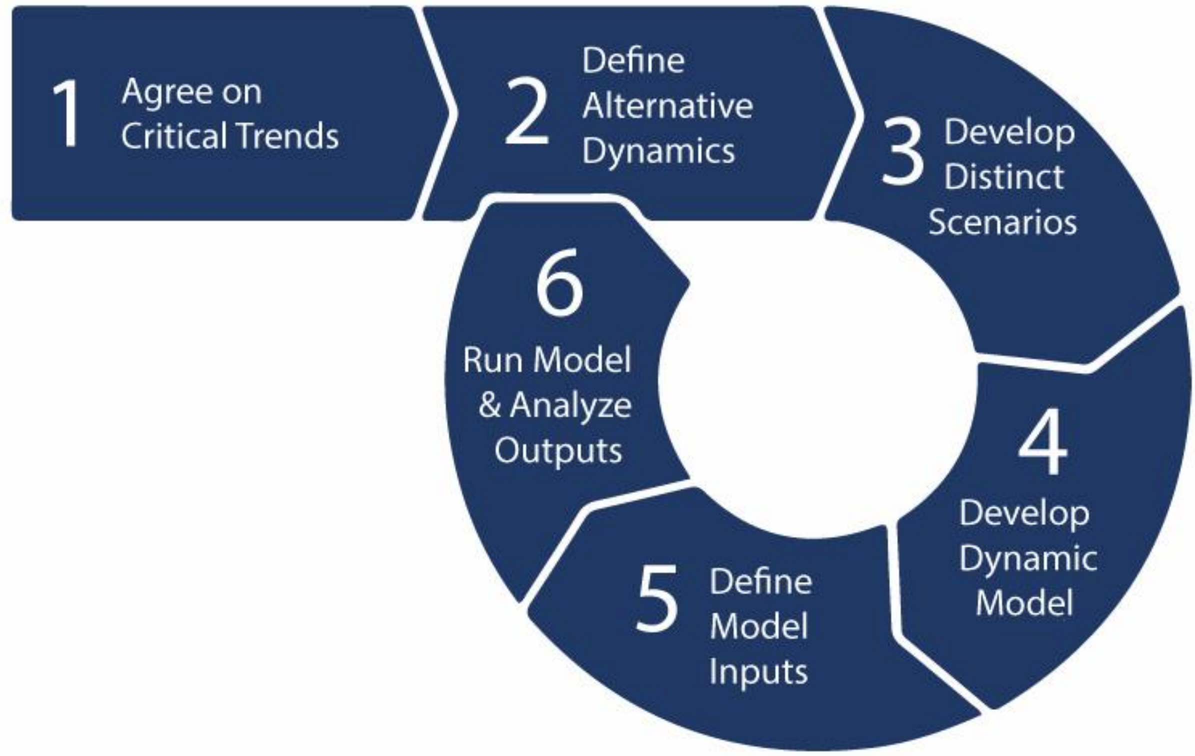

Figure 8 – World Energy Council process, recreated from (World Energy Council, 2016)

The global multi-regional MARKAL model

To quantify and enrich the scenarios the Global Multi-Regional MARKAL Model (GMM) were used (World Energy Council, 2016). GMM is a tool that provides a long-term bottom-up representation of the global energy system. The model contains a detailed representation of energy supply technologies as well as an aggregate representation of demand technologies. The tool models the world divided in 15 regions. Every region has its own set of assumptions on the dynamics of technology characteristics, resource availability and demands. GMM has been developed over the years by the Energy Economics Group at PSI (World Energy Council, 2016, pp. 131-132) (Paul Scherrer Institute, 2018).

For the purpose of the WEC scenarios. The 15 regions in the model were consolidated in to eight regions, shown below in Figure 9.

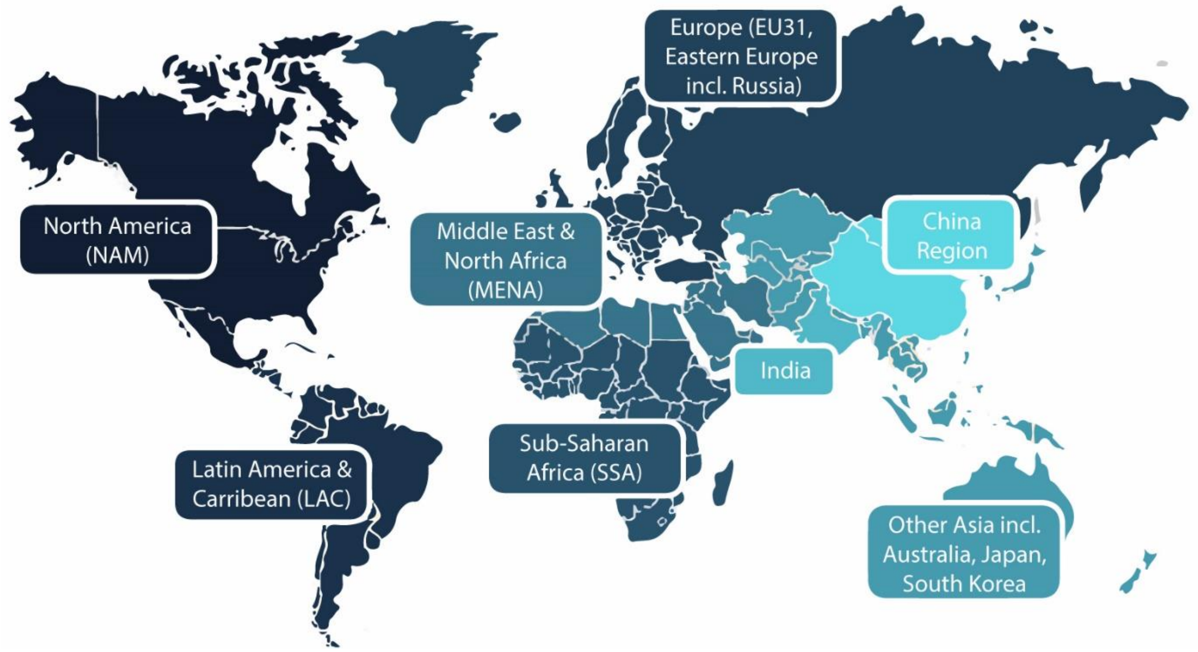

Figure 9 – The 8 world regions for the grand transition narrative, recreated from (World Energy Council, 2016)

5.3 The future and the scenarios

Through the process described in 5.2, the WEC have created plausible futures until 2060. These futures are results from certain and uncertain trends and factors. Even as far as 2060, some trends are fairly certain regardless of future, these trends will change the world and its energy system. The journey to this new world is called *The Grand Transition*.

The key features, or the **known certainties** (predetermineds), of The Grand Transition are:

- Lower population and labour growth
- New powerful technologies
- Greater appreciation of the planets environmental boundaries
- Shift in economic and geopolitical power towards Asia

In short, the Grand Transition takes us into a new world of new economic, geopolitical and environmental realities, but also with the technologies and tools to tackle our problems (World Energy Council, 2016, p. 20).

There are uncertain pathways as well, which will dictate the future world and its energy system. There are four specific **uncertainties** which will be critical in determining and defining the future energy system (World Energy Council, 2016, pp. 21-22):

- Pace of innovation and productivity
- International governance and geo-political change
- Priority given to sustainability and climate change
- Selected “tools for action” – balance between markets and state directive policy

The four critical uncertainties are summarised with metrics and ranges in Table 3 below.

Table 3 – Critical uncertainties in the grand transition, recreated from (World Energy Council, 2016)

Critical uncertainties	Range and Metrics
Productivity	Low-High (1,0-2,6% p.a.)
Changing Power Blocs	Collaborative to Fractured
Climate Challenge	Low to High priority
Dominant Tools for Action	State and Markets

There are many possible future pathways for the energy industry, but no matter the pathway they will likely lead to one of two different types of futures – *the uplands and the lowlands*. In the uplands, sustainable economic growth and productivity are strong and environment issues are addressed in the context of a collaborative international framework. Conversely, the lowlands are characterised by weak economic growth, inadequate attention to climate change and a more nationally oriented policy focus (World Energy Council, 2016, p. 28).

There are of course an infinite number of pathways through the grand transition. To explore these pathways, a set of three scenarios have been constructed from the certain and uncertain factors explained above. The scenarios are *exploratory* routes rather than extremes. Furthermore, they are not utopias or dystopias, nor are they *normative* – designed to meet a future goal. They are simply a range of plausible pathways (World Energy Council, 2016, p. 29).

The first two scenarios explore the *uplands* of the Grand Transition and do so with different dominant tools. One scenario uses predominantly markets and the other predominantly state directives. Furthermore, type and application of technologies are main differentiators between these two scenarios. The first scenario maximises comfort and benefit for individuals, the other maximises use and provision of public goods through large-scale application (World Energy Council, 2016, p. 29). The third scenario explores the *lowlands*. Various groups and stakeholders use different coping strategies, resulting in patchworks of policies and technologies (World Energy Council, 2016, p. 29).

The three scenarios and how they relate are outlined in Figure 10 below. The three scenarios are called Modern Jazz, Unfinished Symphony and Hard Rock. Each scenario describes the development of a possible future energy system at the global and regional level. The three scenarios are summarised in Figure 11 below. In the following three topics, each scenario will be covered in brief and in detail.

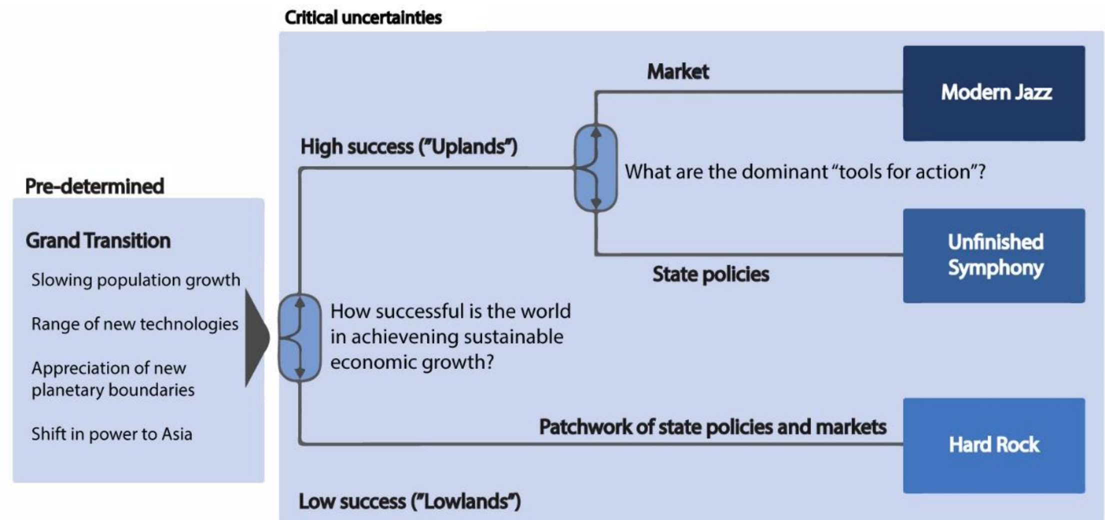

Figure 10 – The grand transition and the three scenarios, recreated from (World Energy Council, 2016, p. 30)

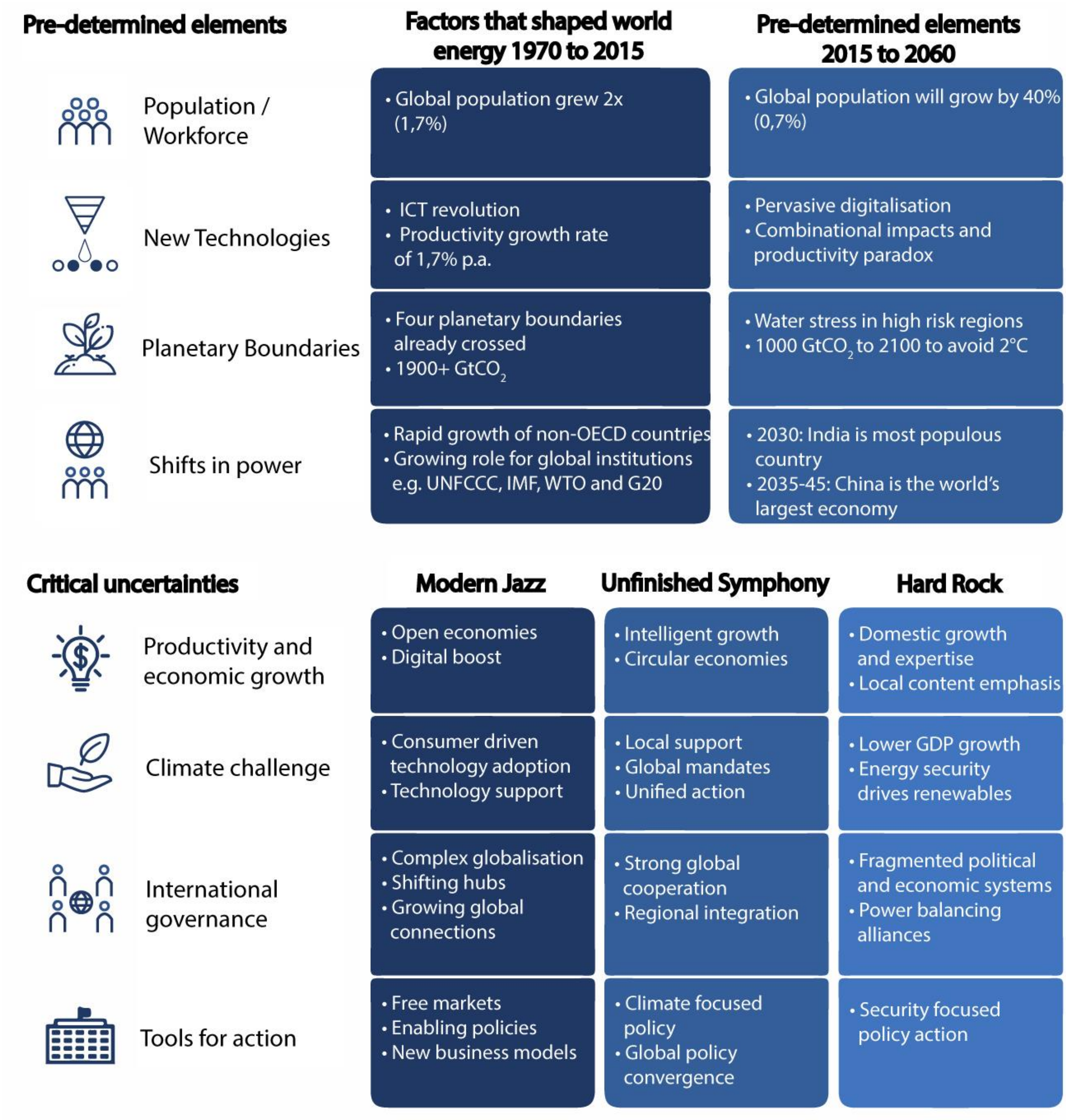

Figure 11 – Summarising the grand transition, recreated from (World Energy Council, 2016)

5.4 Detailed scenario walkthrough

5.4.1 Scenario 1 – Modern Jazz

In Modern Jazz, the outcome in 2060 is a world with a diverse set of resilient and lower-carbon energy systems. It is a competitive world, shaped by market mechanisms and a highly complex and fast-paced economic and energy landscape that is constantly changing and evolving due to rapid technology innovation. The market landscape drives efficiency, innovation, open access to information and rapid deployment of new technologies. Increased globalisation and the continued penetration of digital technologies lead to new markets across industries, driving strong productivity gains and strong economic growth (World Energy Council, 2016, pp. 30, 34).

Lifestyles are modern, urban, mobile and highly dependent on technology. People are more interconnected with each other, their homes and their work and *open economies* enable people to travel and work more easily between different innovation hubs (World Energy Council, 2016, pp. 30, 34).

Emerging technologies are continually disruptive, forcing energy systems to diversifying primary energy. In transport, a diverse fuel mix is had through electric- and natural gas vehicles. Distributed systems' increase in penetration power due to solar, wind and storage solutions. Many developing countries, such as India and parts of Africa, can skip carbon-intensive phases through technology transfer. Changing demand patterns force utilities to adapt and adopt new business models (World Energy Council, 2016, pp. 30, 34).

Policymakers and values in civil society support the energy transition. Policies are of light-touch type. There is no international climate framework, thus, carbon pricing and taxation schemes grow more slowly. The pricing schemes and taxation are furthermore built from bottom up, based on regional, national and local initiatives. Technology innovation enables rapid improvements in the economics of renewable energy and storage technologies. This leads to drastic shifts in energy and carbon intensity globally, without substantial economic disruption (World Energy Council, 2016, pp. 30, 34).

As mentioned, the outcome is a shift to a more resilient, lower-carbon energy system. Although carbon emissions fall to 23 $GtCO_2$ p.a. by 2060, the world does not limit emissions enough to meet the 1000 $GtCO_2$ target for 2°C and faces potential economic losses due to the impact of climate change (World Energy Council, 2016, pp. 30, 34).

Key features of the Modern Jazz world are (World Energy Council, 2016, p. 30):

- The world is highly productive, with fast economic growth and strong technological development.
- Digitalisation changes not only the way people work, but also the way they live, and has a transforming impact on global governance and political systems
- Politics are characterised by rapidly changing loyalties and coalitions; new political movements come and go in rapid succession and media become decisive opinion leaders
- New lifestyles are adopted, facilitated by pervasive, smart and seamless integration of new technologies, especially by younger generations (digitally connected elites)
- The economic and geopolitical shift to Asia is handled well
- Sustainability is addressed with technology innovation and new business models
- Energy costs are reduced due to developments on the energy supply side and the mid-stream, and there is greater access to energy for all.

The scenario will be explained in more detail below.

5.4.1.1 Tools for action

Market forces dominate, and thus private industry is the strongest actor. Development and technology choices are driven by cost, competitiveness and reliability. Markets are driven by freedom of choice and gives a stronger voice to consumers. Consumers values drive a shift towards products and services that meets higher level of environmental and social compliance. The successful companies respond with new business models and new/diverse sets of product/service offerings. Policymakers respond with enabling policies to account for externalities, using a pro-technology and light-touch approach (World Energy Council, 2016, p. 34).

The dominating tools for action in a modern jazz world are (World Energy Council, 2016, p. 34):

- Societal values
- Enabling policies
- New business models

In terms of **societal values**, the global elite consists of technology savvy, well-connected city dwellers. They push for policies that favour liberalisation, reduced entry barriers, and tax reforms. Furthermore, they come from a diverse geographical context and support spread of freedom, societal wellbeing, transparency, economic opportunity and environmental sustainability. They opt for "green energy" with their utility company, and those who can operate their own small-scale clean energy system. Thus, demand for clean energy solutions grows throughout the period. Investments in roof-top solar, wind and storage solutions increase, furthermore community micro-grids with integrated EV-charging becomes more common (World Energy Council, 2016, p. 35).

Lifestyles are heavily technology dependent and people rely on smart phones and digital gadgets to better manage energy use. Such gadgets include smart meters, digitally enabled heating, ventilation and air conditioning (HVAC), and appliances that allow people to time their activities (World Energy Council, 2016, p. 35).

In terms of **enabling policies**, policy makers struggle to keep up with the pace the markets and its business models, making it challenging to establish governance systems and frameworks, especially on national and global scale (World Energy Council, 2016, p. 35).

Governments respond to pressure from the global elites and address the biggest issues through emerging technology and industry partnerships (World Energy Council, 2016, p. 35).

Examples of policies include (World Energy Council, 2016, p. 35):

- Liberalisation of gas and electricity markets
- Emissions-reduction requirements that adjust along with technology deployment
- Light-touch tax schemes for emissions and subsidy schemes for renewables
- Reductions in fossil fuel subsidies
- Industry-led RD&D and innovation supported by government partnerships
- Open borders, liberalised trade, and high global economic cooperation

In terms of **new business models**, shifting demand and new technology creates new opportunities, enables new market entrants and challenges incumbents. Geography shifts and as early as 2025 the majority of consumption takes place in developing countries. Consumer needs and behaviours are increasingly diverse (World Energy Council, 2016, p. 35).

Quick adaption becomes key for companies and flexible and cost-effective business models becomes increasingly important (World Energy Council, 2016, p. 35).

Reputational risk increases when customers demand more transparent supply chains. Companies are increasingly benchmarked, forcing them to emphasize their core strengths and capabilities and shift to cloud-based services and new models for service delivery that heavily depend on technology to stay competitive. Businesses, both core operations and non-core-functions are enhanced via innovative partnerships, transitional business models, and digital tools. These include, robotic and cognitive process automation to new data and analytics enabled by the internet of things (World Energy Council, 2016, p. 35).

5.4.1.2 Productivity and economic growth

Productivity and economic growth are boosted in Modern Jazz through a set of factors. Open economies increase growth in new geographies and enables global competition. Combinatorial effects of digital and technology innovation accelerate the pace of change. The "digital economy" brings revolutionary change in several industries and also upskills the workforce. Rapid change is the norm across many sectors, including energy, consumer goods, and manufacturing. Economic growth averages 3,3 % p.a. from 2014 to 2060 (World Energy Council, 2016, p. 36).

The dominant drivers of economic growth and productivity in a Modern Jazz world are (World Energy Council, 2016, p. 36):

- Open economies
- Digital economies

In terms of **open economies**, the global elite continues to push for reductions in trade and migration barriers to stimulate growth. In most cases, open economies grow more steadily. Technology transfer allows developing countries to catch up while migration reforms allow ageing countries a boost in labour (World Energy Council, 2016, p. 37).

In terms of **digital economies**, it becomes the single most important driver of innovation, competitiveness and growth. Digital economies create opportunities and potential for entrepreneurs and large enterprises alike (World Energy Council, 2016, p. 37).

The digital economy boosts productivity through creating new markets, streamlining business operations, creating new skillsets in the workforce, and fostering new ways of interacting with consumers. By 2030, the world has partially achieved its potential digital boost through the interplay of digital technologies, open economies and technology innovation. Economic momentum is created from this and results in sustained benefit to labour productivity and technology innovation/disruption (World Energy Council, 2016, p. 37).

Digital technologies enable self-learning and rapid upskilling of labour and furthermore change the way people work. The deployment of automation and augmentation technologies, such as intelligent machines, shifts management roles and recasts the workforce. In natural resources and other capital-intensive industries, people managing pipes, wires and other infrastructure increasingly interact with digital technology to monitor infrastructure and improve the system's overall resilience (World Energy Council, 2016, p. 38).

Combinatorial effects of new technologies and market access create significant disruption across all industries. Thus, companies are forced to invest in physical and digital infrastructure and to continuous transition in business models to remain profitable in a highly complex and competitive market. Physical infrastructure also becomes more resilient as asset owners use data and algorithms to manage risks and anticipate failures (World Energy Council, 2016, p. 38).

5.4.1.3 International governance

With rapid economic growth driven and shaped by open economies and digital technologies, the international governance system is shaped by complex globalisation, shifts in economic dominance and a rise in global connections (World Energy Council, 2016, p. 39).

The international governance system/framework is shaped by (World Energy Council, 2016, p. 39):

- Complex globalisation
- Regional transitions

In terms of **complex globalisation**, due to the world being more globalised and technology-driven, people, goods and money flow more rapidly. Political power is diffused across nation states, local governments, industry and voters. These are not necessarily prepared for the growing exposure to systemic risks created by the increasingly connected world (World Energy Council, 2016, p. 40).

In terms of r**egional transitions**, the decline of OECD and rise of Asia continues. Asia becomes the dominant economic region by 2035. Furthermore, China becomes the largest economy and the largest global manufacturer. China also transitions to consumption and services-led growth (World Energy Council, 2016, p. 40).

5.4.1.4 Climate challenge

Technology support for environmentally friendly technologies varies across regions, but on global level there is consensus of the importance of making renewable energy more reliable and competitive. Costs are further driven downs which boosts adoption. Furthermore, policy support creates a favourable environment for utility companies in renewables (World Energy Council, 2016, p. 41).

The drivers of economic de-carbonisation in a modern jazz world are (World Energy Council, 2016, p. 41):

- Technology adoption
- Technology support

Figure 12 summarises the reductions in carbon intensity from 2014 to 2060

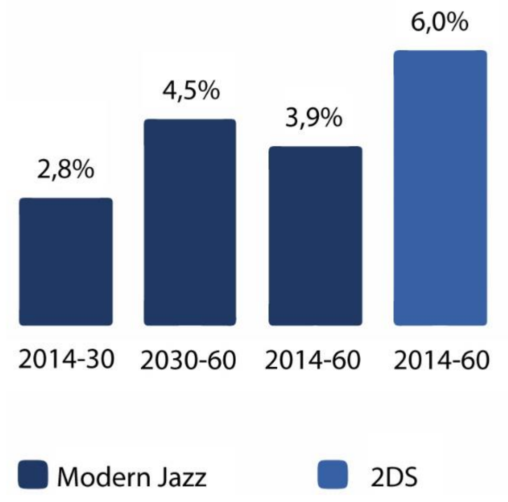

Figure 12 – Modern Jazz reductions in carbon intensity of GDP % p.a. (2014-60), recreated from (World Energy Council, 2016)

In terms of **technology adoption**, consumer preferences affect both energy intensity of GDP and carbon intensity of primary energy. The biggest impacts lie in power and transport systems, where energy efficiency is boosted through adoption of EVs and smarter buildings, homes and offices. Investments in natural gas power generation and deployment of utility-scale and decentralised renewables lead to de-carbonisation of energy systems. Table 4 below outlines the most disruptive technology trends. The trends power varies by region (World Energy Council, 2016, pp. 41-42).

Table 4 – Disruptive technology adoption by sector, recreated from (World Energy Council, 2016)

Systemic Risks	Technology adoption
Transport	EV penetration in transport Biofuels penetration in transport Natural gas transport in heavy freight and marine
Inustry and Power	Natural gas penetration in power and industry Concentrated Solar, PV and storage solutions Electrification of processes and heating
Commercial and Residential	Connected homes, offices and commercial spaces that are more energy efficient Distributed energy systems Electrification of heating and cooking
Non-energy use	Natural gas as a chemical feedstock

In terms of **policy support**, the underlying driver for technology adoption is light-touch policy support. This applies to both developed and developing countries. Policy support includes national subsidy and taxation schemes for renewables as well as direct capital to primary research. Carbon trading schemes with meaningful carbon prices appears around 2030. Prices are passed on to customers who become increasingly aware of the carbon footprint. The economic value of avoiding emissions can better be quantified and measured against implementing alternative energy solutions (World Energy Council, 2016, p. 42).

5.4.1.5 Implications for energy

The implications for energy of a Modern Jazz world are summarised in Table 5 and explored in further detail in the following sections.

Table 5 – Modern Jazz implications for energy, recreated from (World Energy Council, 2016)

Energy Implications	Modern Jazz
Energy Demand	Lifestyles and economies demand more energy Efficiency gains keep consumption growth moderate
Market Structures	Liquid markets Rise of distributed energy Rise of LNG trade
Primary Energy Supply	Consumer-driven penetration of renewables Rise of gas

Energy demand

Total final energy consumption (TFC) grows 25% from 2014 to 2030, averaging 1.4% p.a. growth in the period. Consumption growth is largely driven by rise in industrial activity, transport demand and increase in energy access. Technology development and adoption boost efficiency. Smarter consumers and lifestyles increases efficiency as well. These include EVs, telecommuting, efficient appliances and connected homes and offices (World Energy Council, 2016, p. 43). The total final consumption of energy by sector can be seen below in Figure 13.

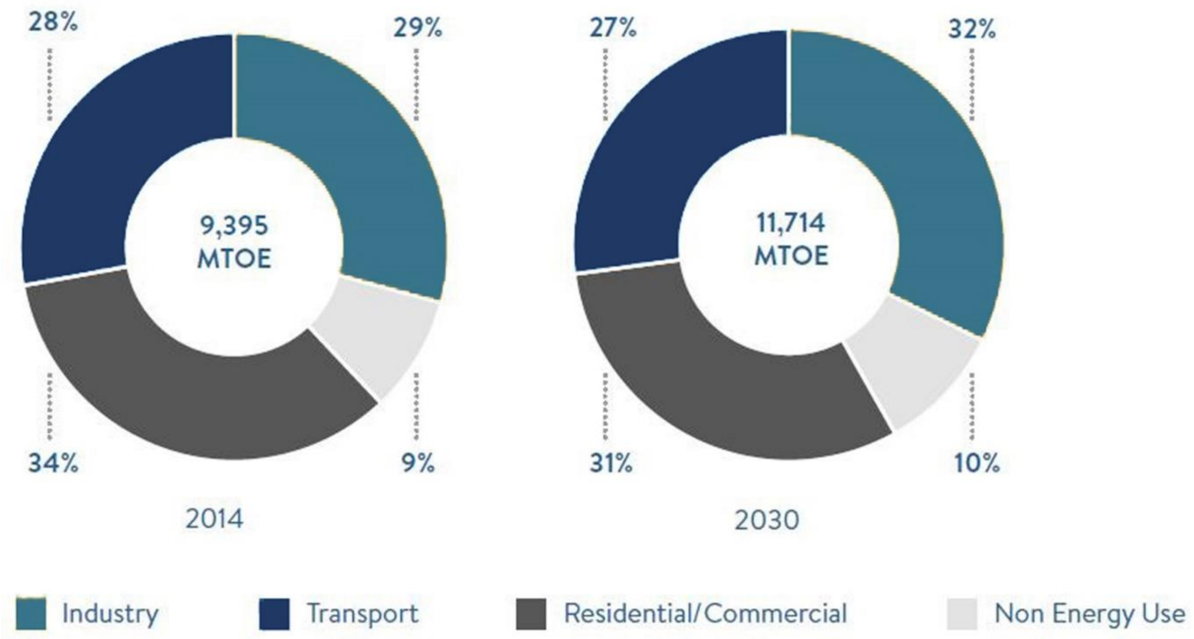

Figure 13 – Modern Jazz total final consumption of energy by sector, recreated from (World Energy Council, 2016)

Energy in transport grows at 1.2% p.a. from 2014 to 2030, before slowing to just 0.2% p.a. in the second half of the period (World Energy Council, 2016, p. 43).

Residential and commercial energy demand use grows at a moderated pace of 0.8% p.a. to 2030. Beyond 2030, continued efficiency gains drive growth to slow to 0.3% p.a. This is due to simultaneous growth in demand and increase in efficiency. Growth is due to people buying more devices to stay connected. Increase in efficiency is due to growing availability of smart grids, smart meters, and smart appliances, all which give information and autonomy to do more with less energy and quantifies the value of investments such as LED lighting, better insulation and electric heating (World Energy Council, 2016, p. 45).

Electricity

Improvements in quality of life, economic growth and increasing technology all adds up to lifestyles demanding more electricity. Lifestyles in combination with a push for efficiency drives rapid electrification of energy systems. By 2030, the electrification of the final consumption rises to 20%, up from 18% in 2014. Growth in demand for electricity averages 1.9% p.a. to 2030 (World Energy Council, 2016, p. 45).

Distributed systems

Distributed Energy Systems gain continued momentum due to growing electricity demand, falling technology costs, new market entrants and new innovative financing models. The implications for the utility sector is large, including reduced load, changed and increased operational complexity and reliability, lower revenues and profits, and accelerated pace of change overall. Figure 14 summarises the interplay of driving forces leading to disruption by distributed energy systems (World Energy Council, 2016, p. 46).

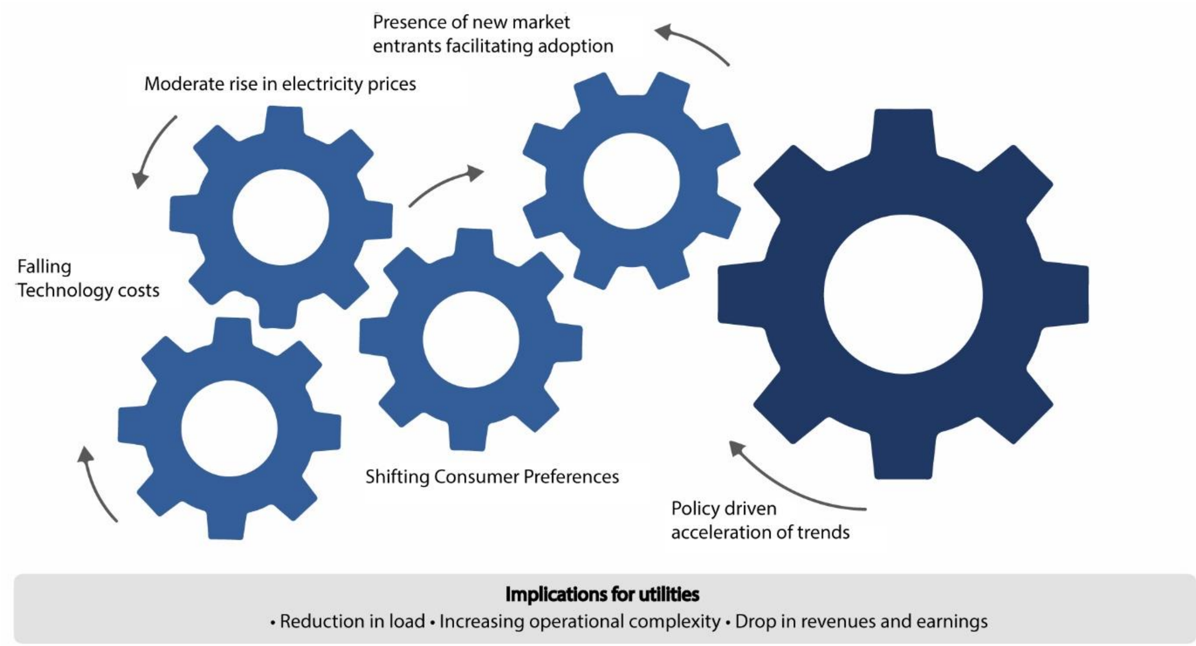

Figure 14 – Modern Jazz cause and effect of distributed energy systems, recreated from (World Energy Council, 2016)

In EUR and NAM, demand for renewable energy and micro-grids is increasing. In developing regions, demand for distributed and modular systems is increasing as well. Distributed systems include stand-alone, as well as community mini-grids, which may be off-grid or grid connected (World Energy Council, 2016, p. 46).

Business models

Traditional utility business models are threatened as increasing demand for distributed energy systems reshapes how the industry interacts with consumers. In particular, new energy technologies, non-traditional competitors, new consumer expectations, new regulatory pressures and rising costs all create substantial challenges. Many large utility companies are forced to remake their business models. The following are three new business models that utilities can use to sustain growth in a world with increasingly distributed energy systems. Each model is supported by digital capabilities (World Energy Council, 2016, p. 47).

- Low-carbon energy producer
- Distribution platform optimiser
- Energy solution integrator

Primary energy

Total primary energy supply (TPES) grows at a rate of 1.0% p.a. from 2014 to 2030, reaching 16,085 MTOE. Disruption across demand sectors and the penetration of renewable energy sources in power drives down the share of fossil fuels to 79% of primary energy in the period (World Energy Council, 2016, p. 48). The primary energy supply for the scenario can be seen in Figure 15, furthermore the scenarios change in primary energy intensity can be seen in Figure 16.

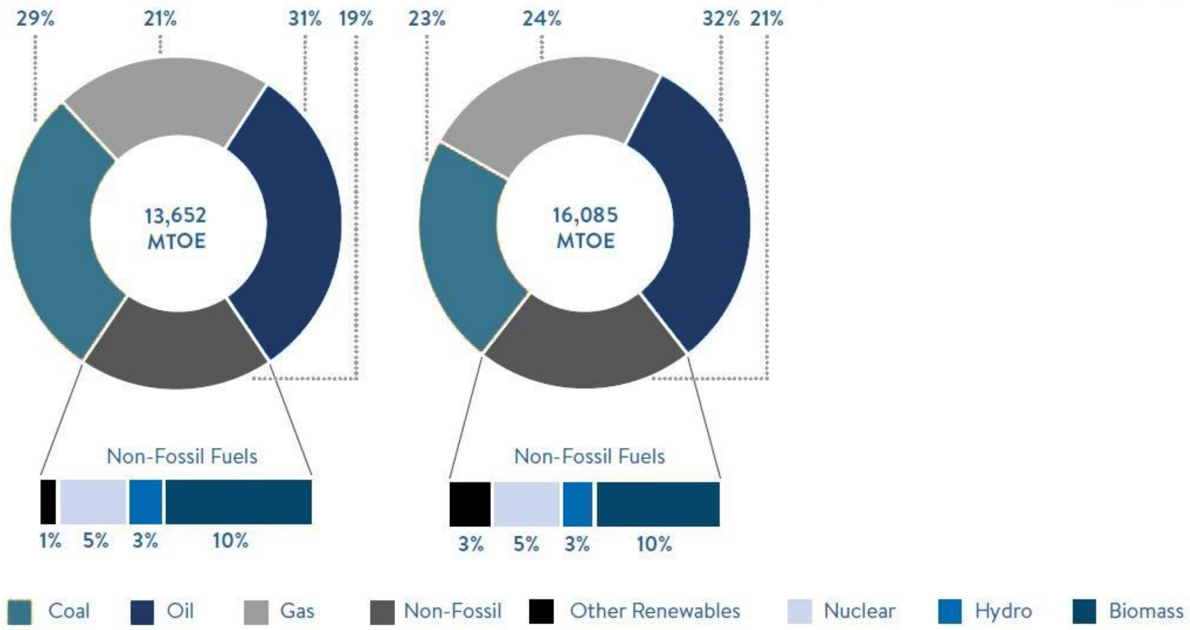

Figure 15 – Modern Jazz primary energy supply (MTOE) % share, recreated from (World Energy Council, 2016)

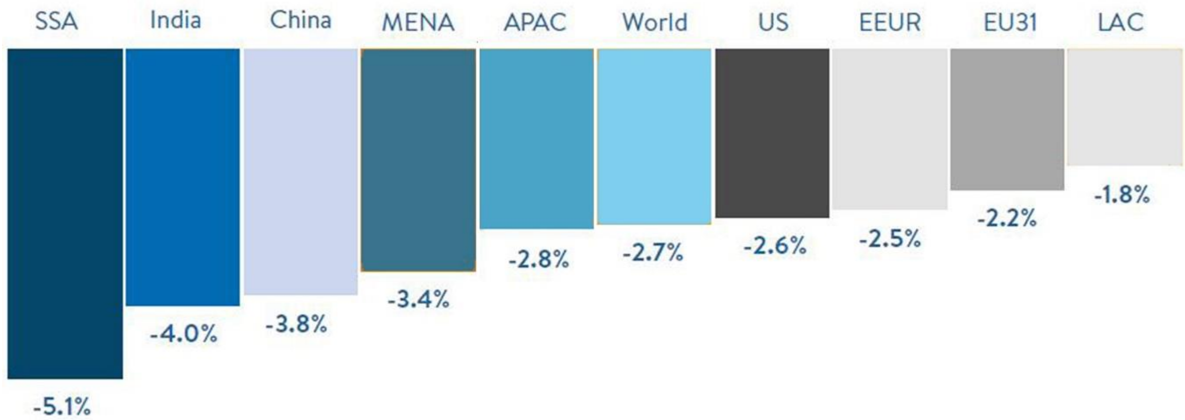

Figure 16 – Modern Jazz change in primary energy intensity % p.a. (2014-2060), recreated from (World Energy Council, 2016)

Other renewables: Wind, solar, geothermal

Solar, wind and geothermal generation grow faster than any other fuel source in primary energy throughout to 2060, averaging 5,1% p.a. Solar grows fastest and drives installed capacity additions. Capital costs for PV and concentrated solar decline more than 75% in the period. Cost reductions are mainly driven by entrepreneurs who foster continued investments in standardisation, modularisation, and materials science innovation (World Energy Council, 2016, p. 52).

Solar electricity generation grows from 198 TWh in 2014 to 1,369 TWh in 2030, and installed capacity rises to more than 1,011 GW by 2030. China accounts for the biggest part of the additions. Wind generation also rises from 717 TWh in 2014 to 2,540 TWh in 2030 and installed capacity surpasses 1,000 GW by 2030. China, India, EUR, NAM and APAC accounts for the largest additions. By 2030, wind and solar generation encompasses 12% of total electricity generation. Innovation in small-scale battery-based storage solutions for EVs and distributed systems such as micro-grids, enable balancing of intermittent renewables in energy systems (World Energy Council, 2016, p. 52).

5.4.2 Scenario 2 – Unfinished Symphony

In Unfinished Symphony, there is consensus and cooperation. The world shifts to a resilient, integrated, global low-carbon energy system. There is global unified action on security, environmental and economic issues. Global institutional and national governments support enabling technologies (World Energy Council, 2016, p. 53).

In the scenario, the world unites against climate change and take effective policy, supported by international governance systems and values of civil society. With focus on sustainability and even distribution, economic growth is moderate. There are high levels of investments in infrastructure. Developments in energy and economic systems are 'smarter', resilient, and more efficient, with technology innovation leading to large-scale integrated solutions (World Energy Council, 2016, p. 53).

Leaders in policy, industry and civil society realises that mass migration caused by climate change may have even larger impact than the migrant crisis of 2015. Systemic risks spread between regions. Civil society demands more effective action from local and national governments. The combinatorial effect creates a strong base for mitigating many different issues, starting with climate change (World Energy Council, 2016, p. 53).

The new policies on global and national level pushes companies and institutions to find new business models. Large utility companies may face collapse. Surviving companies and new entrants find new operating models with more sustainable outcomes. Increasingly, climate benchmarks are pegged to new economic opportunities and increased employment (World Energy Council, 2016, p. 53).

Local, regional and global cooperation extends further than climate change into other issues, accelerating knowledge transfer and standardisation. Cooperation and consensus creates a network of fiscal incentives, such as green subsidies and carbon pricing. This is standardised at first regional and then global presence across sectors. This network is key in unified action on climate change. The network levels the playing field for developing nations, and the result is a steep transition away from fossil fuel energy sources and rapid electrification of the global energy system (World Energy Council, 2016, p. 53).

Key features of the scenario Unfinished Symphony are (World Energy Council, 2016, pp. 31, 53):

- Moderate to fast economic growth, sustainable and more evenly distributed, with high levels of infrastructure investment
- Emergence of new societal goals and behaviours of 'shared economy' models that lead to significantly reduced energy demand
- Significant re-balancing of global wealth through consumer taxes and transfer of technologies from North to South
- Support for a broad-based international governance structure covering security, environmental and energy matters
- An extensive network of fiscal incentives such as green subsidies and carbon pricing, with global standardization across sectors
- Strong technological innovation in large-scale, integrated solutions that drive efficiencies and reduce carbon emissions, although there is more to do to address climate change targets.

5.4.2.1 Tools for action

Markets are shaped by national and global policy, supported by social values. Policy tries to achieve a new equilibrium that reflects cost of environmental and social externalities. Unified action on global issues are supported by collaboration and strong institutional frameworks. Governments focus on long-term planning which ties national targets to global governance milestones. More demanding requirements for compliance with environmental and social standards forces companies to adapt and innovate their business models (World Energy Council, 2016, p. 54).

The dominant tools for action in unfinished symphony are (World Energy Council, 2016, p. 54):

- Societal values
- Strong global governance
- Integrated planning
- Enabling business models

In terms of **societal values**, there is consensus both at individual and institutional level that action must be taken now rather than later. Households themselves seek ways to reduce their carbon footprint and energy consumption and favours “green power” or “clean power” from local utilities. They eat less meat, recycle more, and grow more of their food at home (World Energy Council, 2016, p. 54).

Sense of belonging and global community is strengthened through digital tools enabling constant connectivity. There is strong support for global cooperation and collaboration on challenges such as climate, migration, poverty, disease and terrorism (World Energy Council, 2016, p. 54).

Quality of life improves on global scale. It improves especially in urban areas which become safer and include more green space. Consumers more tolerant to rising prices in line with more sustainability (World Energy Council, 2016, p. 54).

In terms of **strong global governance**, UNFCCC becomes increasingly effective in building global carbon mitigation strategies. Targets for nations to strive for are set, and focus lies in support for technology innovation and technology transfer (World Energy Council, 2016, p. 54).

In terms of **integrated planning**, national governments, supported by the international governance systems, ties national agendas and targets to global sustainable development targets. The long-term objectives make it easier for governments to establish top-down regulatory frameworks to measure bottom-up progress (World Energy Council, 2016, p. 54).

Long-term integrated planning enables governments to collaborate with best-practice nations on building intelligent cities and infrastructure. The outcome is an increasingly efficient deployment of infrastructure and efficient use of energy in urban settings (World Energy Council, 2016, pp. 54-55).

The long-term objectives further support and facilitates steep changes in renewable generation, grid management and integrated systems (World Energy Council, 2016, pp. 54-55).

In terms of **enabling business models**, the regulatory environment and public opinion pushes companies to find new business models, especially those which decouples growth and natural resources consumption (World Energy Council, 2016, p. 55).

Stringent carbon pricing schemes incentivises cleaner technologies, leading utilities to invest in utility-scale wind and solar (World Energy Council, 2016, p. 55).

5.4.2.2 Productivity and economic growth

Policymakers look beyond GDP, trying to assess sustainable growth and effectiveness of policies. Policies are developed with an aim to balance security, environmental and social outcomes. Intelligent infrastructures and Circular economies play a key role in the transition to more sustainable economic growth (World Energy Council, 2016, p. 56).

The dominant drivers of economic performance in unfinished symphony are (World Energy Council, 2016, p. 56):

- Intelligent economies
- Circular economies

Intelligent economies

Governments digitalise economies through investing and deploying "intelligent infrastructure". The digital economy boosts global economy efficiencies and productivity. 100 million sensors will be deployed on substructures by 2030. These will continuously send data to the communications, energy and logistics internets. This allows for real-time communication and analysis that helps reduce maintenance costs and provide better information about how society interacts with infrastructure and equipment. Cities and lifestyles are dramatically changed through the intelligent economy, particularly the electricity systems. Smart grids and smart cities significantly boost efficiency and substantially change building design and consumer behaviours (World Energy Council, 2016, pp. 57-58).

Figure 17 shows how digitalised economies and the deployment of smart infrastructure lead to economic and social benefits.

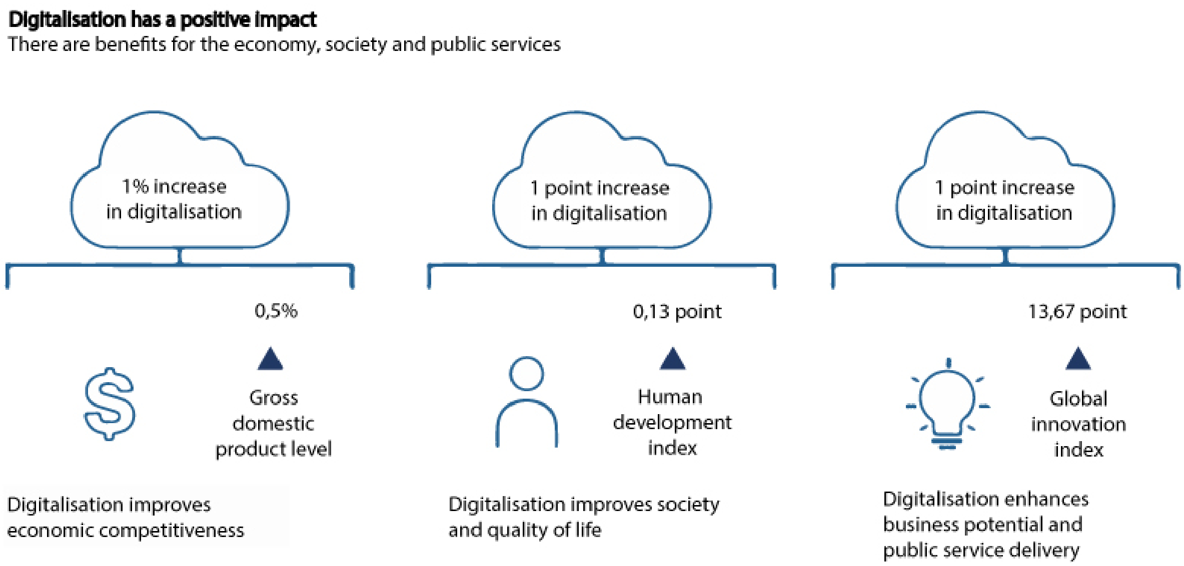

Figure 17 – Unfinished symphony the economic impact of digitally enabled governments, recreated from (World Energy Council, 2016)

Access to data becomes limitless. Internet of things, big data and analytics help governments and companies to develop predictive algorithms that accelerate efficiency gains, increase productivity and lower the marginal cost of producing and distributing physical things, including energy, to near zero (World Energy Council, 2016, pp. 57-58).

Circular economy

Policies to control emissions push business models to their limits, eventually forcing circular business models which create circular economies. This implies eliminating waste and increasing resource productivity. Through disruptive technology and business models based on longevity, renewability, reuse, repair, upgrade, refurbishment, capacity sharing, and dematerialisation, growth becomes decoupled from natural resource consumption (World Energy Council, 2016, pp. 58-59).

5.4.2.3 International governance

Strong global governance structure shapes the scenario, leading to increasing regional and global cooperation (World Energy Council, 2016, p. 60).

The international governance system is shaped by (World Energy Council, 2016, p. 60):

- Strong global cooperation
- Regional integration

Strong global cooperation

Non-OECD countries becomes better represented in UN's governance framework. UNFCCC successfully negotiates agreements between US, China, India and EUR which establish support for technology transfer and funding for sustainable development for India. Bureaucracy lessens as more nations adopt global standards (World Energy Council, 2016, p. 60).

Regional integration

Regional integration increases and regional partnerships forms around integration of energy systems and infrastructure projects. Biggest agreements occur in EUR and Africa (World Energy Council, 2016, p. 60).

5.4.2.4 Climate challenge

At first governments look to themselves to achieve the global mandates set at COP21. It becomes apparent that governments alone cannot bear the financing and infrastructure build-out themselves, thus, UNFCCC provides framework to encourage and increase unified action (World Energy Council, 2016, p. 61).

In 2060, the world will be slightly above the 2 degrees target. There is opportunity to recoup through technology and policy which drive negative carbon emissions (World Energy Council, 2016, p. 61).

The drivers of climate action in Unfinished Symphony are (World Energy Council, 2016, p. 61):

- Local support
- Unified action
- Technology transition

Local support

The primary focus for governments is efficiency. Efficiency gains are made through COP21, local and national support, and through RD&D in demand-side technologies and digital tools that increase efficiency, create smarter cities and help shift consumer behaviour. Incentive schemes keep continuing deployment of solar and wind (World Energy Council, 2016, p. 62).

Unified action

Energy and carbon intensity improve. Consensus that the global frameworks need more financing, and binding targets aligned to the IPCC emissions budget for 2°C (World Energy Council, 2016, p. 62).

UNFCCC pushes for compliance with emission-reduction requirements. Agreements occur between the top four emitting regions: US, EUR, China and India. Agreements regard funding for transition for both developed and developing economies (World Energy Council, 2016, p. 62).

Technology transition

Carbon prices and government support/mandates/policy forces rapid transition in energy technologies. On the **demand side**, top-down mandates and technology support enables consumers to use energy more efficiently. Key technologies are intelligent infrastructure and smarter buildings.

On the **supply side**, large-scale low-carbon energy generation is, with technology support, deployed. Making for a policy-driven technology transition. Table 6 below outlines the most disruptive technology trends.

Table 6 – Unfinished Symphony Disruptive technology transition by sector, recreated from (World Energy Council, 2016)

Sector	Technology adoption
Transport	EV penetration in light-duty segment Biofuels penetration in transport Natural gas transport in heavy freight and marine Low-carbon mass transit solutions
Industry and Power	CC(U)S for coal and natural gas Concentrated Solar, PV and storage solutions Natural gas generation in power and industry Electrification of processes and heating Nuclear rise in China and India
Commercial and Residential	Connected infrastructure, homes, offices and commercial spaces that are more energy efficient Utility-scale solar and integrated systems Electrification of heating and cooking
Non-energy use	Natural gas as a chemical feedstock

Technology transfer and financing are supported for developing regions. Institutional banks and revenues from carbon-pricing schemes finances infrastructure in Africa and Asia (World Energy Council, 2016, pp. 62-63).

5.4.2.5 Implications for energy

The scenario has great impacts in energy, especially in demand, market structures and primary energy supply. Table 7 outlines the implications for energy in Unfinished Symphony, the implications are further explored below (World Energy Council, 2016, pp. 62-63).

Table 7 – Unfinished Symphony implications for energy, recreated from (World Energy Council, 2016)

Energy implications	Unfinished Symphony
Energy Demand	Top-down mandates dampen consumption Efficiency gains keep consumption growth moderate
Market Structures	Integrated digital and physical infrastructure Zero-marginal cost utilities
Primary Energy Supply	Policy-driven penetration of renewables Gas with CCS as transition fuel

Energy demand

TFC grows by 19% to 2030, averaging 1,1% p.a. growth from 2014-2030. Growth is largely driven by industry and transport. Commercial and residential consumption grows only slightly due to efficiencies and top-down pushes for decreased consumption (World Energy Council, 2016, pp. 64-65). The total final consumption of energy by sector is shown in Figure 18 below.

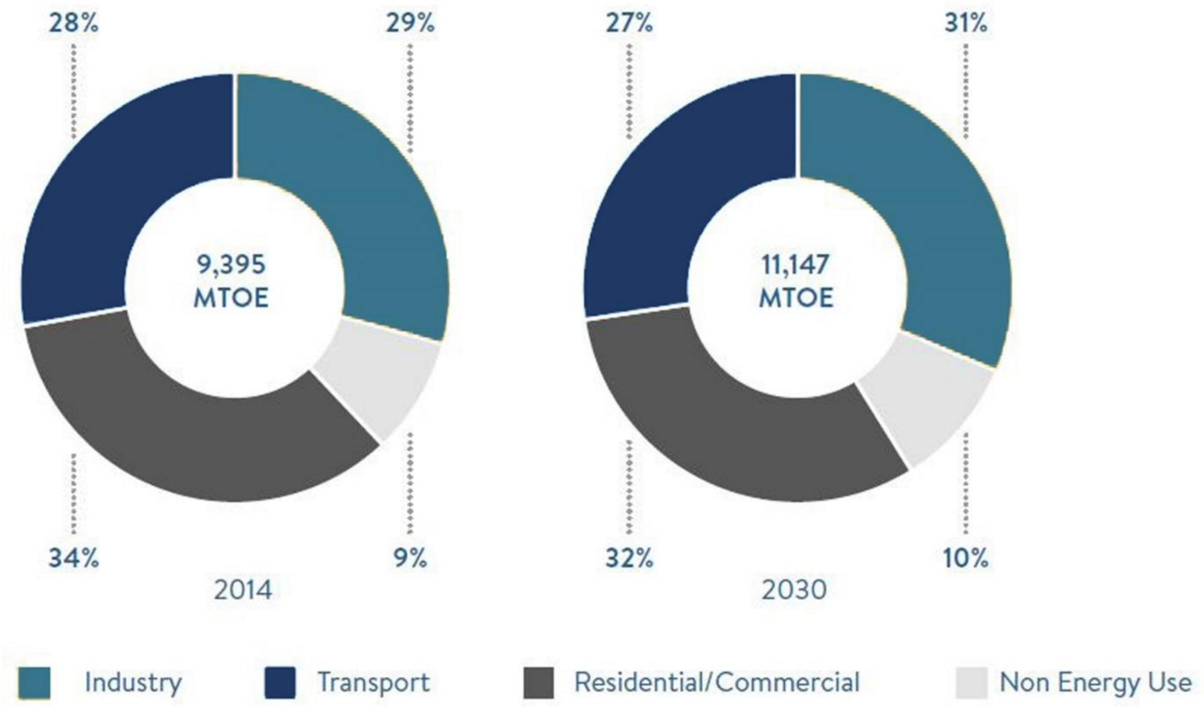

Figure 18 – Unfinished Symphony total final energy consumption of energy by sector (MTOE) % share, recreated from (World Energy Council, 2016)

In transport, breakthroughs in storage enables a revolution in transit. Affordable and constantly available hydrogen-powered driverless mass transit becomes commonplace in some of the world's mega cities (World Energy Council, 2016, pp. 64-65). The share of fuels in transport in the scenario is shown below in Figure 19.

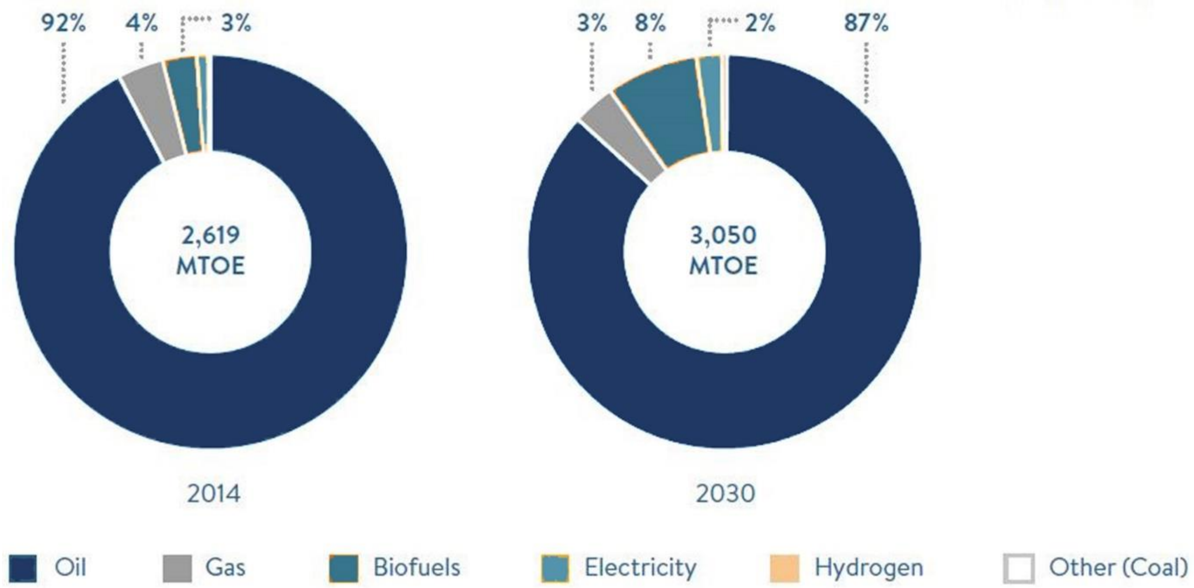

Figure 19 – Unfinished Symphony share of fuels in transport (% share), recreated from (World Energy Council, 2016)

In residential and commercial, top-down mandates requires more efficiency in commercial and residential buildings. A transition to more efficient appliances, lighting and HVAC solutions are subsided by governments. Centrally managed smart cities, integrated with smart buildings, pushes efficiency gains (World Energy Council, 2016, p. 65).

Electricity
Moderated economic growth, higher electricity prices and an emphasis on energy efficiency dampen electricity demand early in the period. The push for efficiency, however, accelerates the electrification of energy systems, as can be seen in Figure 20 below (World Energy Council, 2016, pp. 65-66).

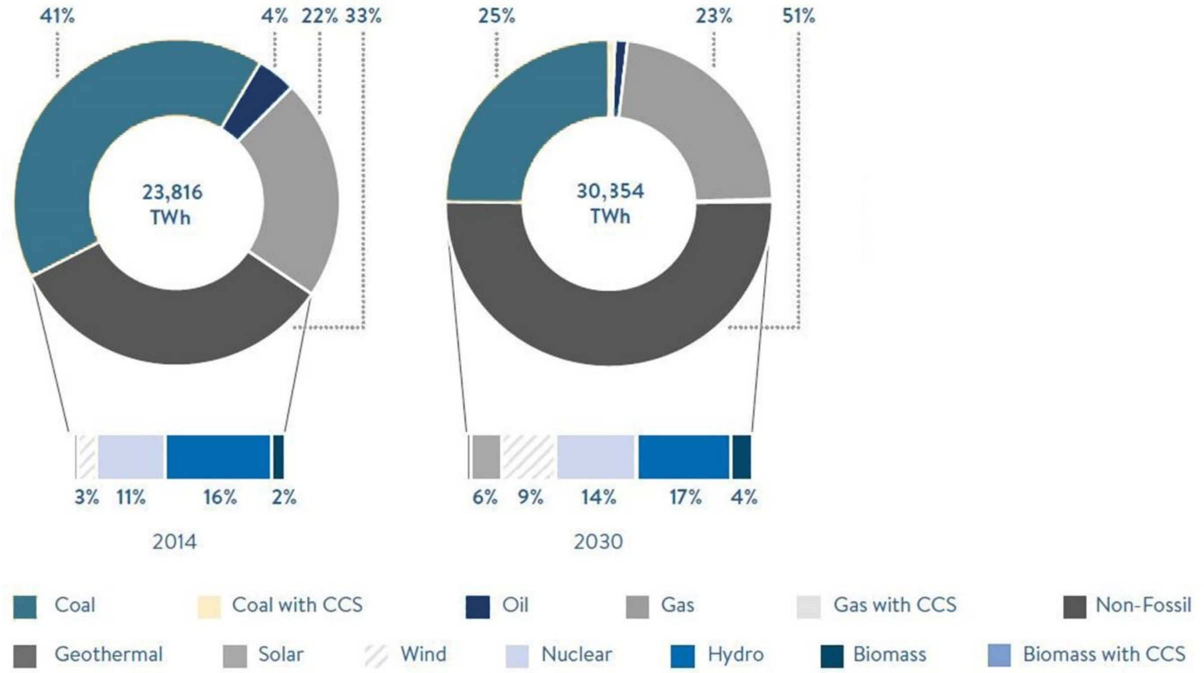

Figure 20 – Unfinished symphony electricity generation TWh % share by fuel type, recreated from (World Energy Council, 2016)

Integrated systems
On Integrated systems, utilities use more variable sources of electricity. Due to smart appliances, EVs and hybrid fuel vehicles, consumer demand becomes more variable as well. To handle the variances in demand and supply, there is strong policy support for infrastructure. Furthermore, there is a high cooperation on regional and global level to allow companies to develop digitally and physically integrated grid solutions (World Energy Council, 2016, p. 66).

Long-term planning, "intelligent economy" and "intelligent infrastructure" enables smart grids, smart buildings and smart cities. The integration of information networks and data systems with energy infrastructure create new opportunities for advanced coordination and control of electricity across large geographic areas (World Energy Council, 2016, p. 66).

Connecting energy infrastructure, communication networks and other traditional infrastructures becomes increasingly common. Leaders rethink paradigms, system planning and operations, this leads to more resilient and connected energy systems (World Energy Council, 2016, p. 66).

Zero marginal cost utilities
Policy support of renewable energy, such as feed-in tariffs and tax credits, guarantee a premium price above market value for renewable generation. Subsidies are passed on to rate payers by utilities, placing a short-term burden on businesses and homeowners. On mid- to long-term, utilities emerge that produce near zero marginal cost energy. If unregulated, losses are created for fossil fuel, nuclear-based generation and newer installations of renewables. If regulated, a challenge is created for the low-cost producer (World Energy Council, 2016, pp. 66-67).

The effect of near-zero marginal cost operators is countered by growing system costs associated with renewables. These include storage and back-up solutions, balancing, grid connection, extension and reinforcement costs. The approach to allocating system costs influences the degree to which the zero-marginal cost effect distorts energy markets. In many markets, utility companies are pushed towards bankruptcy. Those that survive respond through industry consolidation to create economies of scale, and through financial restructuring that allows flexible strategies for regulated and unregulated markets (World Energy Council, 2016, pp. 66-67).

Primary energy

Rapid deployment of renewables and electrification of energy lead to shifts in primary energy supplies. TPES growth slows to 0.7% p.a. from 2014 to 2030, reaching 15,291 MTOE. Fossil fuels falls to 74% of primary energy in the period (World Energy Council, 2016, p. 67). The primary energy supply for the scenario can be seen in Figure 21 below.

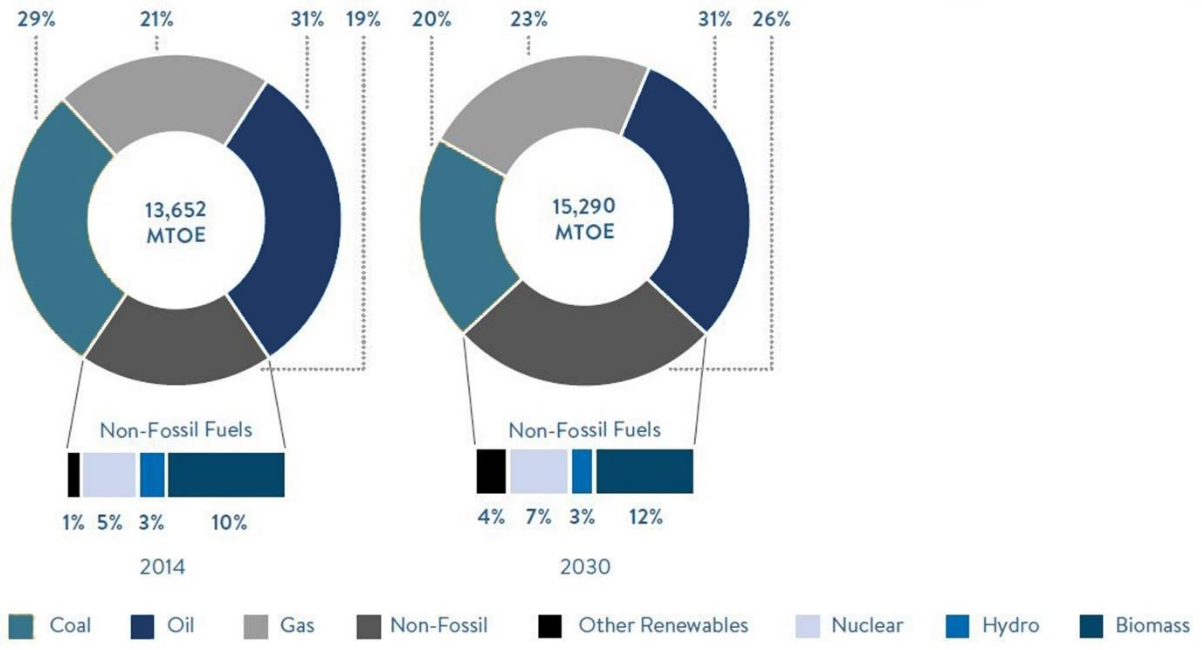

Figure 21 – Unfinished Symphony primary energy supply (MTOE) % share, recreated from (World Energy Council, 2016)

When carbon emissions are heavily taxed, businesses develop new models to survive. Energy intensity of economic activity drops, and industrialised economies move into an era of service, sustainability-led growth and circular economic models. This leads to global energy intensity declines more than 70%, averaging 2.6% p.a. from 2014 to 2060 (World Energy Council, 2016, pp. 66-67).

Carbon Capture and Sequestration (CCS)

The US, EU31 and China enact the world's first-ever national carbon emissions standards that impose carbon capture and sequestration (CCS) on coal-powered generation. Finding commercial uses for captured CO_2 becomes a high priority (World Energy Council, 2016, p. 70).

Non-fossil fuels

Non-fossil fuels in power and transport continues to grow and translates into a rising share of the primary energy mix. From 2014 to 2060, supply grows at 2.3% p.a., boosting non-fossil fuel share of TPES to 26% in 2030. Wind and solar, classified below under other renewables, post the strongest growth (World Energy Council, 2016, p. 71).

Solar installed capacity surpasses 1,100 GW by 2030 and generation rises from 198 TWh in 2014 to 1,694 TWh in 2030. Installed capacity of wind also grows rapidly, reaching more than 1,230 GW by 2030 and generation rises from 717 TWh in 2014 to 2,918 TWh in 2030.

Intermittent renewables reach 15% of electricity generation in 2030. Large-scale pumped hydro and compressed air storage, battery innovation and grid integration provide dependable capacity to balance intermittency (World Energy Council, 2016, p. 72).

5.4.3 Scenario 3 – Hard Rock

The outcome in 2060 is a fractured world, with a diverse set of economic, energy and sustainability outcomes. Nationalist interests prevent countries from collaborating effectively on a global level, with limited attention to addressing climate change. Technologies are mandated based on availability of local resources (World Energy Council, 2016, p. 31).

The Hard Rock scenario explores a world where geopolitical tensions weaken collaboration and international governance systems. Focus is on the local and policies are installed without much consideration for global impacts. This leads to strong regional ties. Markets and political systems diverge in their development. In the scenario, some regions may resemble Modern Jazz and some may resemble Unfinished Symphony, others struggle to achieve any scenario (World Energy Council, 2016, p. 73).

The decline of US and EUR economic importance weakens international governance systems. Nationalist policies weaken cooperation and trade agreements. Global GDP stagnates due to declining importance of export-oriented growth. National policies focus on regional growth and consumption-led growth driven by diversified economies (World Energy Council, 2016, p. 73).

Weak economic performance and low international cooperation makes it difficult to tackle climate change and other global issues. Many regions still have environmental concerns high on the agenda. On national level, policy focus is energy security and climate concerns, which increases demand for solar and wind power. Furthermore, it creates policy support for nuclear energy (World Energy Council, 2016, p. 73).

With a lack in both funding capacity and a global climate framework, countries struggle to cooperate on technology transfer and trade. This makes it difficult to meet UN climate commitments. Tight regulation and bureaucracy hinders private investment. Resulting in fossil fuels remaining the dominant source of energy to 2060. The climate issue is not addressed well until 2060, when governments starts to focus infrastructure resilience and adaption to climate impacts (World Energy Council, 2016, p. 73).

Key features in the scenario Hard Rock are (World Energy Council, 2016, pp. 31, 73):

- Economic growth is slower due to low productivity growth and an aging population with slow growth in labour force
- Poverty and inequity rise, weakening the social fabric
- Ineffective international policies refocus priorities and a strong North-South divide leads to political conflicts and occasional armed conflicts
- Self-centred and nationalistic behaviours prevail, based on widespread fear that people will become losers in an ever-increasing battle for resources and wealth.

- Large-scale domestic energy solutions are driven by security concerns: for example, hydro, nuclear and fossil fuels
- There is underinvestment in energy systems and weakening resilience
- Commodity prices are volatile, with periods of shortage and peak prices followed by underinvestment and recession
- Regional coping strategies start to emerge and differentiate winners from losers, and there are pockets of best-practice solutions to the energy trilemma.

5.4.3.1 Tools for action

In Hard Rock, both policy systems and market structures become increasingly fragmented. National and local needs are first priority. Diversifying local economies and adapting to a new world with high geopolitical tensions become the primary focus. The global cooperation that is in place is driven by security and power-balancing alliances. The predominant tools in the scenario are thus strong national governments, societal values and state-owned enterprises (World Energy Council, 2016, p. 73).

The dominant tools for action in hard rock are (World Energy Council, 2016, p. 73):

- Strong national governments
- Societal values
- Local business models
- State owned enterprises

Strong national governments

Geopolitical tensions rise as a reaction on global migration, weak economic performance and nationalist- and protectionist policies. Political systems face increasing and extreme pressure. The weak economic growth limits funding for renewables support schemes and social programs. Top-down mandates are used to balance environmental sustainability, energy equity and security concerns (World Energy Council, 2016, p. 74).

Governments invest in RD&D but with a strict focus on national interests. Low cooperation means much RD&D is conducted in isolation, with many actors working on the same things, with sub-optimised outcomes (World Energy Council, 2016, p. 74).

Technology areas of emphasis for RD&D include (World Energy Council, 2016, p. 74):

- Electricity and power
- Nuclear energy
- Energy, Water and Food (EWF)
- Solar and wind energy
- Quantum computing
- Cyber security

Societal values

Societal values are widely different across geographic socioeconomic groups. Many communities seek to locally build a more sustainable and resilient future. The public at large demands more regulation of industries and stricter requirements for creating local benefit. Products and services need to be increasingly customised for local contexts (World Energy Council, 2016, p. 75).

Local business models

Each region has increasingly different values, requirements and governance systems. Thus, businesses must adapt and navigate the challenges as well as balance the conflicting demands and requirements between regions. Allowing flexibility in local operations and increasing focus on local solutions becomes increasingly important (World Energy Council, 2016, p. 75).

Leading multi-national companies overcome an increasingly fragmented global marketplace by (World Energy Council, 2016, p. 75):

- Engaging with local communities
- Employing and training local staff
- Developing local knowledge
- Adapting global best practices to local context
- Developing new technologies for local needs
- Tailoring customer offerings to local context
- Managing reputational risk

State-owned enterprises
Economic power and influence are increasingly transferred to central state authorities. National companies deploy technologies and drive innovation and National banks deploy capital. By having direct channels to government officials, state owned enterprises and entities can overcome political obstacles easily. However, state-owned enterprises also struggle with growing levels of corruption, too much political interference and control, and lower profitability (World Energy Council, 2016, pp. 75-76).

5.4.3.2 Productivity and economic growth
Due to divergence in market structures and political systems, global economic growth is slowed. Global cooperation, technology innovation and trade all slows. Both developed and developing economies struggle to keep up with historical levels of productivity growth and technological development. Technology transfer slows down as well, making it difficult for developing regions to catch up (World Energy Council, 2016, p. 76).

The dominant drivers of economic performance in hard rock are (World Energy Council, 2016, p. 76):

- Diversified domestic economies
- Domestic expertise
- Local content development

Diversified domestic economies
Export-led growth no longer a sustainable model. A lack of competition due to low global cooperation and trade leads to inefficiencies in market structures (World Energy Council, 2016, p. 77).

Domestic expertise
When global cooperation is reduced, brain drain becomes less of an issue. This leads to local development of expert problem solving and complex communication skills and a growing number of domestic workers who can use technology and manage people in both technical and professional settings. Due to deployment of technology in especially industries, middle- and low skilled labour segments are disrupted (World Energy Council, 2016, p. 77).

Local content development
To create expertise, diversify the domestic economy and build local skillsets and local industry, local content development becomes a focal point, especially in resource-rich economies. Successful policies require use of local workers and infrastructure. The best local content frameworks focus on value-

added job creation. The frameworks help overcoming obstacles in attracting foreign investment, including (World Energy Council, 2016, p. 78):

- Uncertainty of future demand
- Difficult access to finance
- Poor infrastructure
- Bureaucracy
- Shortage of skilled people
- Certification process
- Capacity constraints of suppliers

5.4.3.3 International governance
Increasing fragmentation in political and economic systems weaken international governance systems. This results in trade relationships focused on economic and energy security concerns (World Energy Council, 2016, p. 79).

The international governance system is shaped by (World Energy Council, 2016, p. 79):

- Fragmentation in political and economic systems
- Power balancing alliances

Fragmentation in political and economic systems
Low global cooperation and concerns about security poses a challenge for international governance systems. Economic and political tensions in LAC, MENA and SSA counter strong intra-regional partnerships in NAM, EUR, and Asia. National governments choose lowest cost and/or most attractive resources to promote their national agendas (World Energy Council, 2016, p. 79).

Power balancing alliances
Global trade and cooperation is increasingly sustained. China's rise increases geopolitical tensions. This creates additional incentives for the US to create a balancing coalition to contain China (World Energy Council, 2016, p. 79).

5.4.3.4 Climate challenge
Low economic cooperation, reduced investing capacity and emphasis on national economic and security agendas pushes climate change further down the priorities. Most countries do not reach INDC commitments set at COP21. Reduction in carbon intensity averages just 1.5% p.a. from 2014-2016 (World Energy Council, 2016, p. 80).

The drivers of economic de-carbonisation in hard rock are (World Energy Council, 2016, p. 80):

- Lower economic activity
- Energy security

Lower economic activity
Lower economic growth results in less energy use. Reductions in EU and US are offset by continued growth in carbon emissions in China and India (World Energy Council, 2016, p. 80).

Energy security
Less cooperation and trade relationships, governments pushes deployment of technologies that increase energy efficiency to satisfy energy demand under strict energy security considerations. Solar and wind grows, due to being seen as domestic and cheap sources of electricity. Many governments seek to diversify domestic sources of supply, resulting in China and India reviving policy support for

nuclear energy (World Energy Council, 2016, pp. 80-81). Technology choices in the scenario can be seen in Table 8 below.

Table 8 – Security-driven technology choices, recreated from (World Energy Council, 2016)

Sector	Technology transition
Transport	Biofuels penetration in transport
Industry and Power	Coal resilient in power in China and India Concentrated solar, PV, wind and storage solutions Some electrification of energy use Revival of nuclear
Commercial and Residential	More efficient appliances
Non-energy use	Natural gas as a chemical feedstock in MENA and NAM

5.4.3.5 Implications for energy

Hard Rock's implications for energy are summarised in Table 9 below and explored in further detail in the following sections.

Table 9 – Hard Rock implications for energy, recreated from (World Energy Council, 2016)

Energy implications	Hard Rock
Energy Demand	Slower economic growth dampens energy demand Slower efficiency gains keep consumption growth high
Market Structures	Fragmented market structures across regions Business models emphasise local context
Primary Energy Supply	Security-driven penetration of renewables Resilience of coal in the energy mix

Energy demand

Final energy consumption

Growth to 2030 averages 1.3% p.a. and reaches 11,625 MTOE. Beyond 2030, consumption growth moderates, averaging 0.6% p.a. and reaching 13,717 MTOE in 2060. Residential and commercial energy demand rises more slowly as lower economic growth slows the increase in individual energy access (World Energy Council, 2016, p. 81). The final consumption of energy by sector in the scenario can be seen in Figure 22 below.

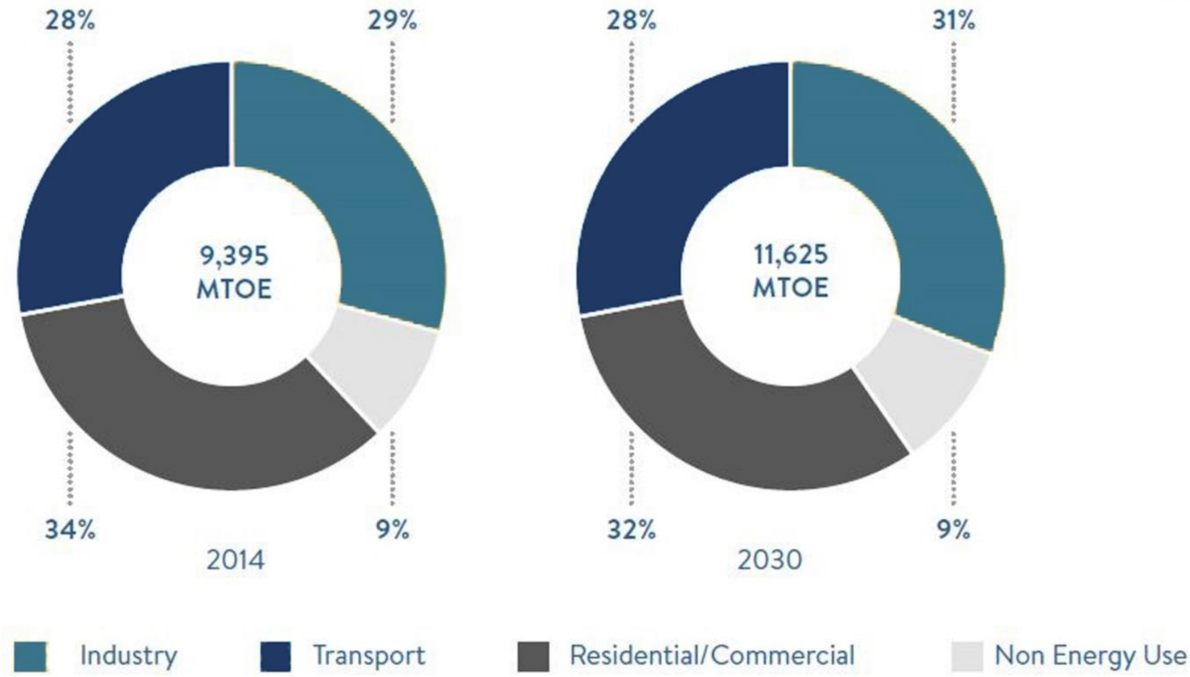

Figure 22 – Hard Rock total final consumption of energy by sector (MTOE), recreated from (World Energy Council, 2016)

Industry

Due to slowed economic growth, Industrial demand for energy grows at a rate of 1.7% p.a. from 2014 to 2030 (World Energy Council, 2016, p. 82).

Transport

Due to reduced investments in infrastructure, demand for personal transport remains high to 2060. Furthermore, reduced infrastructure build-out and lower economic growth results in transport fuels being slow to diversify (World Energy Council, 2016, pp. 82-83). The share of fuels in transport in the scenario can be seen in Figure 23.

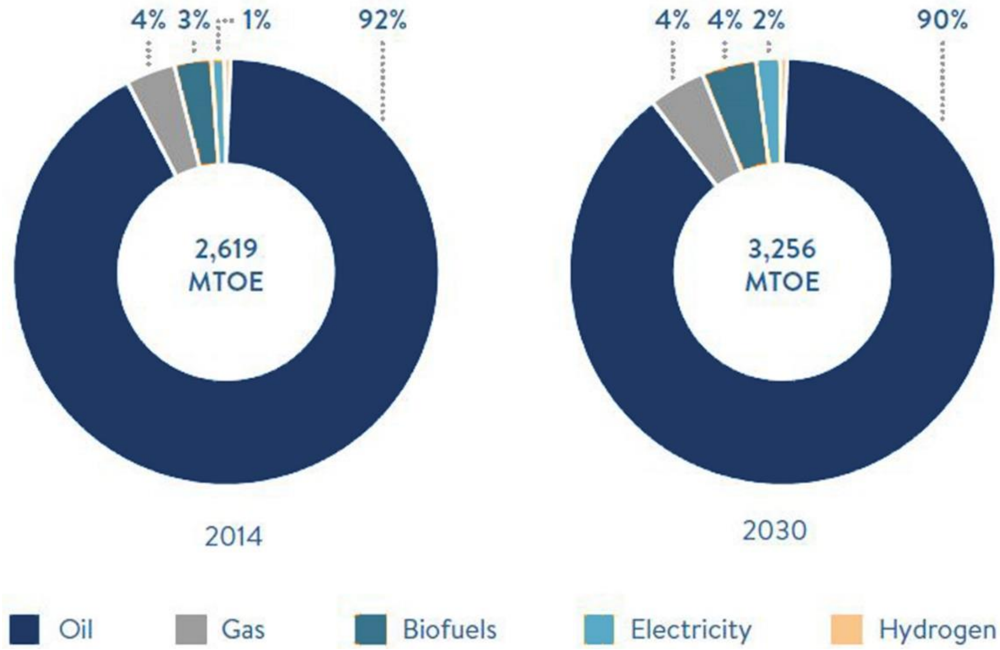

Figure 23 – Hard Rock share of fuels in transport (% share), recreated from (World Energy Council, 2016)

Residential and commercial
Top-down mandates for energy efficiency and conservation becomes ineffective without supporting infrastructure investments. Thus, residential and commercial energy demand use grows by 0.8% p.a. to 2030, despite lower economic activity (World Energy Council, 2016, p. 83).

Non-energy use
Demand for fuels in non-energy use increases by 1.9% p.a. from 2014 to 2030, underpinned by demand for chemicals from emerging markets such as China and India (World Energy Council, 2016, p. 83).

Electricity
Less funding for infrastructure together with slowed economic growth reduce electricity demand. However, growing focus on domestic energy sources and efficiency boost electricity demand to a steady 1.6% p.a. to 2030. Electrification of final energy use rises from 18% in 2014 to 19% in 2030 (World Energy Council, 2016, pp. 83-84). The scenarios electricity generation by fuel type can be seen in Figure 24 below.

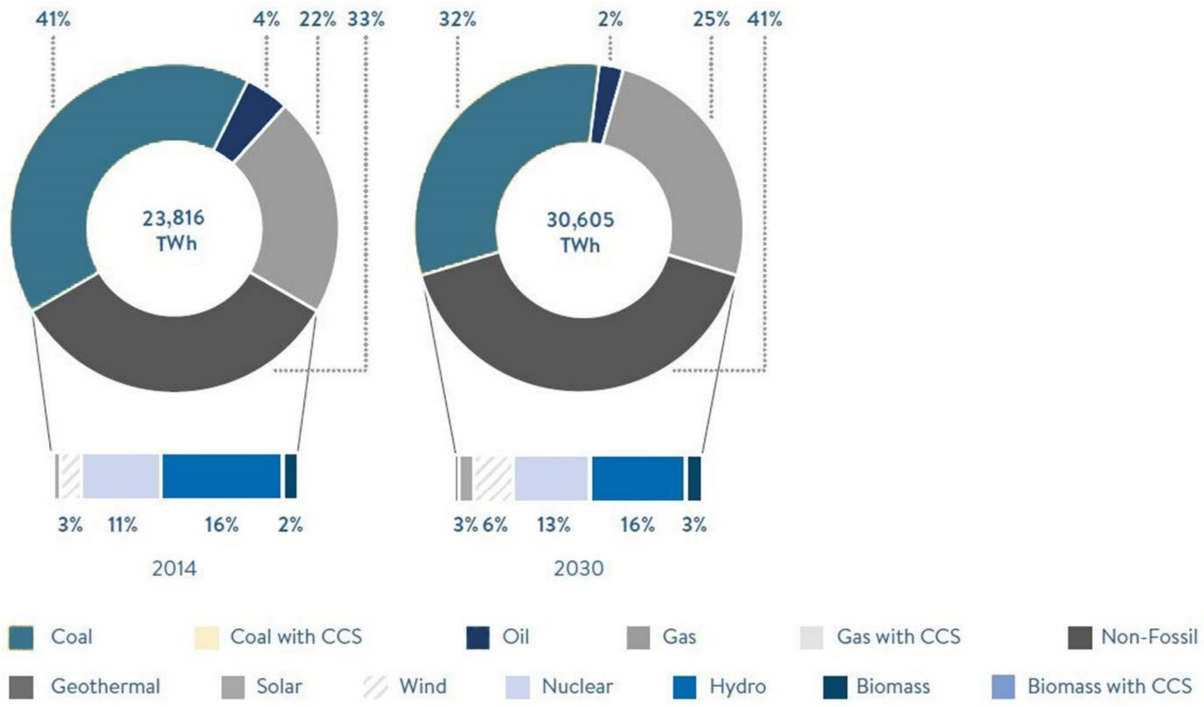

Figure 24 – Hard Rock electricity generation TWh % share by fuel type, recreated from (World Energy Council, 2016)

Business models
Utility models are disrupted and adapted. Clean energy technology adoption increases with prices falling. Distributed generation and grid parity remains an opportunity/risk. Technology support for renewables decline with slower economic growth (World Energy Council, 2016, p. 84).

In developed nations, attempts to reform pricing and establish new tariff structures are unsuccessful and grid investments are waning. Increasingly, consumers who need more reliable electricity generation turn to non-exporting solar and battery systems and other micro-grid solutions (World Energy Council, 2016, p. 84).

Consumer sentiments towards renewable energy vary based on socio-economic status (World Energy Council, 2016, p. 84).

Challenges and demand, and thus business models, varies between regions. The most successful companies can nimbly adjust to the needs of the local context (World Energy Council, 2016, p. 84).

Energy commodity price volatility

Energy commodity prices become increasingly volatile and pricing at regional hubs sees widening differentials (World Energy Council, 2016, p. 85).

Primary energy

Population growth, and slow progress on energy intensity translates into TPES growth of 34% from 2014 to 2060, averaging 0.6% p.a., reaching 16,154 MTOE in 2030 and 18,272 MTOE in 2060 (World Energy Council, 2016, p. 85). The primary energy supply for the scenario can be seen in Figure 25 below.

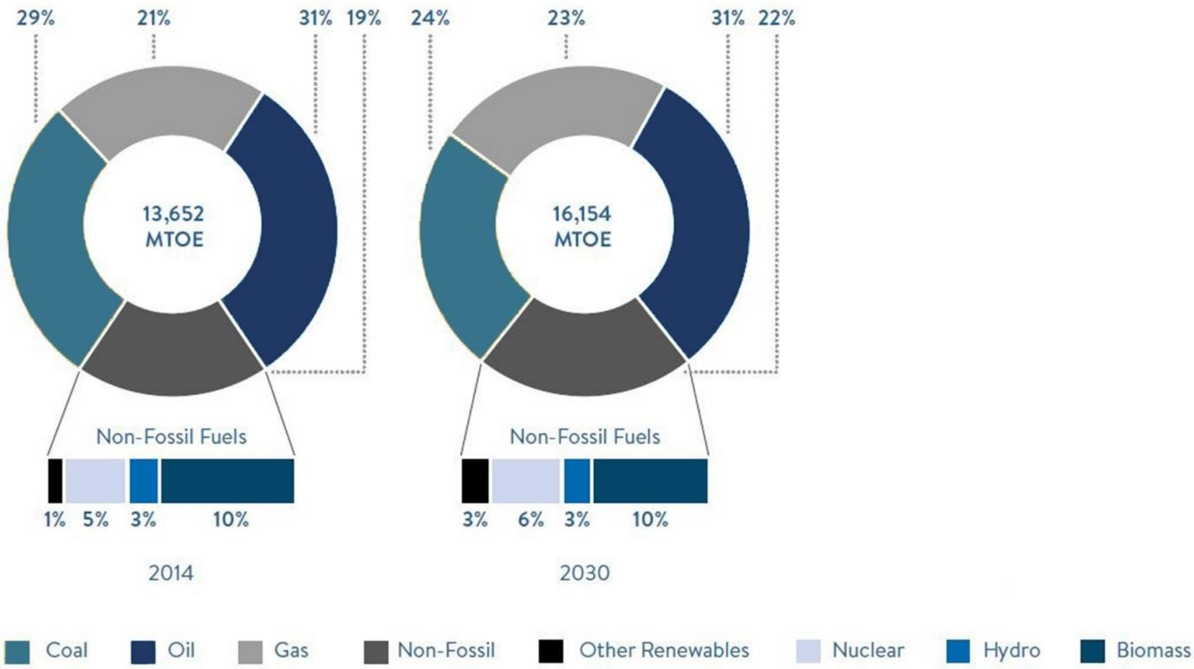

Figure 25 – Hard Rock primary energy supply (MTOE) % share, recreated from (World Energy Council, 2016)

Reduced funding capacity leads to lower investment in clean energy technologies, especially in transport. Many countries find they no longer can support EV incentives and renewable energy subsidies beyond 2020, leading to higher prices and lower consumer demand for new, cleaner sources of electricity and transport. Thus, the primary energy mix remains heavily dependent on fossil fuels to meet demand (World Energy Council, 2016, p. 85).

Final energy intensity of GDP declines at a rate of 1.0% p.a. from 2014 to 2060 (World Energy Council, 2016, p. 85).

Other renewables

Governments look to renewables as a domestic source of electricity generation. Solar, wind and geothermal generation grow more rapidly than any other fuel source in primary energy to 2060, averaging 4.2% p.a. in the period (World Energy Council, 2016, p. 89).

Solar electricity generation grows from 198 TWh in 2014 to 793 TWh in 2030 and installed capacity surpasses 919 GW by 2030. Wind electricity generation grows from 717 TWh in 2014 to 1,983 TWh in 2030 and Global installed capacity also grows rapidly, reaching 839 GW by 2030 (World Energy Council, 2016, p. 89).

5.5 Implication of scenarios – Capabilities and technology needed in the future

The scenarios, if they turn true, implicate different things and requirements for a supplier. This section is purposed to, as suggested by the frame of reference and problem formula, *broadly and speculatively* interpret the scenarios and provide input regarding what will be required of a supplier to the energy sector in terms of technologies and capabilities in the future.

What is clear is that there will be substantial change in the energy sector, no matter which scenario the future will be the most alike. The scenarios in themselves are very different to each other (see sections 5.3-5.4), however, the requirements they may pose share a lot of major elements. Tables 10 and 11 below shows a short summary of some major technologies and technology implications which will have impact in the Modern Jazz- and Unfinished Symphony scenarios. Hard Rock will have a mixture of technologies from both scenarios, depending on geographic region.

Table 10 – Major technologies and technology in Modern Jazz, (Author)

Modern Jazz:	
Decentralised (clean) energy systems	Roof-top solar, wind and storage solutions (Increasing operational complexity)
Micro grids (community or otherwise) with integrated charging	
Smart grids, Smart meters, and Smart (efficient) appliances gives consumers more information, autonomy and efficiency	Quantifies value of LED, insulation and electric heating, Efficient appliances (based on data and algorithms)
Energy Management	Smart meters, digitally enabled heating, ventilation and air conditioning (HVAC), timing activities
EV's and charging	
Smart buildings, homes and offices	
Connected homes and offices	
Digital technology to monitor infrastructure and interact with capital-intensive industries	
Data and algorithms to manage risks and anticipate failures in physical infrastructure (resilience)	
Consumer-driven penetration of renewables	
Cloud-based services and new models for service delivery	
New energy business models	Distribution Platform Optimizer
	Energy Solution Integrator

Table 11 – Major technologies and technology in Unfinished Symphony, (Author)

Unfinished Symphony:	
Intelligent Economies	Digitalisation of economies
	100 trillion sensors, send data, real-time communication, analysis
	Internet of Things
	Big Data, Analytics and Algorithms
	Smart buildings
Energy- and economic systems more smart, resilient and efficient	Large-scale integrated solutions
Intelligent Infrastructure	
Centralised management of energy consumption (connected to intelligent infrastructure)	
Smart Grids, Smart Buildings and Smart Cities are all enabled by integrated long-term planning and the rise of the 'Intelligent Economy' and 'Intelligent Infrastructure'	Integration of information networks and data systems with energy infrastructure
	New opportunities for advanced coordination and control of electricity across large geographic areas
	Intelligent infrastructure and smarter grids allow utilities to better manage the complexity
Centrally managed Smart Cities that are integrated with Smart Buildings	
Digitally and Physically integrated grid solutions	
Integrated digital and physical infrastructure	
Grid management and integrated systems	
Demand-side technologies and digital tools that increase efficiency and create smarter cities	
Utility-scale wind and solar	
Storage Technologies, batteries	
Variable consumer demand (from smart appliances, EVs and hybrid fuel vehicles	

As can be seen in Tables 10 and 11, in Jazz, there will be more connected devices, smart homes, smart vehicles, appliances and more decentralised production. Symphony will have many of Jazz's elements as well, but also more utility-scale renewables and more integrated infrastructure. The elements in themselves are different, but the underlying technologies and capabilities are close to the same. Both lists of technologies and impacts revolves around **creating efficiency through measuring data (in real-time), controlling with data, integrating systems and increasing connectivity**. Furthermore, optimising using data and offering a service will be a key requirement as well. Thus, the knowledge, capabilities, expertise and technology in these areas/scenarios are roughly the same, however, the difference between the scenarios is *where* these capabilities will be needed. Jazz will be more decentralised while Symphony will be more centralised (large-scale/utility-scale). The Hard Rock scenario will in many regions and markets require the same things as in Jazz and Symphony, however, it will vary widely what will be required, depending on the market.

In short, the scenarios will, in terms of technologies and capabilities, be focused around **creating efficiency through measuring data, using data to control in real-time, optimising with data, creating services, integrating systems and using internet of things.** A main difference between the scenarios will regard *where* the capabilities will be needed, in terms of scale (decentralised/utility) for Jazz and Symphony and in terms of geography in Rock. The implications will be summarised in Figure 26 below.

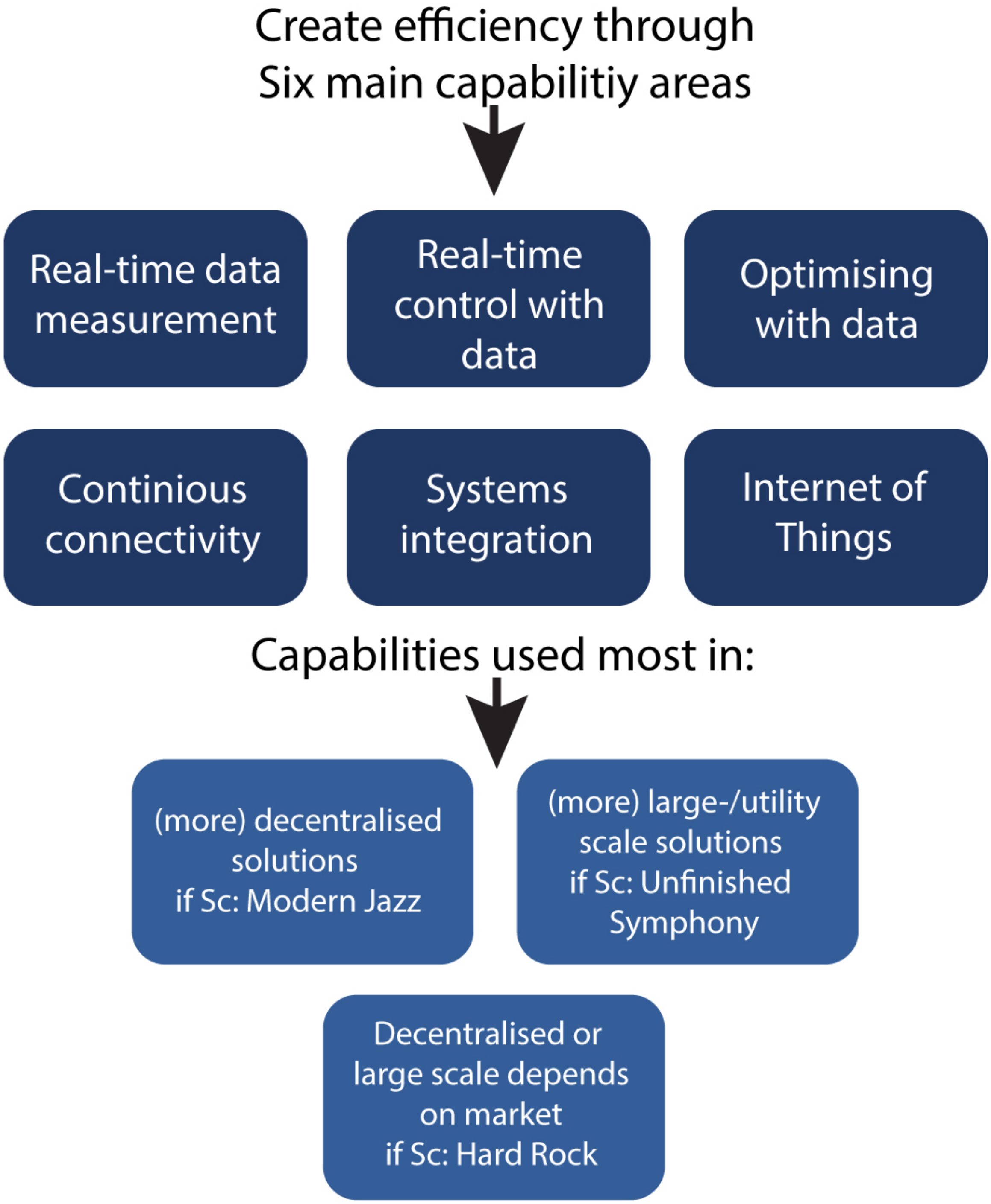

Figure 26 – Main capabilities needed in the future, (Author)

To clarify, the six capability areas will briefly be explained and summarised below.

Real-time data measurement relates to the ability to, in real-time, generate/produce valuable data that is made in such a way that it is fairly easy to use in later processes/stages, preferably in such a way that it can be stored/used in cloud solutions.

Real-time control with data relates to the ability to, in real-time, control products and processes with data, preferably autonomously with feedback-loops.

Optimising products, processes and services with data relates to the ability to optimise, for example increase efficiency, with data. This should preferably be autonomous, and preferably be so advanced that the system is self-learning (machine learning or such).

Continuous connectivity relates to the ability to create services through having devices/products/processes connected at all times. Basic examples would include smart alarms, slightly more advanced examples would include for example intelligent maintenance.

Systems integration relates to the ability to take integrator-responsibility in installing, maintaining and optimising large complex systems.

Internet of things is a broad concept, in this case it is going to be defined as the ability to make many devices, products and processes ability to communicate with each other, and preferably control and optimise themselves based on each other's performance.

6. Empirical – Company results

This chapter will explain and show the results from the investigation and research at the case company to verify the functionality of the framework. The chapter will present results only, analysis (gap- and otherwise) will be presented in chapter 7.

6.1 Interview results case company

The investigation and test at the case company is made up of mainly interviews with key personnel. 11 interviews with 12 people were made. Their roles in the company are shown in Table 12 below.

Table 12 – Interviewed personnel at the case company, (Author)

Person	Role
1	Responsible for the department Marketing and Product management
2	President of a business unit, member of the (Energy) division management team
3	Responsible for the marketing and portfolio management for a business unit
4	Business developer
5	President of a business unit, member of the (Energy) division management team
6	President for a business unit, and Vice president in the energy division, member of the (Energy) division management team
7	President of a business unit, member of the (Energy) division management team
8	Service Sales & Portfolio
9	Global key account manager
10	Responsible for Global Service
11	President for the Energy Division, Division Manager
12	Head of CC-teams Development, Vice President of a business unit

The author requested which types/roles of personnel that would be beneficial to interview. These requests were then handled by the supervisor at the company who appointed interviewees who would meet the requests. The twelve interviewees cover the focused business area, including all of its business units as well as top management well. In other words, the full picture of the company's business area connected to energy would be had.

To make the results easy to read and understand, every interview has been summarised using an interview framework. An empty framework can be seen in Figure 27 below, furthermore, an explanation of the level-coding used in the interview framework can be seen in Figure 28. In the interview frameworks, every capability area is mapped according to three different time perspectives: what is **already developed** (available today), **currently developing** (development started and on-going) and **planned development** (planned but not started). Furthermore, every capability area is mapped on three levels in the company: **business unit level** (the Business Unit of the current interviewee), **division level** (energy division) and **company level** (Company/corporate wide). Regarding the three different time perspectives, capabilities are mapped in terms of if they are/will be available in the *operating network*.

Capability	Location	Already developed	Currently developing	Planned development
Real-time data measurement	BU			
	Division			
	Company			
Real-time control with data	BU			
	Division			
	Company			
Optimising products, processes and services with data	BU			
	Division			
	Company			
Continuous connectivity	BU			
	Division			
	Company			
Systems integration	BU			
	Division			
	Company			
Internet of things	BU			
	Division			
	Company			

Figure 27 – Empty interview framework used in interviews, (Author)

Level	Already developed	Currently developing	Planned development
N/A	Not discussed / Not relevant	Not discussed / Not relevant	Not discussed / Not relevant
None	No capability what so ever	No current development what so ever	No plans to development what so ever
Low	Have basic capability	Development currently running, but low ambition and/or no target/direction	Development plans, very basic, might be a vision but no real target
Medium	Have competence	Current development, Medium ambition or clear target/direction	Planned development Medium ambition or clear target/direction
High	Have expertise	Current development, High ambition and clear target/direction	Planned development, High ambition and clear target/direction

Figure 28 – Explanation of results coding, (Author)

One framework for every interview was made. The interviewees responses were interpreted to form the correct corresponding level of capability. Thus, 11 fully coded interview frameworks where had. The 11 interview frameworks were then consolidated to one framework, showing the final results of the interview process. BU-data from the 11 interview frameworks were consolidated to division-level. The full consolidated result will be presented in figure 29 in 6.1.1.

6.1.1 Test results – Consolidated company results

The full consolidated results can be seen in Figure 29 below.

Capability	Location	Already developed	Currently developing	Planned development
Real-time data measurement	Division	Medium	Low	Low
	Company	Medium	Medium	Medium
Real-time control with data	Division	Low	Low	Low
	Company	Medium	Low	Low
Optimising products, processes and services with data	Division	Medium	Low	Low
	Company	Medium	Low	Low
Continuous connectivity	Division	Low	Low	Low
	Company	Low	Medium	Low
Systems integration	Division	None	None	None
	Company	Low	None	None
Internet of Things	Division	None	Low	Low
	Company	Low	Low	Low

Figure 29 – Full consolidated company results from interviews, (Author)

The interviews, discussions and results about the six areas in the framework shows that the used scenarios and the detailed content of the framework is an excellent tool for the defined purpose. The results will be further analysed in chapter 7.

7. Analysis

This chapter will analyse the results. First, a gap-analysis will be presented, explaining where the gaps between the future requirements and the company's capabilities are. Second, reasons for the gaps, in other words why there are gaps, will be presented as a speculative analysis. Third, recommendations on how to handle the gaps will be presented, also as a speculative analysis. Fourth, and finally, the work process and frameworks will be verified or rejected as solid methods to conduct this type of project.

7.1 Gap-analysis

As can be seen in the consolidating framework in 6.1.1 above, the case company is, as a whole, in a decent position in terms of future requirements and the company's capabilities. It can be seen that the case company has fairly good capabilities in the older, arguably less advanced, technologies, while having fairly weak capabilities in the newer, arguably more advanced, technologies. Furthermore, it can be seen that the case company likely has development-focus placed somewhere else than on these six technology areas.

More specifically, in terms of **already developed** capabilities, the maximum capability the case company reaches is medium capabilities which are reached in company- and divisional level on real-time data measurement and optimising products, processes and services with data. Furthermore, they also reach medium level on company capabilities in real-time control with data. On the rest of the capability areas only a low level of capability is reached, except for on systems integration and internet of things on divisional level where no capability is reached at all.

In terms of **currently developing** capabilities, the case company reaches only a low capability of the majority of capability areas and organisational levels. The only areas where they reach a medium level is on real-time data measurement and continuous connectivity on company level. Moreover, they have no development what so ever on systems integration, on either level.

In terms of **planned development** of capabilities, the case is the same as in **currently developing**, with the only difference that real-time data measurement on company level is on a low capability as well.

All in all, it is fairly clear that the case company has decent capabilities in real-time data measurement, control and optimisation, while having weaker capabilities in continuous connectivity, systems integration and internet of things. It is also fairly clear that development is lacking, both in current development and planned development, this is consistent through the six areas.

7.2 Reasons for the gaps

With a capability gap observed, one can speculate why there is a gap in the first place. This is likely due to a mix of three main reasons, traditional (historic) technologies, market preferences and organisation structure.

7.2.1 Historic tech

The first and foremost issue, the case company has been reliant and thrived on the same key technologies for a very long time. In this sense they have been traditional/historic in what they do. Their applications may be new, but in general the technologies have basically been the same. The technologies have not needed radical innovation, they have rather been incrementally improved, optimising for example how thin the products can be made. The said technologies have been reliant on mainly mechanical- and chemical engineering. Data- and IT-engineering have thus not really been relevant for the company until now. In fact, for the technology in itself, one could argue that IT-engineering still is not relevant, however, the applications such as optimising and using the technology in its optimal way becomes an IT-/Data-engineering heavy activity. Thus, since the technologies traditionally do not use IT-engineering, a lack of capabilities related to IT/Data is expected, which now is apparent in the company.

7.2.2 Market preferences

The second issue is perhaps one of the more traditional ones in terms of companies' directions, capabilities and products: market preferences. Although, the interest in Data- and IT-related optimisation, activities and value have been on the rise for a long time, it still has a way to go before becoming mainstream, especially in heavy industry. The case company's customers are many and diverse, but they are still to some degree concentrated to specific sectors, companies and areas. These have for a long time been used to purchasing components and products, rather than services and effects. Furthermore, when for example optimisation or other data-services is discussed, it is rather an addon to a product or component rather than being sold in itself. Market preferences most often steer companies' offerings, and thus their capabilities, and the case here is not an exception.

Related to markets, there is a specific reason for the lack in the systems integration capability, which is business model choice. The case company sells components to system integrators, should they start take integrator responsibility themselves they would compete with their customers, something which may ultimately be bad for the results. It is clear from the interviews that this is indeed an active choice. Although the case company likely can continue not taking integrator responsibility, they likely need better knowledge of the systems in the future to develop products and solutions fit for these future systems.

7.2.3 Organisation

The third issue relates to how the company is organised, both in general but also more specifically around these technologies/areas. Regardless of historic technologies or market matureness (for data-services), according to the interviews, the discussions of these six areas have circled around the company for some time. It is likely that the organisation of the company stops the discussion from bearing fruit. The company is organised in three divisions and 12 business units. This organisation was set in the latest re-organisation and one of its main purpose was to move authority and decision making down in the organisation by giving it to the different business units.

First, the business units, and their presidents, are responsible for their own profit and loss statements, basically working against 3-year plans and predictions. Developing these new capabilities, especially the more advanced ones, would likely require more than 3 years and thus negatively impact the 3-year financial statement, at least until the capabilities were fully developed and the customers ready for it. Thus, the business units in themselves will through incitements likely not push for its development, and so interest and speed will be lacking.

Second, and likely more important, it was in the re-organisation decided to give Carl Carlsson (fictitious name used onwards) and his teams (CC-teams) the responsibility, at least the technical responsibility, to develop the (modular) solutions as well as the "platform" for these areas. From the interviews it became clear that the people within the business units were happy with the decision, likely as it gives someone else the responsibility, and thus gives them the freedom to focus on what works best in their favours (and in their financial statements). By giving a small team the responsibility for the entire development, you ensure a coherent direction which is likely positive, but at the same time you sacrifice speed and volume.

Third, as can be seen in the consolidated results, the case company has a fair bit to go. Making a transition such as the one the case company has to make likely requires the entire company, or at least a substantial part of it, to pitch in and work together on development. The idea is that Carl Carlsson's teams should lead the transition and development. However, by giving one team development responsibility, without a common agenda for the rest of the company, in combination with 3-year plans, you end up with a situation where the team is not leading development, they are "pulling" it. Thus, you miss the needed speed and volume.

7.3 Recommendations

The capability areas are, as seen in the scenarios, very important in the future. There are two specific reasons that should be mentioned in terms of why it is important to start developing these capabilities for the case company now. The first one is that the technologies related to the capabilities have gotten so far that substantial value can be created with them in combination with the case company's normal offerings. The second one is that in B2B and heavy industries etc., there is a trend to sell services or effect instead of components or products. To effectively be able to sell a service, you need to effectively know exactly what your service is doing and/or achieving. To know what your service is achieving you need to know your systems and products on a completely new level. To know your products and systems on that level, you need to be able to use data and effective analysing tools. This is especially important in assurance contracts with specific efficiencies etc.

Both reasons would in themselves validate pushing for development of stronger capabilities in the six areas. To fill the capability gaps, both in terms of current capabilities, currently developing and planned development, there are many possible ways. Something to note is that, even though there may be many years before the six capability areas are critically needed or considered threshold capabilities, a large company like the case company will likely take a long time to properly re-align. Thus, it is important to start the transition and development well ahead of time, as well as push for speed in whatever capability strategy chosen.

The needed capabilities can be had in essentially two ways, organic or inorganic.

Organic (internal) development is basically what the case company currently uses today. Benefits includes ability to (often) steer towards specific capabilities, as well as controlled growth with less cultural and integrational challenges (compared to inorganic growth). Drawbacks include time requirement, capital straining and not enough resources (EY, 2014).

Inorganic (external) development includes *mergers and acquisitions* and *joint venture alliances*. Speed, in acquiring the capabilities, is one of the main benefits from using inorganic development. However, sudden increases in size can present management challenges around complexity, people and branding, as well as issues with scaling systems and support (EY, 2014).

Organic development

Starting with internal development, as mentioned, it is what the case company mainly uses today. From the results of the capability map, it is clear that, *today,* it is likely not fast enough, because if it were fast enough then the case company should be in a better position. The speed is key in this transition, both due to the rate of technology development in these areas, but also due to the rate of change in the energy sector, which this project is aimed at. It may be possible to increase the speed of the internal development, in this case the key to doing this is likely in setting a common agenda which the entire company can get behind. In doing so it would not be Carl Carlsson's teams sole responsibility to develop the (technical) capabilities, but rather to lead the company's development. Today, officially it is Carl's teams responsibility to lead the development. However, without a common agenda, they are rather pulling than leading the development. Setting a common agenda would likely communicate the direction and the importance to the entire company, which could then increase the shear volume of development. Other issues will arise as well of course, should the development teams need to be extended, one issue will be finding qualified personnel that would like to work with data in the case company. The issue here is that those who are qualified enough would likely want to work at a company who is at the forefront of the technologies.

Inorganic development

If the case company instead would try to acquire the capabilities externally, the speed issue could likely be handled. However, doing so there are a number of issues that will surface. Most of the issues are related to finding the right company/department to acquire, which is a trade-off and consideration of size, volume of capability, relative skill acquired personnel and integration (bureaucracy).

Should the case company acquire a large company, the case company would first enjoy the benefit of acquiring a large volume of capability (number of people) at the same time. That is beneficial, not only due to the fact that you acquire a large volume of capability, but also if you would like to spread capability throughout the company to a greater deal than today (the next level of a common agenda). The relative skill of every acquired person may be smaller comparing to a smaller niche company, thus if the cc-teams today consists of only highly skilled people this may present an issue. Acquiring a larger company may be easier to integrate in to the case company compared to a niche company (like a start-up) due to a larger company is likely more used to the bureaucracy that is common in the case company.

Should the case company instead acquire a smaller company, the case company would likely only get a handful of people, however these may be highly skilled if the acquired company is an advanced niche company. This can be beneficial if it is decided to keep the current structure with knowledge centres (Carlsson's teams) but to reinforce the knowledge base in them. The greatest issues with acquiring a small company are likely circling around integration and structure. An advanced, small, niche company usually works in a very different way compared to large OMX30 companies. The acquired personnel may not enjoy working in the bureaucratic environments that are often present in large companies. Thus, careful structuring must be made to ensure that the new employees can thrive within the new environment. A way to handling such a company/department integration is to make use of *skunk works*, keeping the department/company separate from the rest of the organisation, letting them keep working in their normal structure/approach (Rogers, 2003). However, using the skunk works approach presents new issues, one of them being actually getting anything useful out of the skunked department to the larger company. Another issue connected to skunk works that may arise is related to NIH, short for *not invented here syndrome* (Piezunka & Dahlander, 2014). Basically, technology or products that is developed somewhere else than within the company may be resented by the personnel in the company. The main considerations of purchasing a smaller or larger company have been summarised in Table 13 below.

Table 13 – Considerations in external acquisition

Considerations in external acquisition	Large company	Small company
Volume of Capability (Number of people * Skill level)	+	-
Relative expertise (Best in field)	-	+
Integrative ease (Culture, fit, bureaucracy)	+	-

In line with the discussion above, whether one goes for internal or external development, and whether one goes for a small or large company, everything boils down to a question and discussion of how to organise. In this question and discussion there are, as seen, different approaches, all with their own benefits and issues. No matter which approach is chosen, handling a lot of the issues that arises could be done by having a clear, ambitious, common agenda for the entire company. Having a common agenda is sort of the baseline for the transition, with the different approaches being tools to sprung from said baseline. Without a common agenda, there are large risks both in terms of actual capabilities and in terms of organisation and culture. Actual capabilities meaning actually getting the required, needed and wanted capabilities. Without the common agenda, and thus the clear direction, there is a risk of ending up somewhere else than wanted. Then there are risks in organisation and culture. Should the case company make a major acquisition, or ramp up internal development substantially, without having a clear direction and agenda, there is likely going to be confusion and resentment within the "original" company which may want to keep things the way they have been.

Another alternative within inorganic development that needs to be mentioned, that does not include acquiring a company if not done jointly, is a *joint venture alliance* (JVA). A JVA means creating the capability together with one or many other companies/institutions. Benefits include possibility to gain more perspectives on a situation, more knowledge and more resources (Roos, et al., 2014). Another advantage specific to this case, which will be discussed in the next section, is that a JVA have the possibility to amass huge amounts of data. Drawbacks include organisational and legal complexity, as well as difficulty to align goals and objectives. The drawbacks imply longer startup-times, and as mentioned, time is of the essence in this project, thus this is a clear minus in this specific instance. Should one decide to pursue this option, the question is which companies/institutions that one should partner with. Just as in acquiring a company, one can, for simplicity, discuss in terms of large and small companies/institutions. In deciding which companies to partner with, one should consider different types of synergies. Should one partner with a small (niche) company, considering that the case company is a large company, both sides of the partnership would likely be able to get something they currently do not have. The case company would for example, if partnering with the right niche company, be able to get access to new expertise, while the niche company would for example likely get access to large networks of customers and partners. Should one partner with a larger company, there would likely be less immediate synergies, as there would basically be more of the same. Although, there are benefits of partnering with a large company, first there would likely be more resources available than if partnering with a small company, furthermore it is likely easier to *practically* organise a fruitful partnership. Practically, meaning in terms of working in a way which both partners are comfortable with, similar to the earlier discussion of bureaucracy in acquiring large and small companies. There are indeed, as mentioned, many possibilities and benefits in joint venture alliances. The issue lies in speed. Due to the earlier explained rate of change, the case company needs to get started as soon as possible, a JVA will be very difficult to get up and running in time. However, even though a JVA may not be attractive today, it may be a good solution to gain more external experiences and capabilities when the transition is already started.

Case Company Information AB

With a common agenda set, and decisions made on acquiring the capabilities externally or internally, one will have to think about how to structure and organise the departments, if any, inside the case company. This is important to explore both due to value of data being different compared to normal products, as well as due to the organisation structure of the case company. First of all, data becomes, generally, more valuable the more data you have, both volume and number of types. Thus, you need to store all data in the company in the same place. Second, adding the ability to collect data and control with data will likely require adding some sort of sensor or other type of equipment on the products. The added sensor/equipment will of course incur cost, but may not generate revenue until later when the volume of data has become sufficient. The business units will likely not want to bear this cost until revenues can be generated, due to carrying responsibility for their P&L-statements, resulting in a catch 22. Currently, as mentioned, Carl Carlsson and his team has the technical responsibility to make signals into data, in other words makes the data centrally available, sort of creating the logistics around it. However, you need to make others work to make available data into valuable information/value in general. Furthermore, as mentioned, to really make valuable information/value propositions you need large volumes of data that can be used. For this, another, separate, entity will be needed. This entity will handle both issues of amassing data and bearing costs.

To amass the amount of data you need efficiently, someone has to own the data going in, and someone, preferably the same entity, has to work to make the data valuable and useful. The business units have capital sales with margins, the data would initially be a cost for them, and they would thus not want to bear them. Thus, you need a separate entity, a "Case Company Information AB", that bears the cost. The Information AB can bear the cost of adding the data-equipment on the solutions and products. The entity owns the data, and when the data comes in and is transformed into information and value, the business units pay for that information when sold or added to solutions and products (essentially when the information is actually valuable). It is likely necessary to have a separate entity to bear the costs to have the business units onboard with the transition and agenda, otherwise they might not follow through and bear the costs on their P&L statement. A separate entity solution like this solves the cost issues as well as solves the data amassing and storage issues. Furthermore, a solution like this would also make the organisation more logical, meaning everyday business would flow easier. Should there not be a separate entity, there would likely be issues with who owns what data/information/value, who bears the cost for what data/information/value, and who enjoys the profits of the data/information/value. With the entity however, all data is available at the same place, so all business units can go to one place to get all data they need, and there will be no issues in terms of who bears the costs, who owns the data and who gets the revenues of the data. Ownership of data and revenues immediately becomes an important discussion if data should be sold or used externally. Selling data externally can indeed be profitable and reveal many unexpected revenue sources. Examples of this are VESTAS, the wind turbine company which started selling data and information to DMI, the Danish Meteorological Institute, a revenue source not planned for initially.

There are other benefits as well in creating Case Company Information AB (CCIAB). Making the necessary transition towards expertise in data and its handling will require data engineers and data scientists. Whether they are acquired through hiring or acquisition, it must be ensured that they want to work within the company, something that may be hard due to the case company currently not being a data company in that sense. By having Carl Carlsson's teams and CCIAB, the cutting-edge expertise can be concentrated, reaching a critical mass of skill and knowledge which ensures that people want to work there. Furthermore, in organising the entity and its relation to the company, there should be people that can act as the link between the teams, CCIAB and the business units. Organising in this way would also protect the case company core ideas, in terms of keeping the core skills intact, adding support around them to make them even more valuable.

In discussing an information entity, one could connect back to the discussion of creating joint venture alliances. It is indeed possible to create the entity together with one or multiple partners. The whole discussion from the earlier section is valid in this case as well. However, there are some points that are worth raising. In the case of an information entity, there is a great benefit. As mentioned above, all data becomes more valuable through having more volume and more types of data. Through partnering, it is likely possible to jointly amass a huge amount of data, both in volume and in types. Worth noting here is that the data must not necessarily be product related, different types of for example customer activity data is valuable as well, rationalising the diversity of data that two completely different companies would amass. However, the amassing of data comes with a drawback.

In the case of sharing data, which the whole benefit revolves around, there are issues in sharing sensitive data. Due to the nature of the data, one is likely more limited in selection of partners in the case of information entities compared to selection of partners in the case of building capabilities. The partners one should choose should likely be companies that are not competing with the case company in any way, but preferably also in B2B/specialised industry. There are, however, further issues with a JVA set-up for an information entity. The whole point of building the information entity was to simplify organisation and business-logic within the company. However, when setting up an entity with partners, there are immediately new organisation complexity issues. Legal- and other issues would immediately arise within data ownership, data use and sharing and revenues. Revenues would especially be complex if external sale of data would be on the table. Just as in the JVA discussion, there may be benefits and opportunities in an information entity JVA that are worth pursuing in the future. But currently, as the transition has to start and be up and running as soon as possible, it is recommended to start the entity solo, and eventually pursue a JVA at a later stage.

Summary of recommendations

In short, the case company needs to transition and cover the capability gap fairly quickly, due to the speed of change. Thus, acquisition is likely the best approach. Since the capability gap is fairly large, and the case company also lacks a lot of people in these areas, it is likely best to acquire a mid-sized/large company/department. Acquiring a larger company or department would also, as discussed earlier, make the integration easier in terms of bureaucracy and culture. Due to the way the organisation is structured with P&L-responsible business units, the case company should develop an entity that can bear the costs of the data-equipment, own the data-inputs, develop the information and its value, and finally reap the internal revenues from the business units. To ensure smooth linkage between Carl Calsson's teams, the information entity and the business units, there should be at least one person in every business units with both expertise in the six areas but also the business unit that can be main contact between the three entities (business unit, CC-teams and CCIAB). Before going further with any plans, the case company should commit to a true transition plan (Case Company DaTra 2020) and install a common agenda that the whole company can get behind, so that everyone works together to achieve the future capabilities and expertise. Doing this would make Carl Carlsson, his teams, and the information entity, the "Leaders" of the transition, rather than the "Pullers" of it.

7.4 Verification of the frameworks and work process

The work process of constructing the scenario framework, selecting external scenarios, interpreting the scenarios to a capability framework and mapping said framework, in short; works. The capability framework proved to spark a discussion to such a degree that all capabilities could be mapped with a fair certainty. Thus, the constructed framework worked as intended. Furthermore, since the framework could be used to develop strategic input, the frameworks and work process all in all proved fruitful.

Should the framework and the process *not* have worked, then the interviews and discussions would have ended up *flat*. In other words, they would not have sparked any interest or mapped valuable information and/or insights.

The work process, in essence, creates value through giving a clear structure while keeping flexibility in terms of use cases. The structure makes use of scenarios to create two frameworks to develop strategic basis and input. Even though the project was intended for actors in or related to the energy sector, the work process and its frameworks can be used in more situations than this specific company/sector. Some starting-points were already given in this project. By adding steps to define these starting-points to the process used in this project, a rigorous work process is had that can be used to create strategic input in many situations and projects. For clarity, some steps have been broken up in to two. The work process can be summarised as follows:

1. Define business unit/area
2. Define ambitions for business unit/area
3. Evaluate potential scenarios and select scenarios to use
4. Develop data collection structure
5. Define data collection sources (interviewees)
6. Data collection and analysis
7. Define gaps
8. Action Plan

The process is further explained and clarified below in Figure 30.

Define use-area

1. Define business unit/area
   - Where should it be used?
2. Define ambitions for the business unit/area
   - What is the aim, what should be achieved?

Define data map

3. Evaluate scenarios and select scenarios to use
   - Use scenario framework to select best scenarios
4. Develop data collection structure
   - Interpret scenarios to define parameters to map, preferably on different levels and time perspectives

Define data location

5. Define data collection sources
   - Define how and where to gather the data (interviewees or otherwise)
6. Data collection and analysis
   - Collect and map data, analyse structures and causes

Define remedy

7. Define gaps
   - Analyse gaps between required- and actual capabilities, developing and current
8. Create action plan
   - Develop strategic input or actual strategy to fill capability gaps

Figure 30 – Model of the verified work process, (Author)

8. Discussion of results and methods

This chapter will discuss the results and methods of the project, first in general terms and then in specifics for the four respective objectives/phases. The general part will briefly discuss if the objective was reached, what implications the results has and if it could have been made better. The specifics will discuss the respective results and factors that may affect the results, implications if the factors *actually* affect the results, and finally if it is believed that they really *did* affect the results.

First and foremost, the four major objectives in the four phases were reached. The results have several implications. **From the first objective**, anyone can now use the scenario framework to evaluate which scenarios are of high quality. This framework can be used in both the academia and in the industry. This project was about energy scenarios/industry, but the scenario framework was made to be general and can thus be used with any type of scenario. **From the second objective**, anyone can now have quality input into what will be needed for a supplier, and to some degree anyone, to the energy sector in the future. Furthermore, anyone can use similar frameworks to map capability requirements in other situations. **From the third objective**, the case company have now received a deep mapping of the status of the capabilities in the needed areas for the future, giving important input to corporate development. **Lastly, from the fourth objective**, the case company has now received quality analysis of where and why the gaps between current and needed capabilities are. Furthermore, the case company has, even though it went beyond the scope of the original project, received input of how to solve these capability gaps. From the entire project in total, the case company has now received quality input to make well-informed decisions about how to proceed in the capability decisions and corporate development decisions for the future. **From the entire project and all objectives,** the entire work process with both the scenario framework and the capability framework can be, as discussed in 7.4, verified to function well. With this work process and these frameworks, anyone can now conduct a study of their own to develop strategic input based on scenarios.

Whether the results could have been better, on a general level, relates mostly to the size of the project. As mentioned in 1.7, the projected was originally limited by 20 weeks of full-time work. However, the scope of the project was so big that it to some degree covers four separate full-time topics. When the scope also extended to include recommendations and solutions in objective four, the size of the project increased even further. The original limitation of 20 weeks full-time was quickly abandoned, and through a smart way of working the results should be the same as if four different projects by four different people were made. Other eventual issues for the different objectives are explored in the sections below.

8.1 Discussion of phase and objective 1

As mentioned above, the result is a framework to evaluate the quality of external scenarios. The framework can be used in multiple settings and evaluates if the scenarios are made in line with correct scenario theory. This is in line with the original objective and the results are legitimate.

In terms of what could affect the results, the major issue is which theory/literature that is used to develop the framework, in other words the risk of using the wrong literature. If this would be an issue it could result in a framework which is not theoretically correct, or at least not optimal. This is with almost full certainty not a problem in this project. This is due to, as mentioned in 2.2, a lot of literature on scenarios basically discuss the same things and originates from the same original sources. Thus, through using the citation pearl growing approach, the original sources were found, which in combination with modern sources created a fairly exhaustive framework.

8.2 Discussion of phase and objective 2

As mentioned above, objective two related finding of the highest quality scenarios and interpreting what they mean for a supplier. The results were the WEC Energy Scenarios, which were interpreted to map out six capability areas. These results are legitimate, the scenarios found were to a fair degree of certainty the best ones available, and the interpretation was not a particularly hard one as well. Indeed, the interpretation is turned out to follow the notions of Industry 4.0.

In terms of what could affect the results, given that the assumption that there are no issues in objective one, there are three major issues. The first two being finding (all) scenarios and interpreting/analysing skills. The last one relates to finding different types of scenarios, namely industry focused scenarios.

In terms of finding all scenarios, the issue is simply being sure of finding as much scenarios as possible, and especially all that can be good enough to qualify to be the best ones. If one does not find the best scenarios, one will have to resolve to using sub-par scenarios. This would not necessarily be catastrophic, but the results would of course not be of as high quality as they could be. It is believed that this is not an issue, due to the fact that there are way fewer (public) energy scenarios than expected. Furthermore, after searching for a long and extensive time, and using the framework, it was not a discussion which scenarios that were best, it was clearly WEC that were superior.

In terms of interpreting the scenarios, the issue is that depending on the knowledge- and skill level of the person doing the interpretation, the results could be affected. Should this actually be an issue, it would risk resulting in capability areas that are not the actual ones that should be considered. It is believed that this is not an issue in this case, due to the fact that the author was well supported by experts from both academia and industry throughout the project. The work process was made agile to be discussed with said experts throughout the project. Furthermore, the interpretation in this case was not particularly hard and in line with the notion of Industry 4.0.

The final issue, related to the first one, is about what type of scenarios that can be found. The project revolves around what a supplier to the energy sector need to be able to do in the future, thus, it would make sense to have scenarios that are written with a focus on what happens in the industries. However, as expected, there are almost no (public) scenarios that are written from an industry point of view, they are all from a consumer point of view. This is not necessarily an issue, it just means that one has to interpret what the consumer changes mean for the industry, instead of having it already done by the scenario itself. Should this be an issue, in other words if it would be difficult to analyse and interpret the scenarios, then of course the results in terms of capability areas could be flawed. However, it is believed this is not an issue, due to, as mentioned, extensive support from experts as well as an analysis and interpretation that was not particularly difficult.

8.3 Discussion of phase and objective 3

As mentioned above, objective three relates to mapping the case company's current state on the six capability areas found in objective two. The results were a map of the status in terms of current, currently developing, and planned development, for the six capability areas, on the three different levels business unit, (energy) division, and company/corporate. The results were had through interviewing key personnel on different levels of the company, thus, the issues revolve around the interviews and factors around them. Mainly, there are two issues worth mentioning, the first one relates to consistent understanding of the question of all interviewees, and hidden agendas.

The first issue relates, as mentioned, to if it was possible to keep a fair and consistent understanding of the questions for all interviewees. In other words, making sure that everyone knew which question they were answering. If this would be an issue it would mean that the interview results could be flawed. In this case it is believed it is not an issue, due to a rigorous interview process. First, a lot of material was sent beforehand, the project in itself, the interview guide with questions and with explanations of what was going to be mapped. During the interviews it was made sure that the interviewees knew all questions and could otherwise ask if something was unclear. Furthermore, after the interview, the results of the interview were sent to respective interviewee to give them a chance to correct anything that could have been misunderstood, and to clear up any unclear answers.

The second issue relates to hidden agendas, in other words if any of the interviewees wanted to convey a message which not necessarily was the truth. This could happen as the project would be presented and read to many people of high status in the company, and individuals could want to convey a message that would be favourable to them in the company politics. Should this be an issue, the interview results could again be flawed, as it could be based on false answers. It is believed that is not an issue, or at least an issue that was avoided, due to the shear breadth and volume of the interviews. By interviewing as many people and as many *different* people as the project did, a broad and fair picture was had.

It should be mentioned, in terms of interviews as the choice of method, other methods have been considered. The method except for interviews that may be one of the more effective ones is likely survey. With a survey one could reach even more people within the case company. This could also give a quantitative material to base hypothesises and conclusions from. However, the main reason it wasn't used was due to the somewhat complex model and subject. Using a survey would risk misunderstanding and misinterpretation of the material and the questions from the respondents.

8.4 Discussion of phase and objective 4

As mentioned above, objective four relates to analysing the gaps between the results of objective two and three, as well as analysing likely reasons to why the gaps are present. Furthermore, the scope of the project was extended to include some limited analysis of solutions to the gaps. The issues in this case are few or none as the premise was to be speculative and open-minded in the analysis to provide new input to the case company to broaden views.

9. Conclusion

This section will shortly summarise results and implications of the project as well as conclude what the case company should do to become/remain a qualified supplier in the future.

Through constructing a framework for finding the highest quality scenarios, the WEC Energy Scenarios from 2016 deemed the best candidate to understand and evaluate future requirements. Six different capability areas were found, Real-time data measurement, Real-time control with data, Optimising products, processes and services with data, Continuous Connectivity, Systems Integration and Internet of Things. These six areas represent capabilities/expertise that will be needed in the future for a qualified supplier to the energy sector. They are all connected to each other to some degree, and in some cases are actually different levels of the same underlying theory. The six areas are all heavy in understanding- and use of data, witnessing that success for a qualified supplier in the future will to a large extent be how well one handles data. Through mapping the status of the six areas at the case company, it could be seen that the company has at least started development and discussions but has a lot to do before being set for the future, especially in the last three of the six areas. It was found that the main reasons the case company lacks in some of the areas are historic tech, market preferences and organisation. It was further found that handling the gaps and becoming capable in these six areas would require several things. First, setting a common agenda that the entire company can get behind, that sets the official direction and commitment to becoming capable in these data-related areas. Second, creating a new entity/department which can bear the costs of the data equipment on the products and solutions, turn data into valuable information and insights, as well as enjoy the revenues of the value created through the data and information. Lastly, acquire a mid- to large-sized company/department that is already capable in these six areas.

From this entire project, it can be concluded that the work process of constructing a scenario framework and a capability framework is well functioning and a solid method to develop strategic input.

10. Contributions and future research suggestions

This section will shortly describe the contributions and value created for the academia/theory as well as for the case company. Furthermore, suggestions for future research will be provided.

10.1 Contributions to theory

There are mainly three contributions to theory/academia through this project. These are a literature study of consolidating nature around scenarios and scenario analysis, a framework for selecting scenarios and a method for using the scenario framework in a specific work process to create strategic input. This work process including frameworks has also been tested and verified in a case study, to see how a company's level of capability matches with the future requirements.

The first one relates to the literature study made to develop the theory chapter on scenarios and scenario analysis. Scenarios and scenario analysis have been around for a long time, with a large array of books and articles on the subject. When the material on a subject becomes large, especially on a subject which has many viewpoints, there are a lot of material which may carry agendas in their presentation. It can be difficult to find the good material. In these cases, a deep-dive into the subject and a consolidation of the information can be a good way to clear up and separate concepts and viewpoints. A literature study that consolidated all the articles and books on the subject of scenarios was not found prior to writing this thesis.

The second contribution relates to the framework developed for the first objective. Again, there are a lot of materials on scenarios, and there are even more actual scenarios, having a clear and fairly fast way of evaluating the scenarios is valuable. This framework was developed in line with theory and academia and provides value in itself by clearing up essential parts of scenarios and scenario construction, as well as a practical case of Scenario theory.

The third contribution relates to the work process of using the scenario framework to evaluate scenarios and develop a capability framework to map capabilities on different levels and time perspectives. This work process is valuable due to it being able to give a clear structure, while keeping flexibility to be useful in many situations. This work process was tested as a practical case study that was made with the case company, showcasing how closely or far a company can be in their current, developing and planned development of capabilities. This case verified the method of using the frameworks to develop strategic input as useful and solid.

10.2 Contributions to the case company and industry

There are multiple contributions to both the case company and the industry at large. The contributions to the industry relates to the scenario framework, the map of capabilities that are important in the (near) future as well as a method and approach to make well-informed capability development decisions based on scenarios. Beyond these, the case company has also received the contribution/value of specific mapping of their capabilities and furthermore analysis on these.

Starting with the industry, the framework can be used in industry just as well as in academia. It can furthermore be used with any type of scenario, not only energy related ones. Thus, the industry now has a way of quickly evaluating the quality of scenarios. This is important due to the number of scenarios available, using the right scenario can be the difference of the right and the wrong decision.

The map of capabilities that are important in the near future provides value to any supplier to the energy sector, as well as to many other actors and sectors as well. This provides value to many companies in terms of what they need to focus on to be able to keep being qualified in the future. The approach used in this project, with the framework, selection and analysis, can be mimicked and used by any player in any industry to make a new case study to make well-informed decisions. This gives industry players the ability to take better control of their future in turns of capability, something which may be the difference between survival and death of a company.

The case company will of course enjoy every contribution made to the industry at large, but beyond those they have also received the full analysis on their specific case on every step in this projects approach. The mapping of the company's capabilities against the scenarios capabilities gives the company important input for the future. This has given the company quality input to make well-informed decisions about how to proceed in the capability decisions.

10.3 Suggestions for future research

There are a few areas that could be further researched to gain an even better understanding of these subjects. These relate to the respective phase of the project, as well as how to develop the needed capabilities in the fastest way possible.

First, the four respective objectives/phases could, as mentioned in chapter 8 be researched even more. Each objective could be scoped in such a way that they extend to a project of this size each. It is, as discussed, unlikely that the results would be different, but nonetheless there is value in confirming that it actually is the case. Especially objective one would provide more value than the others, due to its slightly stronger generalisability and wider use cases. The first objective could be extended to cover "all" literature that have been released on the subject, to make a truly exhaustive consolidation research.

Second, since it was seen that the case company lacks some of the capabilities, it would be interesting to review what the best possible ways are to handle these capability gaps. The analysis in 7.3 covered this to some degree, but this could be extended to be even more exhaustive.

Lastly, it would be very interesting to see the work process and its framework developed in this project, tested on more cases. Perhaps the work process could become even more refined with a an even more effective process, resulting in even better strategic inputs.

References

Aaker, D., 2001. *Strategic Market Management.*

Accenture, 2018. *Company.* [Online]
Available at: https://www.accenture.com/us-en/company
[Accessed 25 April 2018].

Bea, F. & Haas, J., 2005. *Strategisches Management.*

Bradfield, R., 2005. The origins and evolution of scenario techniques in long range business planning.

Cairns, G. W. G., 2011. *Scenario Thinking Preparing your organization for the future in an unpredictable world.*

Cairns, G. & Wright, G., 2011. *Scenario Thinking Preparing your organization for the future in an unpredictable world.*

Cambridge, 2018. [Online]
Available at: https://dictionary.cambridge.org/dictionary/english/scenario
[Accessed 11 April 2018].

Consultancy United Kingdom, 2015. *10 Largest management consulting firms of the globe.* [Online]
Available at: https://www.consultancy.uk/news/2149/10-largest-management-consulting-firms-of-the-globe
[Accessed 15 April 2018].

Davenport, S., Campbel-Hunt, C. & Solomon, J., 2003. The dynamics of technology strategy.

EY, 2014. *EY Voice, Organic vs. Inorganic: Which Way To Grow?.* [Online]
Available at: https://www.forbes.com/sites/ey/2014/01/14/organic-vs-inorganic-which-way-to-grow/#26e678d22d80
[Accessed 23 April 2018].

Ford, D., 1988. Develop Your Technology Strategy.

Heijden, K., 2005. *The Art of the Strategic Conversation.*

Heijden, K. et al., 2002. *The Sixth Sense Accelerating Organizational Learning with Scenarios.*

Höst, M., Regnell, B. & Runeson, P., 2006. *Att genomföra examensarbete.*

Jefferson, M., 2000. Long-term energy scenarios: the approach of The World Energy Council. *Global Energy Issues, Vol. 13.*

Kalsson, C., Hakkarainen, E. & Larsson, P., 1983. *Energibeslut.*

Kovacs, G. & Spens, K., 2005. Abductive reasoning in logistics.

Lindgren, M. & Bandhold, H., 2003. *Scenario Planning The link between future and strategy.*

Paltsev, S., 2016. Energy Scenarios: The Value and Limits of Scenario Analysis.

Paul Scherrer Institute, 2018. *Methods and Tools.* [Online]
Available at: https://www.psi.ch/eem/methods-and-tools
[Accessed 22 April 2018].

Paul Scherrer Institute, 2018. *PSI in brief.* [Online]
Available at: https://www.psi.ch/about/psi-in-brief
[Accessed 13 April 2018].

Piezunka, H. & Dahlander, L., 2014. Distant Search, Narrow Attention: How Crowding Alters Organizations' Filtering of Suggestions in Crowdsourcing.

Robson, C., 2002. *Real world research.*

Rogers, E., 2003. *Diffusion of Innovation.*

Roos, A. et al., 2014. Getting more value from Joint Ventures.

Rowley, J. & Slack, F., 2004. Conducting a literature review. *Management Research News.*

Runeson, P. & Höst, M., 2008. Guidelines for conducting and reporting case study.

Schoemaker, P., 1995. Scenario Planning: A Tool for Strategic Thinking. *Sloan Management Review.*

Wack, P., 1985. Scenarios: Uncharted waters ahead.

World Energy Council A, 2018. *About Us.* [Online]
Available at: https://www.worldenergy.org/about-wec/
[Accessed 14 April 2018].

World Energy Council B, 2018. *Global Energy Scenarios.* [Online]
Available at: https://www.worldenergy.org/work-programme/strategic-insight/global-energy-scenarios/
[Accessed 25 April 2018].

World Energy Council C, 2018. *WECs Global Expertise in Scenario Design.* [Online]
Available at: https://www.worldenergy.org/work-programme/strategic-insight/global-energy-scenarios/wecs-global-expertise-in-scenario-design/
[Accessed 15 April 2018].

World Energy Council, 2016. *World Energy Scenarios 2016 The Grand Transition.*

Yin, R., 1994. *Case study research.*

Appendices

Appendix A – Interview guide, case company

Before the interview

1. Determine time and place for the interview
2. Send the interview guide to the interviewee

During the interview

1. Present myself and the master thesis
    a. Present myself
    b. Present my work at the case company
    c. Present the overall questions intended to be asked
        i. Open and Closed questions on Developed/Developing/Planned Capabilities/Technologies/Competencies
        ii. Views on Scenario Analysis/Scenario Planning
        iii. Future beliefs (explore world views, if closed/open)
2. Introductory questions
    a. What is your role at the case company?
    b. How would you shortly describe your work in relation to Strategy Development
    c. What are your views on Scenario Analysis/Scenario Planning
3. State of **specific** Capabilities/Technologies
    a. Current had/Currently developing/Planned development/Active non-pursuit of Capabilities/Technologies/Competencies related to:
        i. Real-time data measurement
        ii. Real-time control with data
        iii. Optimising products/processes/services with data
        iv. Continuous connectivity
        v. Systems integration
        vi. IoT
4. Future Beliefs (explore mindset and world-view, open or closed)
    a. What are your current beliefs about the world up to 2030
        i. Customers values
        ii. Technologies
5. Concluding questions/Comments
    a. Possible specific business area questions
    b. Anything else that you feel is relevant, that I have missed to ask you?
    c. Do you have access to any documentation or similar that you can share with me? I appreciate everything. (regarding current development plans etc.)
    d. Do you have any overall tips/viewpoints on companies that are in the process of setting their technology strategy/developing new capabilities for the future?
    e. How may I use this interview in the final master thesis report?
6. Thank you for taking the time to help me.
    a. Is it okay if I reach out to you if we have any follow up questions?
    b. Would you like me to send you the report when it is done?

After the interview

1. Send feedback and possible follow up questions by e-mail.