Dealing with uncertainty in the challenge of the energy transition

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by

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to obtain the degree of Master of Science
at the Delft University of Technology,
to be presented on August 29th, 2022.

Project duration:	February 18th, 2022 – August 29, 2022	
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Worley energy | chemicals | resources

”All projects are uncertain. Uncertainty is inevitable since projects are unique and temporary undertakings based on assumptions and constraints, delivering project results to multiple stakeholders with different requirements.”

PMI-RM (2009)

Preface

Nearly a year ago I started orienting for a thesis topic to start working on in February of this year. As I thoroughly enjoyed the courses of my master degree, my main goal was to find a topic that I was enthusiastic about and believed would continue to capture my enthusiasm during the larger part of the thesis process. For me, an important aspect in this was the feeling of researching something that was not only of interest to me, but also to my supervisors. Finding the topic description on Brightspace on 'the certainty of uncertainty' triggered me immediately: I found myself enthusiastic about the topic, it was initiated by two of my lecturers and it was very open and vague (so that's got to be challenging and exciting, right?!). When I was still excited about the concept of uncertainty once I started developing my research proposal in February, I was convinced that topic-wise it would be a good match.

Now, eleven months after taking that first step, I can definitely say that I managed to achieve that main goal I described. Not only the topic, but also my supervisors have played a very important role in this. I therefore want to start with expressing my sincerest gratitude to my TU Delft supervisors Marleen Hermans, Marian Bosch-Rekveldt and Leonie Koops, who have been supportive, inspiring and critical throughout the process. Sharing ideas, allowing me to ask all my questions and the critical remarks on my progress helped me to look at things differently and to continuously improve my thesis.

Furthermore, I want to thank my external supervisor, Jacco van der Bij, who took me under his wing at Worley, introduced me to the people there and was always available for questions. I truly appreciate his involvement during the process of writing this thesis and the time he took to sit down for feedback or a spontaneous brainstorm session when I was in need of that. Finally, I want to express my gratitude to the interviewees and members of the expert panel who showed interest in my research and took the time to talk to me about a concept that in itself is vague and unclear, yet so interesting!

S. Toonen
Rotterdam, August 2022

Summary

Project management has been practiced for as long as humans have lived on this planet. Since then, the art of managing projects has developed immensely. Nowadays, the field of project management is still evolving with ongoing research that is performed on a wide scale. Always present, but usually not actively managed are uncertainties in projects. Uncertainty is a condition of a lack of knowledge that is present more dominantly in projects of an innovative nature. The energy industry is seeing a transition from oil and gas projects to new energy projects and sees significant changes in uncertainty as a result of that novelty. Successful uncertainty management is said to improve project success and this research looked into what features are needed for that. The research question was as follows:

"What features does a management approach need in order to deal with uncertainties in energy transition projects?"

Building upon a conceptual framework of elements that play a role in the management of uncertainties, an empirical study was performed to supplement the framework with experience from practice. The empirical study consisted of twelve interviews with project managers and sales managers within Worley Netherlands. These were followed by an expert panel and an external client interview. The latter two served the purpose of putting interview findings in perspective and provide an additional view on the concept op uncertainty in the energy transition.

From literature, it was found that uncertainty is an unavoidable element of project management. It is a lack of knowledge about something and its probability of occurrence and potential outcome are usually unquantifiable and immeasurable. Uncertainty is a dynamic concept of which the magnitude decreases over time as more information becomes available. Its presence complicates the management of projects as this means choices need to be made without all relevant information. Literature further showed that uncertainty management consists of different core elements: identification, classification and the act of dealing with uncertainties.

The interviews showed that currently uncertainties are not purposely handled. Based on examples and context, it could however be concluded that elements of uncertainty management are subconsciously applied. Unknowingly in the sense that they are often not used to tackle uncertainties specifically, but risks instead. The empirical study also aimed to identify the differences between the conventional energy industry and the energy transition industry. This was done to determine whether these differences would lead to necessary adaptations in the project management approach.

The final conclusion of the research is that first and foremost, the management approach should be complemented with an uncertainty management plan that extends current risk management practices. The management of uncertainties should include an identification and classification procedure before deciding on the way of dealing with uncertainties, accompanied by an appropriate response. As uncertainty develops over time, monitoring of uncertainties should be done on a regular basis throughout the duration of a project. The overall management approach thus requires a flexible attitude so that changes in the management process of a project can be made if deemed suitable or necessary.

With the research limitations of a single perspective, future research should look into a more extensive case study to get a better understanding of the situation in the industry as a whole. Similarly, the concept of dealing with uncertainty should be studied across different industries. The study should be performed and results should be compared in order to draw parallels and identify differences for cross-industry learning purposes. In addition to that, the components of the conceptual framework should be tested for applicability in practice and finally, an uncertainty management plan should be developed.

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Introduction

Project management has been practiced for as long as humans have lived on this planet. Way before the existence of project management tools, knowledge books and overarching project management institutes existed, many large projects had already been successfully completed (Seymour and Hussein, 2014). Since then, the art of managing projects has developed immensely. It has become more clearly defined and the above mentioned tools and guidelines have been developed. Nowadays, the field of project management is still evolving with ongoing research that is performed on a wide scale. Globalization, limited resources, stakeholders, competition, economy, and a number of other variables are all contributing to the evolution of businesses and their environments and require reactive project management (Construction Industry Institute, 2014).

In future one thing is certain: project managers in the twenty-first century must be flexible to constant change, uncertainty, and disruptions in order to thrive (Seymour and Hussein, 2014). Over the course of history, the identification of risk and its management has become an indispensable element of project management as it aims to systematize knowledge, information, and uncertainties regarding the phenomena researched (Flage et al., 2014). Nevertheless the concept of risk and uncertainty is one that is not always well understood (Padalkar and Gopinath, 2016). The terms risk and uncertainty are often used interchangeably, despite not being the same (Koleczko, 2012; Mentis, 2015). Better understanding of the difference, as well as the definition of both terms separately can improve project success (Padalkar and Gopinath, 2016).

Uncertainty is a condition of a lack of knowledge (Koleczko, 2012) and requires project managers to anticipate in order to limit negative outcomes. Despite the ever present uncertainties in projects, project management seems to be failing in focusing on all the uncertainties that may influence project outcomes (Atkinson et al., 2006). In meetings of the Rethinking Project Management Network it was suggested that an explanation for this is that project management is generally too focused on operational planning and control (Atkinson et al., 2006; Daniel and Daniel, 2018). Planning, coordination, setting goals, and change control procedures all aim to directly handle uncertainty (Atkinson et al., 2006). Still, the variety of sources, as well as the impact a coordinated approach may have on uncertainty management are often not recognized.

Naturally, experience plays a large part in recognizing uncertainties and handling them. A project manager who has been working in the field for a longer time and has more experience than someone who is new to it is likely to identify more, and a greater variety, of uncertainties (Atkinson et al., 2006). However, what happens if uncertainties are unforeseen not because of a lack of experience, but because of technological innovation in a project or the fact that the project is in a new, partially known market (De Meyer et al., 2002a)?

As a result of high complexity and rapidly changing environments in which projects need to be carried out, the need for uncertainty management is high. Generally, this is with the motivation of reducing negative outcomes of uncertainty rather than seeking the opportunities that may come out of

uncertainty (Hillson, 2002; Johansen et al., 2014; Ward and Chapman, 2003). Especially because of a constantly changing project environment and the naturally dynamic nature of projects, the management process should be considered to be something continuous, rather than something that is only needed when something unexpected occurs (Jaafari, 2001). It is therefore something that should be managed throughout the entire project. Kolltveit et al. (2005) do say that, if managed strategically, in pre-execution phases the opportunities can be seized and risks can be avoided.

Academics agree that within projects of an innovative nature, uncertainties play a very important role (De Meyer et al., 2002a; Russo et al., 2013; Williams et al., 2021). In fact, uncertainty is a knowledge gap that is inherently present in innovation projects (Williams et al., 2021) and by reducing this uncertainty, the success rate of these projects can be increased (Lievens and Moenaert, 2000). Not only the recognizing of new uncertainties, but also their management in a new industry is a complicated task. It therefore requires identification of uncertainties that may arise within this new context and an analysis of the suitable way of managing these type of projects. Furthermore, Russo et al. (2013) claim that the more innovative a project is, the more likely it is that unforeseeable uncertainties will occur. However, if managed insufficiently, unforeseeable uncertainties may have a great negative influence on the outcome of said project (Weick, 1995).

With the current energy transition, driven by global sustainability goals that impact national development plans, sustainability goals and political strategies, new challenges arise, bringing new uncertainties. In order to achieve said goals, often new technologies are developed to be implemented. In 2020, Worley has set the commitment to reduce their carbon emissions with 50% by 2025 and with 100% by 2030 in scope 1 and 2. Scope 1 referring to the direct emissions from sources that Worley owns or controls (e.g. emissions from burning LPG) and scope 2 to the indirect emissions that come from purchased energy (used to power fabrication yards and office buildings). In addition to this, the company strives to derive 75% of its revenue from sustainability-related business by 2026 (Worley, nd). An important element in enabling this is the shift from the traditional oil and gas industry to more sustainable energy projects. The closer we get to the 2030 deadline, the higher the pressure to make changes for the better. These projects will bring new uncertainties that are still to be discovered. Needless to say, with (a) new (type of) uncertainties, project management methods have to be tested to the new situation and may have to be reconsidered. These green(er) projects are part of a still developing market and as Worley wants to be part of this transition, they want to gain market share in this industry. All these different aspects may play a role in a change in the type of uncertainties that occur in these new projects. However, what can be observed in practice?

This research aims to fill the gap of what kind of new uncertainties can be expected with the energy transition and what features are required for project management approaches to deal with these new (type of) uncertainties appropriately. In sections 1.1 and 1.2, the scope of this research is defined and the thesis outline is laid out.

1.1. Scope

As this research forms a master thesis, there is a limited time-frame of six-and-a-half months. Therefore, to narrow down the field of research into uncertainties, the choice was made to focus on energy transition projects specifically. In the following subsections, a number of scope defining elements are elaborated. First, the context of the research is touched upon, after which different concepts of the research questions are discussed in order to demarcate what aspects are considered in this thesis. This concerns the 'uncertainties', the 'management of projects' and the 'type of projects' that are considered, both when talking about energy transition projects, as well as conventional projects.

1.1.1. Context

This thesis is written in collaboration with Worley: a global provider of project and asset services in the energy, chemical and resources sectors. Worley therefore forms the context for the empirical study in this research project. Moving away from traditional oil and gas industry, the company strives for 75% of their projects in the near future to be in the sustainability related business. More information on Worley as case-study can be found in chapter 4.

1.1.2. Uncertainties

Uncertainties arise due to a lack of knowledge. An observation from the literature is the recurring emphasis on the difference between uncertainties and risks. These terms are often used interchangeably, as if the same, but that's not the case (Koleczko, 2012; Mentis, 2015). In early literature, risks and uncertainties are considered two different types of uncertainty (Knight, 1921). The explanation of the two terms in recent literature is still based on this definition. The overall consensus seems to be that risks have a probability of occurrence and uncertainties are usually unquantifiable and immeasurable (Daniel and Daniel, 2018; Koleczko, 2012; Mentis, 2015; Regan and Gold Coast, 2011).

In this thesis, risk is considered a subset of uncertainty. Both concepts are taken into account and shall not be used interchangeably. Furthermore, risks may be positive or negative. Whereas negative risks are often referred to in literature as threats, positive risks are known as opportunities or simply as positive risks. Threat and opportunity are placed at a same level as subset of uncertainty. A more elaborate description of uncertainty in relation to risk can be found in section 3.1. The following definition of uncertainty, as assembled from the literature study, was leading:

"Uncertainty is a lack of understanding which may grow to be a risk or an opportunity as more information becomes available. Risk is therefore a subset of uncertainty (Hillson, 2003) and is quantifiable as a result of knowledge and past experiences. For uncertainty, both the probability of occurrence, as well as the potential impact cannot be quantified (Daniel and Daniel, 2018; Koleczko, 2012; Mentis, 2015; Regan and Gold Coast, 2011)"

1.1.3. Management of projects

Early in the 21st century, a lack of unifying theory related to the two different perspective of project management and management of projects was starting to be recognized (Smyth and Morris, 2007). This is one of the reasons for the difficulty experienced in managing complex projects. Daniel and Daniel (2018) elaborate these two perspectives on project management: project management is the narrow sense and management of projects considers the broad sense. The first perspective is execution based and focuses on the output of a project, in line with the Project Management Institute's model. The second allows for a new definition of project success, is more strategic and therefore focuses on the outcome of the project implementation phase (Pinto and Winch, 2016; Turner and Cochrane, 1993). These perspectives were similarly linked to the 'task' perspective and the 'organisational' perspective respectively (Andersen, 2014) of which the differences are presented in table 1.1.

	Task perspective	Organisational perspective
Main focus	Execute defined task	Create desirable development in another organisation
Project success	Stick to planning, minimize costs and optimize quality	Achieve goals
Nature of goals	Determined at the start	Changing targets
Plans and planning	Activity oriented	Milestone oriented
Philosophy of delivery	As quickly as possible	In line with organisation's processes
Team	Hierarchical structure	Includes stakeholders
Type of organisation	Action-oriented	Action- and political-oriented
Leadership style	Transactional	Transformational
Controlling	Time, cost, quality	Holistic view on value creation

Table 1.1: Difference between task and organisational perspective (Andersen, 2014)

As both terms include different elements it is important to elaborate on what is considered in this thesis and why. A lot of research is done into how uncertainties can be managed best in order to manage different elements of projects, such as cost and time. However, because of the fact this thesis

considers uncertainties in a new market, with a significant degree of innovation, the scope should not be limited to only these elements. The management of projects, rather than project management, throughout this thesis can be considered management not only of projects, but also project portfolios. It will be explored how projects are currently defined when a project is initiated. How much freedom do project managers have to alter their strategy when they run into (insurmountable) uncertainties? This broad definition of the management of projects will allow for broad data to be gathered and final results of interviews to provide an insight into how to alter the management of uncertainties for the better.

1.1.4. Projects

In this thesis, three project phases are considered: the initiation, preparation and execution phase. Furthermore, in the empirical research, two types of project are distinguished: energy transition projects and conventional energy projects. Considering also the conventional energy projects provides a base-case for the study. Namely, this industry is well known and professionals have experience in that industry. Therefore, being able to compare both industries based on their characteristics, the uncertainties that arise and the way these are dealt with, allows for an insight into how uncertainties can be better dealt with. Both types are briefly explained next.

Energy transition projects

Energy transition projects refer to the new type of project within Worley. These concern hydrogen, biochemicals and biofuels projects, but also improvements of conventional structures, making them more sustainable. These projects contribute to Worley's goal of having 75% sustainable business by 2026. Many, but not all, of these projects are performed for clients that have been working with Worley for a longer period of time, already in the conventional oil and gas industry, who are also transitioning towards a greener business. These projects can often be characterized further by different (types) of technologies, making these projects technologically innovative to some extend.

Conventional projects

The conventional energy projects are the type of projects that used to be Worley's sole and main business. These were in the more traditional energy industry, namely that of refining and petrochemicals. While Worley is transitioning to a different type of projects, the company still has projects in this industry.

1.2. Thesis outline

Figure 1.1 shows the different chapters of this thesis and how they relate to the sub-questions. It starts with a literature study on the concept of uncertainty in chapter 3 which resulted in the conceptual framework that served as the basis for the empirical study. For background purposes for the case-study, chapter 4 describes processes and procedures that Worley maintains. In chapter 5, the results of the empirical study, the interviews, are presented, analysed and interpreted on the basis of the theoretical framework developed before. This is followed by the findings on the difference between the energy transition and conventional energy industries in chapter 6. Putting the interview results in perspective of Worley context and out of the boundaries of project and sales management, an expert panel was organized and a client was interviewed for an outside perspective. The reflection of these sessions in relation to the interview results are presented in chapter 7.

Finally, chapter 8 provides the discussion, followed by the conclusions and recommendations for future research in chapters 9 and 10 respectively.

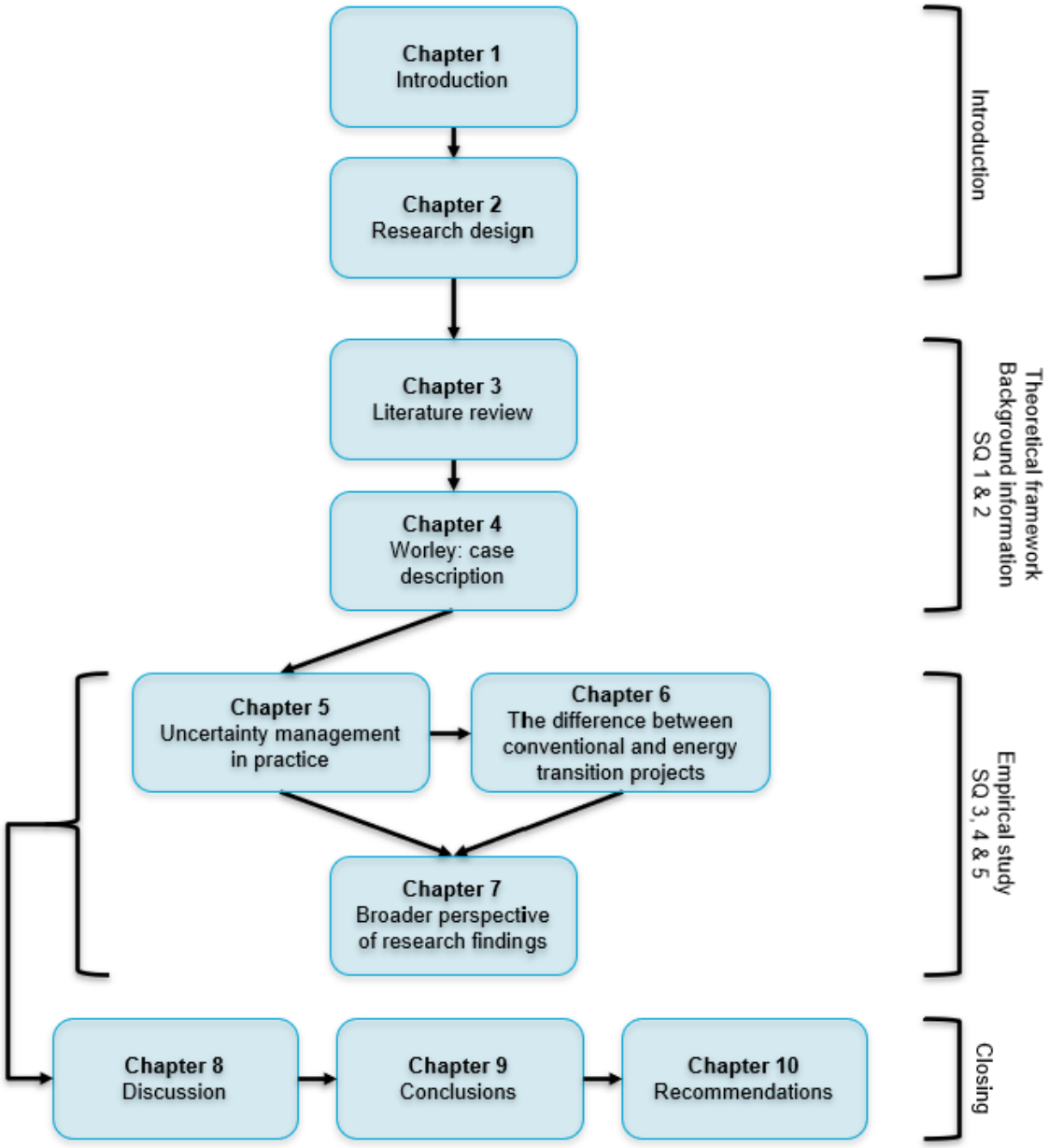


Figure 1.1: Thesis outline

2

Research design

This chapter describes the research design. The first two sections describe the research objective, followed by the research question. Finally, the research and data gathering methods are discussed.

2.1. Research objective

The objective of this research is to identify important features of a project management approach to deal with uncertainties that occur under the new circumstances of projects associated with the energy transition. To do so, awareness needs to be created as to the relevance of different uncertainties in the energy transition industry and a framework shall be developed to help respond to these uncertainties.

2.2. Research question

This research answers the following question:

"What features does a management approach need in order to deal with uncertainties in energy transition projects?"

To form a better understanding and to answer the main research question, the following sub-questions are formulated.

1. What are uncertainties in projects?
2. How can uncertainties be dealt with from a broad project management perspective?
3. How are uncertainties currently handled in energy transition projects?
4. What makes energy transition projects different from conventional projects?
5. What changes in management methods could be implemented to deal with uncertainties in energy transition projects?

2.3. Research methods and data gathering

The research is composed of two parts: a literature study (secondary data) and an empirical study (primary data). At first, a literature review was performed on the topic of uncertainty in project management within the defined scope. This part of the study aimed to answer sub-questions 1 and 2 and elaborated on what uncertainties are and how they can be managed. Next, exploratory qualitative research was performed through an empirical study. By means of interviews and an expert panel, sub-questions 3 and 4 were answered on the basis of practical experiences. Finally, the findings from literature and from the empirical study were compared to answer sub-question 5. To eventually find an answer to the main research question, answers to sub-questions 2, 3, 4 and 5 were considered.

Figure 2.1 shows a schematic representation of the research process. The black lines show the order in which the different elements of the research are addressed. The dotted lines indicate the origin of the input. This means that to answer sub-question 5, results from sub-questions 2 through 4 are used as input.

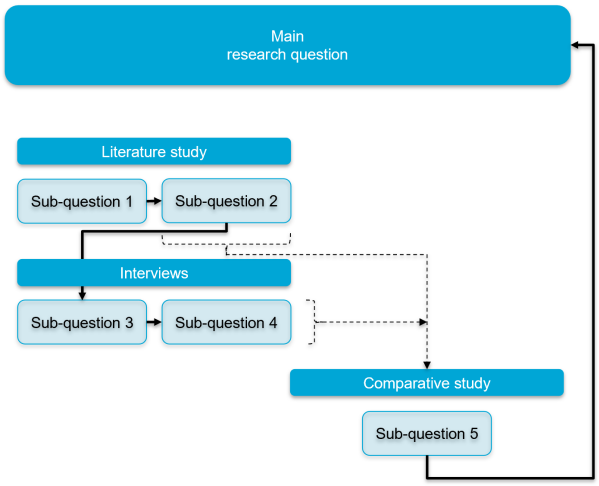


Figure 2.1: A schematic representation of the research methods per sub-question

In subsections 2.3.1 and 2.3.2, the choice for a literature study and interviews is justified, the intended approach is elaborated on and the data collection is explained. These are followed by subsection 2.3.3 that explains about the expert panel and finally, section 2.3.4 describes the methods for analysing the data.

2.3.1. Literature study

First of all, a clear picture had to be formed of the concept of uncertainty. As a lot of research has been done on this topic already, a literature study was deemed most suitable to provide a conceptual framework. The literature study was needed in this thesis for a number of reasons. It contributed to gaining methodological insights (Gall et al., 1996) on the topic of uncertainty and provided further context of the problem, as well as understanding of the structure of the subject (Hart, 1998).

For the literature study for sub-questions 1 and 2, a great variety of papers was consulted, aiming to develop a conceptual framework which formed the basis for the empirical study. However, due to the abundance of literature on the concept of uncertainty, demarcating the scope was crucial (see section 1.1). The starting point for the literature study concerned what uncertainties actually are, how they can be identified and managed. Keywords and phrases used in this early phase were:

- Risk and uncertainty
- Complexity
- Uncertainty
- Uncertainty management

Only scientific sources were used from the following scientific databases: Scopus, JSTOR and ScienceDirect. Preferably, these sources were published in the past ten years. However, this rule was deviated from if it concerned sources that were still relevant despite their age. Furthermore, the literature study was considered completed once the same sources kept coming up and no additional information was found.

2.3.2. Interviews

This thesis was subject to a certain degree of confidentiality related to projects that are discussed in the interviews. For this purpose, all (company) names and projects have been anonymized.

The choice for interviews was made to acquire information from practice rather than theory in order to get a more complete overview of the research problem. With the interviews, information was sought to answer sub-questions 3 and 4. The interviewees were organized in two groups: sales managers involved in acquiring projects and project managers, mostly involved in the preparatory and execution phases of projects. The interviews helped to understand what the managers run into in the current handling of uncertainties in energy transition projects, which was an important basis for answering sub-question 5 and the main research question as well.

In addition to that, a project manager from the client side was also interviewed. The reason for this was to get an outside view on the topic and gain a first idea of clients' perception of uncertainties in energy transition projects.

The interviews were semi-structured, allowing for in-depth interviews that were conducted once (Strauss and Corbin, 1998). Each interview lasted 60 minutes, in line with the usual range of a 30 to 60 minute duration of semi-structured interviews (Crabtree and DiCicco-Bloom, 2006). To ensure that all required topics were covered in the interviews, as well as to get comparable information from the interviewees, an interview guide was developed as a guideline for the interviews. The interview guide was developed along the framework guidelines by Kallio et al. (2016). Three pilot sessions were held to optimize the guide step-by-step. The final guides, for both Worley interviews and the client interview are presented in appendix A.1.

The choice for semi-structured instead of fully structured was made in order to preserve the option of asking follow-up questions. The format of a focus group was not deemed suitable because of the limited number of questions that are usually discussed, as well as the variety in background when interviewing people from two different groups. Furthermore, organizing a group discussion was not the desired process for gathering information related to experiences. In addition to that, the effectiveness would have depended on the way the participants interact with one another (Bhasin, 2019) which also made the format of a group discussion unsuitable.

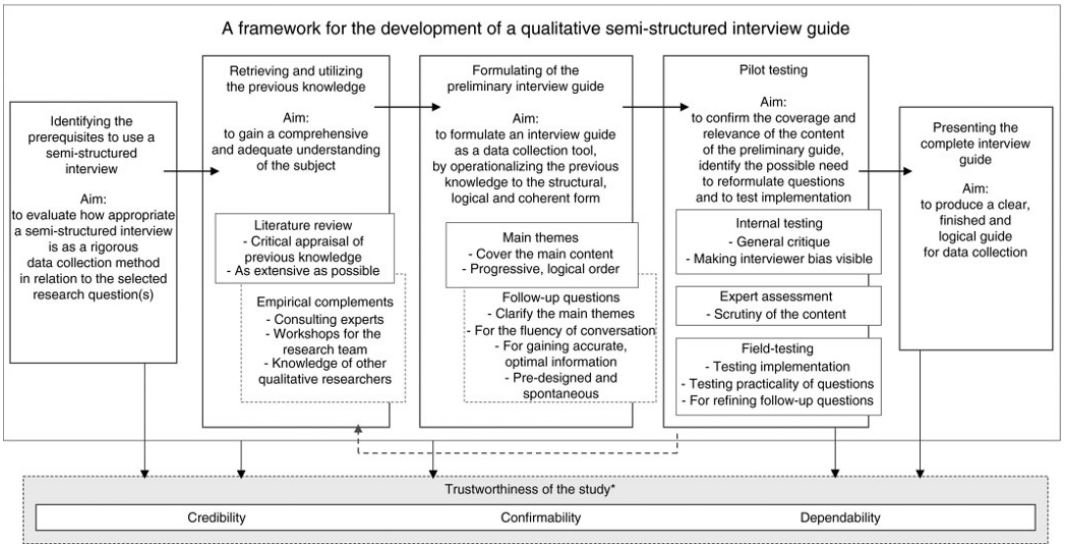


Figure 2.2: The phases of a semi-structured interview guide (Kallio et al., 2016)

Prior to the interviews, the interviewees were not given any detailed information about the topic other than the general description of uncertainties and the energy transition. This was done to avoid getting 'desired' replies. Each interview was recorded and afterwards summarized in the form of a report to be approved by the interviewee.

2.3.3. Expert panel

After the interviews, based on key findings, statements were developed and presented in a five-headed expert panel composed of members of the management team of Worley Netherlands. Due to the limited time available for the session, the choice was made to present three statements and spend twenty minutes on each of them. The goal of this session was to spark the discussion on these three topics, in order to provide a broader context for the results and potentially complement these results. The panel members were asked to share their thoughts on the topic from a broader perspective, not on project level within the boundaries of managing a project or the processes around sales. The preliminary findings that underlie the statements were then shared with the experts in order to allow the panel members to react to this in the discussion that followed.

2.3.4. Data analysis

For the literature review, the findings from different sources were compared, juxtaposed and combined to result in a conceptual framework. This was done within the elements of uncertainty management that showed to be the most common themes in the concept. Next, the interview results were analysed with a content and thematic analysis. For the latter, the themes were deducted from the literature study. This analysis process was performed twice, both times from scratch. The results were then combined to create a more complete analysis. Finally, the client interview and the expert panel were used to reflect on the findings from the interviews with sales and project managers and put the responses in a broader perspective.

3

Literature review

In this chapter, a theoretical framework is developed to form the basis of the empirical study in chapters 5, 6 and 7. The literature study aims to provide the information needed to answer sub-questions 1 and 2. It will form the context for the interviews. In order to do so, uncertainties are first defined for better understanding of the concept. Next, in section 3.2, the presence of uncertainty in projects specifically is discussed and it is followed by a section on how to deal with this uncertainty and the human reactions to uncertainty. Finally, key takeaways are schematized in a theoretical framework.

3.1. Defining uncertainty

Despite a lot of research on the topic, the concept of uncertainty remains vague and unknown. The characteristics of uncertainty make it challenging to define uncertainties in the first place, but even more so to anticipate on them. As the term 'uncertainty' is often loosely used in project management, it is often used incorrectly or used to indicate varying occurrences. The interpretation of its definition has therefore become multi-interpretable, making it key to consult literature to define uncertainty. First, the relationship between complexity and uncertainty is discussed, after which the difference between risk and uncertainty is studied.

3.1.1. The relationship between complexity and uncertainty

Daniel and Daniel (2018) performed a comparative analysis of the literature on uncertainty and complexity which showed several similarities. First of all, the study showed that the two concepts are likely to be confused with one another and concluded that both are regarded as disjointed. The overall consensus is that uncertainty within a project is often associated with its (perceived) complexity (Daniel and Daniel, 2018; Sommer et al., 2009; Turner and Cochrane, 1993; Williams et al., 1995). According to Ward and Chapman (2003), the inter-dependencies of potentially influential factors on the course of a project is a component of complexity. He also argues the degree of project uncertainty is determined by said complexity. Where Atkinson et al. (2006) agree with this line of thought and hence consider complexity as an element of uncertainty, Geraldi and Adlbrecht (2007) and Geraldi et al. (2011) support the notion that it is the other way around: uncertainty as an element of complexity. Complexity is increased because of the changing circumstances that arise due to uncertainties (Dunović et al., 2014). Literature further shows a third argument, namely that of complexity and uncertainty being independent of one another (Padalkar and Gopinath, 2016).

A lot of research done on the complexity of projects acknowledges two types of complexity: structural and dynamic (Benbya and McKelvey, 2006; Maylor et al., 2008; Remington and Pollack, 2007; Ribbers and Schoo, 2002; Xia and Lee, 2005). Both concern a relationship between complexity and the managerial capacity of prediction, which, in its turn, is needed for dealing with uncertainty. Structural complexity concerns the interactions that lead to inexplicable effects, whereas dynamic complexity focuses on the processes that lead to such effects (Floricel et al., 2016).

Having shown from literature the unclear relationship between complexity and uncertainty, it is of interest to discuss the sources of complexity to see what impacts the degree of uncertainty in this context. According to the Project Management Institute (PMI), sources of complexity can be categorized into human behaviour, system behaviour and ambiguity (Project Management Institute, 2004) which corresponds with the dimensions as described by de Bruijn et al. (1996) and further research building upon that categorization. Seeking an improved means for characterization and understanding of complexity, Bosch-Rekveldt et al. (2011) developed a framework for characterizing project complexity in large engineering projects, which is said to be one of the most exhaustive efforts in doing so (Floricel et al., 2016). This framework, called the TOE framework, classifies complexity contributors in the categories technological, organizational and environmental. These categories are each divided into subcategories which are then subdivided into elements. This setup allows for amendments and expansion for making it useful in a variety of industries (Bosch-Rekveldt et al., 2011).

3.1.2. The difference between risk and uncertainty

Uncertainty and risk are elements in project management that are made up of aspects coming from engineering, human behaviour, mathematics, psychology and sociology (Smithson, 2015; Song et al., 2007). The two are by some considered crucial elements in the successful completion of a project (Al Hasani, 2018). As overarching term to cover both risk and uncertainty, therefore implying they may be similar, but not the same, Mentis (2015) uses the term 'threat'. However, observed from literature is the recurring emphasis on the difference between uncertainties and risks. These terms are often used interchangeably, as if the same, but that's not the case (Koleczko, 2012; Kolltveit et al., 2005; Mentis, 2015). Not only in its definition, but also in ways they are treated and/or dealt with (Perminova et al., 2008). The Project Management Book of Knowledge (PMBOK) states risk and uncertainty are very similar, but have a cause/consequence relation rather than being the same. Atkinson et al. (2006) argue that it is dangerous to confuse uncertainty and risk as it is said to lead to a focus on planning and operational control rather than strategic issues. It is therefore important to emphasize the difference between the two.

In early literature, risks and uncertainties are considered two different types of uncertainty (Knight, 1921). This definition still underlies the explanation of the two terms in more recent literature. Uncertainty is defined as something that arises when past experiences and observations cannot produce a subjective probability or relative frequency for the future (Davidson, 1991). This case in which not all relevant parameters can be known is termed differently by a great variety of authors. 'Unawareness' and 'unforeseen contingencies' (Kreps, 1992; Modica and Rustichini, 1994), 'unstable non-determination' (Littauer, 1967), 'wicked problems' (Rittel and Webber, 1973) and 'unknown unknowns' (Wideman, 1992) have been different terms for the same situation that was described by Davidson (1991).

In more recent literature, the overall consensus seems to be that risks have a probability of occurrence and uncertainties arise due to a lack of knowledge (Koleczko, 2012); they are usually unquantifiable and immeasurable (Al Hasani, 2018; Daniel and Daniel, 2018; Koleczko, 2012; McLain, 2009; Mentis, 2015; Regan and Gold Coast, 2011). Uncertainty is considered an unavoidable element of project management in which assumptions have to be made in order to develop expectations about the outcome of a project (Lechler et al., 2012). Risk on the other hand refers to the combination of probability and consequence of not meeting a specific project goal (Al Hasani, 2018) and can be quantified on the basis of past experiences and/or events. Lechler et al. (2012) define uncertainties as "unknown unknowns" and risks as "known unknowns".

The core difference between risk and uncertainty was first noted by Bayes, whose research showed the influence of environmental factors on uncertainties (Skinns, 2011). Table 3.1 shows different traditional perceptions of the concepts of risk and uncertainty in an overview.

Streams	Uncertainty	Risk
Hey J.	Lack of certainty	Uncontrolled certainty
Keynes J.M.	Unquantifiable	Quantifiable
Knight F.H.	No probabilistic determination	Certainly a probability
Neo-classical	Vague, non compensatory risk	Certain equivalent of uncertainty
Neo-Keynesien	Unpredictable damage	Predictable loss

Table 3.1: Difference between uncertainty and risk (Toma et al., 2012)

To elaborate a little more on the differences between uncertainty and risk, it is clear that when it comes to uncertainty, a decision maker lacks information for identifying possible events and their occurrence probability as a result of their impossible objective predictability (Spencer, 1962; Toma et al., 2012). In addition, the potential outcome of an uncertain event is also unknown and incalculable (Al Hasani, 2018). In contrast, true assumptions based on objective predictability can be made when it comes to risks and it is a state of uncertainty of which the outcome can in fact be known.

When it comes to decision making, the concepts of risk and uncertainty in relation to complexity are seemingly linked through the concept of predictability (Daniel and Daniel, 2018). The conditions with which decision are made under risk and uncertainty are however of a different nature. When dealing with risk, conditions are close to problems of disorganized complexity, whereas with uncertainties, the conditions tend towards organized complexity.

3.2. Uncertainties in projects

The cause for uncertainty is a lack of information when decisions ought to be made (Jaafari, 2001; Winch, 2015). As each project has at least some degree of uniqueness to it, uncertainties can never be eliminated. In fact, as a result of this uniqueness it is challenging to know the extent and detail of information needed for making a decision. During the course of a project, both the type, as well as the degree of uncertainty develop dynamically (Kreye et al., 2019; Winch, 2015). Throughout the project, as more information becomes available, the degree of uncertainty decreases. Jaafari (2001) schematized this development of uncertainty in different project stages and under influence of a varying number of variables (figure 3.1).

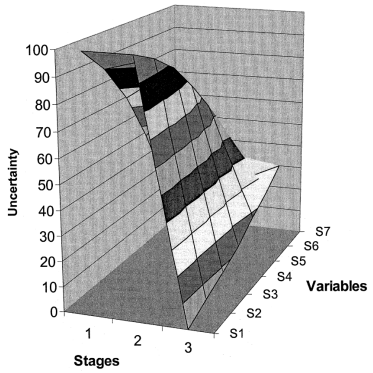


Figure 3.1: A schematic representation of uncertainty at different project stages (Jaafari, 2001)

High degrees of uncertainty characterize highly unpredictable situations caused by factors such as a volatile environment, difficult work, or a lack of clarity in organizational processes (Kreye et al., 2019). Similarly, according to Jaafari (2001), project uncertainty has one of the following three underlying causes: external factors, changing business objectives and vaguely defined realisation methods. External factors may include market induced pressure, a misalignment of social, political and institutional norms or stakeholders changing their requirements. Vaguely defined realisation methods often result from a combination of a lack of knowledge, as well as experience and the fact that each project should be approached differently.

In the following subsections, first, the identification of uncertainties is discussed, followed by the classification.

3.2.1. Identification of uncertainties

To identify uncertainties, one must know their origin. When considering sources of uncertainty, one finds that this is very closely related to classifying uncertainties. Because in fact, many classifications are based on type and characteristics which are two aspects that are somewhat inherent to the specific sources of uncertainty.

Network discussions during the Network on Rethinking Project Management in 2006 lead to a distinction between uncertainties related to estimating, project parties and stages of the project life cycle (Atkinson et al., 2006). In developing estimates, there are a number of complicating factors involved. Often, one deals with a lack of knowledge and/or experience on a specific topic, activity or process. When it comes to project parties, the involvement of multiple parties is said to contribute to project uncertainty (Atkinson et al., 2006). Elements that contribute to this type of uncertainty may relate to (a misalignment of) party's individual objectives, the quality of work performed and deliverables and the abilities, combined with availability of each party involved (Ward, 1999). Finally, Atkinson et al. (2006) acknowledge that each stage of the project life cycle brings specific sources of uncertainty due to life cycle specific processes. This may therefore also include estimate related uncertainty.

For engineering projects specifically, O'Connor and Rice (2013) categorize uncertainty under 'technical', 'market', 'organisational' and 'resource' uncertainty. Kreye et al. (2019) find these similar types in their study of seven papers in engineering-management literature.

1. **Technical uncertainty:** Uncertainty related to scientific knowledge of the product, most often when it involves new technologies (Yao et al., 2013).
2. **Market uncertainty:** Concerns the challenges of understanding customer needs and ensuring the product fulfills these (Chu et al., 2018; O'Connor and Rice, 2013).
3. **Organisational uncertainty:** Arises with the growing need for communication within an organization (Preston et al., 2006; Santiago and Bifano, 2005).
4. **Resource uncertainty:** Concerns external resources such as financial resources, as well as certain skill of which amount and timing of supply may vary (O'Connor and Rice, 2013).

Linking back to the distinction made between internal and external uncertainties, Zheng and Monteiro De Carvalho (2016) schematize these sources of uncertainty according to this method. As seen in figure 3.2, internal uncertainties arise in a project itself, whereas external uncertainties come from the organization. The first are split between characteristics of an activity (its variety and analyzability) and organizational independence.

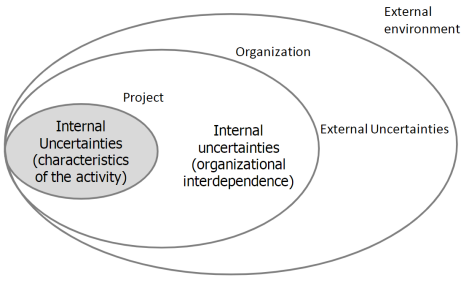


Figure 3.2: Classification of uncertainty sources (Zheng and Monteiro De Carvalho, 2016)

In his book titled "Effective opportunity management for projects - exploiting positive risk", Hillson (2003) looks into the identification of risks, where risks are considered "any uncertainty which, if it occurs, would affect one or more project objectives" (Hillson, 2003, p. 57). He considers risk a subset of

uncertainty and further distinguishes threats and opportunities. Hillson (2003) further suggests different ways for identifying threats and opportunities in an appropriate and thorough manner. He argues the use of a risk identification checklist, risk interviews, the SWOT (Strength-Weakness-Opportunity-Threat) analysis, the constraints analysis, force-field analysis and finally, scenario thinking.

The methods listed above as suggested by Hillson (2003) are all generally known and existing methods. Around the same time that Hillson published his book, Chapman and Ward (2003) published a paper with a more specific approach to identifying uncertainties. They developed a six W's framework consisting of six questions for which associated uncertainties are to be considered in addition to their interrelatednes.

1. Who are the parties involved?
2. What are each party's objectives?
3. What are each party's interests?
4. Which way will each party perform their work?
5. What resources are needed?
6. When is the work due?

Motivated by the proposition of dealing with uncertainty throughout the entire project life cycle, rather than limit the activity to the preparation phase, Johansen et al. (2014) built upon the six W's framework by Chapman and Ward (2003) and developed a nine step framework for the identification and management of uncertainties. The steps are depicted in the scheme as shown in figure 3.3. Step 1 and 2 imply the preparation phase of the process, step 3 through 7 are a group process in which uncertainties, both positive and negative, are identified and appropriate actions are decided on and finally step 8 and 9 represent the implementation of said actions and the adequate reviews.

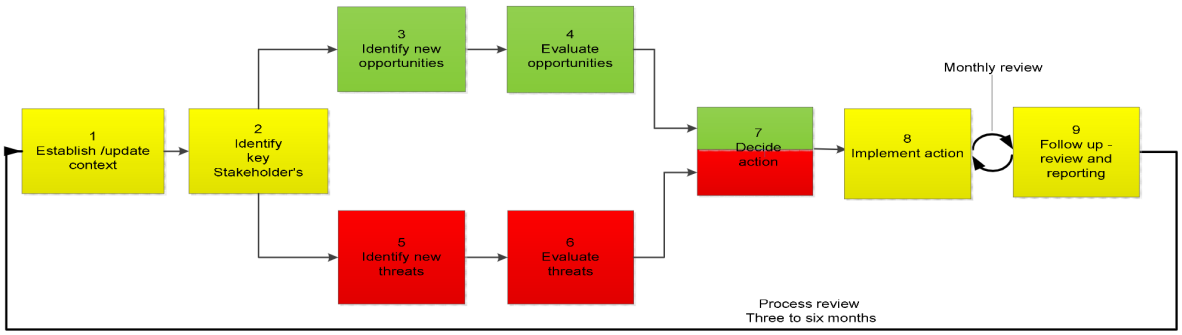


Figure 3.3: Nine step framework for identifying and managing uncertainty in projects (Johansen et al., 2014)

3.2.2. Classification of uncertainties

Literature shows a great number of ways of classifying uncertainties, based on different origins and characteristics. Taking into account the amount of information available about potential impacts, De Meyer et al. (2002b) identify four types of uncertainty:

1. **Variation:** Too small ranges and impacts of values to plan for, yet with the potential of impacting performance measures to vary around projected values.
2. **Foreseen uncertainty:** Identified uncertainties of which the impact is uncertain. Performance measures are therefore defined in terms of ranges rather than values and orderly risk management is required.

3. **Unforeseen uncertainty:** These are not identified in early project phases and thus can't be prepared for with a predefined response. This type of uncertainty is often present in (technologically) innovative projects or projects that enter a new market.

4. **Chaos/Turbulence:** Fundamental uncertainty about the structure of the project plan which arises when starting up a completely new project such as research projects.

Bradley and Drechsler (2014) propose a classification of uncertainties in a project based on three dimensions: its nature, object and severity. For the first type, a further subdivision is made into modal, empirical and normative uncertainty in relation to the nature of a certain decision. Modal uncertainty concerns what is possible and may be the case, whereas empirical uncertainty concerns what actually is the case and normative uncertainty relates to what is preferable. The object dimension considers the aspect about which a decision is being made and is split-up into factual and counterfactual uncertainty. Factual uncertainty concerning the way the world is and counterfactual if it were different from the way things are. Finally, the third dimension concerns the difficulty experienced when making a decision, which is often related to the amount of information available when having to make the decision. The latter category includes a classification similar to that of De Meyer et al. (2002b), on the basis of information available, but in relation to decision-making rather than impact. Luce and Raiffa (2022) developed a classification ranging from ignorance to certainty, with severe and mild uncertainty in between respectively. Ignorance is the situation with no information available for making a judgement. Severe uncertainty implies a situation with just sufficient information to make a partial judgement. Precise judgements can be made with sufficient information available in the situation of mild uncertainty and finally, certainty is achieved when a judgement can be valued without assumptions or approximations.

Most often literature on uncertainties distinguishes internal and external uncertainty (Hazir and Ulusoy, 2020; Kolltveit et al., 2005; Sicotte and Bourgault, 2008; Zheng and Monteiro De Carvalho, 2016) as defined by Galbraith (1973); Perrow (1967); Tushman and Nadler (1978) in what is considered groundbreaking research on the topic. Internal uncertainty is influenced by internal factors. Kolltveit et al. (2005) combined these two forms of uncertainty in creating four uncertainty profiles in which projects can be placed (see figure 3.4). Projects that fall within quadrant A1 can be characterized by overall low levels of uncertainty and should therefore be completed within time, budget and in accordance with pre-determined quality specifications without much trouble. In the top right quadrant, B2, both internal and external uncertainty is high. Such projects are more prone to risk and opportunities which both, if handled appropriately, can be of added value to a project outcome.

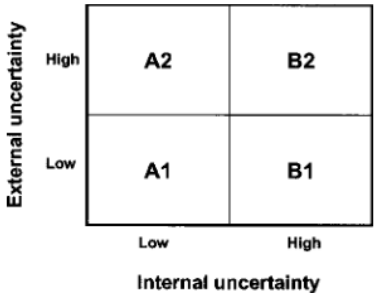


Figure 3.4: Project uncertainty profiles (Kolltveit et al., 2005)

Among these internal factors are factors related to the project's goals, its technical concept and the project management competence and organisational structure concerned with the project. The external factors that on the other end are of influence on the external uncertainty include relations with political or cultural situations, contractual arrangements, financial stability in terms of stability of a chosen currency for instance, but also local infrastructure. Based on a literature study of 47 papers published between 1996 and 2019, Hazir and Ulusoy (2020) categorized and schematized internal and external uncertainties as seen in figure 3.5.

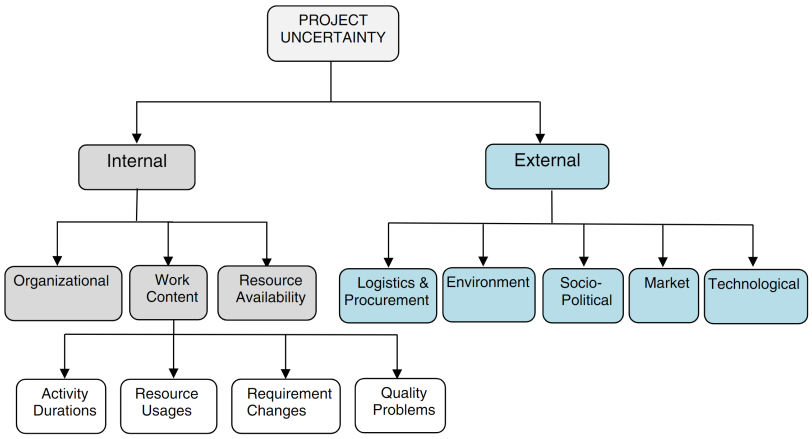


Figure 3.5: Internal and external uncertainty sources (Hazir and Ulusoy, 2020)

3.3. Dealing with uncertainties

”Project managers’ perception of uncertainty is important to understand and manage uncertainty”, so claims Perminova et al. (2008). A start with uncertainty management is made by identifying (relevant) sources of uncertainty for a specific project. The intuitive nature of this process supports the claim of the importance of different perceptions of uncertainty. After having identified and classified uncertainties and having considered their sources, once they actually arise, uncertainties ought to be dealt with. However, opinions are divided on what aspects need to be handled. Loch et al. (2008) suggest considering the degree of uncertainty and complexity when managing uncertainties. However, others suggest to tackle the impact of an event (Howell et al., 2010; Thamhain, 2013) or the context of the project (Barki et al., 2001; Howell et al., 2010).

Traditional project management often sees a focus on the performance measures time, budget and scope. Perminova et al. (2008) claim this focus limits the ability to learn from experiences and act in a flexible manner, which in its turn complicates reacting to uncertainty. Namely, one of the elements of uncertainty is the variability of said measures (Ward and Chapman, 2003) as it concerns estimates (Atkinson et al., 2006; Ward and Chapman, 2003). In contrast to risk management, uncertainty management is currently not commonly done in an active manner and therefore is also not very advanced. In risk management, basic sources of uncertainty are often overlooked as a result of considering only limited project life cycle stages (Atkinson et al., 2006). They explain this to be the result of the fact that uncertainty management takes into account all sources of compelling uncertainty, whereas the management of risks does not consider events that occur resulting from a lack of information. Taking into account a separate definition for uncertainties, rather than considering uncertainties and risks as one, a greater variety of uncertainties is likely to be identified and more responses can be prepared for (Ward and Chapman, 2003). A common misunderstanding is that when talking about uncertainties, only negative potential outcomes are considered. In reality, uncertainty management is a combination of risk management and opportunity management and therefore includes potential positive outcomes as well (Hillson, 2002; Ward and Chapman, 2003; Zheng and Monteiro De Carvalho, 2016).

Due to its conceptual nature and a continuously changing project environment, a flexible approach to dealing with uncertainty is required (Jaafari, 2001; Perminova et al., 2008). When failing to do so, potential risks and opportunities are more easily overlooked. In the management of uncertainties it is important to not only focus on cost, time and quality, but also on environmental, social, political and community aspects (Jaafari, 2001). Furthermore, it is important to regularly reflect on the changing environment in order to identify threats and opportunities in a timely manner (Perminova et al., 2008).

Another important element of handling uncertainties is the allocation of responsibility of uncertainties (Atkinson et al., 2006). This becomes complex when unforeseen uncertainties arise, yet still it can often be predefined who is responsible in different situations. Furthermore, the development of strate-

gies are useful and important in identifying sources of uncertainties (Atkinson et al., 2006).

In 1997, Hillson first published a paper describing his four-level maturity model for assessing an organization's uncertainty management awareness (Hillson, 1997). When *naive*, an organizations is fully unaware of the need for uncertainty management. An organization is deemed *novice* when a structured uncertainty management plan lacks, yet people start implementing it individually. Once an uncertainty management approach has been accepted and implemented organization-wide, the organization is considered *normalized*. Finally, a company reached the level *natural* if it takes on a pro-active approach to the management of uncertainties, both potential threats, as well as opportunities. Since this publication many more maturity models were developed. However, most concern the maturity of risk management, only considering the negative annotation of uncertainty. Hopkinson (2011) does support Hillson's model and defined the four levels in more detail in his book.

Looking at actual uncertainty management, Zheng and Monteiro De Carvalho (2016) developed a framework connecting the driver of management approaches to types of uncertainties based on their specific characteristics. This was developed on the basis of a literature study on managing uncertainties and is shown in figure 3.6.

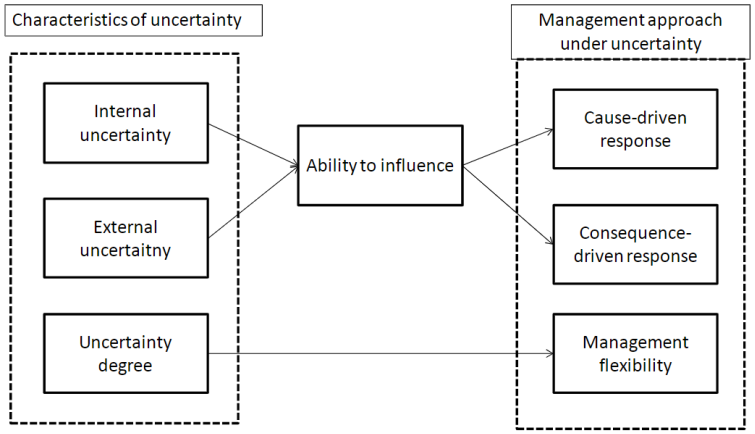


Figure 3.6: Framework connecting uncertainties to management approaches (Zheng and Monteiro De Carvalho, 2016)

As explained before, uncertainty management seeks to include both risk and opportunity management. The PMI described a six-phase risk process in the Project Management Book of Knowledge (PMBoK), consisting of the following steps:

1. Risk management planning
2. Risk identification
3. Qualitative risk analysis
4. Quantitative risk analysis
5. Risk response planning
6. Risk monitoring and control

In his study, Hillson (2002) aims to extend this risk process to manage opportunities as well, making that a relevant example to managing uncertainties according to the definition within the scope of this thesis. He extends the risk responses 'avoid', 'transfer', 'mitigate' and 'accept' with 'exploit', 'share', 'enhance' and 'ignore' for responding to opportunities and claims this extension can be made for every type of risk process.

The above responses can be roughly divided into responses that reduce uncertainty and ones that embrace it. Both are elaborated below.

3.3.1. Reducing uncertainty

Most literature on risk and uncertainty management focuses on its reduction rather than embracing it. Naturally, this has to do with the fact that many consider threat only and forget about potential opportunities. In addition to that, people rather make decisions without too much uncertainty in order to be confident about them (Webler et al., 1991).

Linking back to the risk responses by Hillson (2002), 'avoid', 'transfer' and 'mitigate' each aim to reduce this type of uncertainty; 'avoid' by taking measures to make it impossible for the risk to occur, 'mitigate' to reduce the negative effect of the uncertainty by tackling probability of occurrence and/or the impact. 'Transfer' is different in the sense that nothing is changed to either the event, the probability or the impact, but, once transferred, the uncertainty is reduced for initial party. One of the responses to opportunities also aims to reduce uncertainty. Exploiting opportunities seeks to eliminate uncertainty completely by making something happen for sure.

Despite a natural decrease in uncertainty as a project progresses, complete certainty is only reached when a project is finalized and delivered, and performance, cost and duration are all known. However, different things can be done to reduce the level of uncertainty throughout the process of a project. For instance, Atkinson et al. (2006) explain that the degree of uncertainty can be positively influenced when a higher degree of stakeholder involvement is observed. In accordance with the split between 'project mission uncertainty' and 'project dynamic uncertainty' as initiated by Winch (2010), Winch (2015) explains that the latter type can be reduced by for instance writing up comprehensive agreements with stakeholders in order to limit progress disruption threats.

Another way of reducing uncertainty is described by De Meyer et al. (2002a), who claim that with the right amount of effort invested, unforeseen uncertainties can be made foreseen which in a sense equals reduction of uncertainty. However, while some uncertainties can be changed into certainties, uncertainty can never be fully removed (Al Hasani, 2018).

3.3.2. Embracing uncertainty

As uncertainties may also create opportunities, you can argue that completely eliminating uncertainties is undesirable and one may want to embrace (a certain degree of) uncertainty instead. As Solnit (2016) states, recognizing and embracing uncertainty helps people to understand that they may be able to influence the event. In line with this suggestion, threats can be limited and opportunities may be seized. Embracing uncertainty doesn't equal simply accepting its existence and leaving it for what it is. In fact, embracing uncertainty may include active uncertainty management, yet not solely with the goal of reducing it.

For opportunities, Hillson (2002)'s responses 'share', 'enhance' and 'ignore' are of an embracing nature rather than reducing. Sharing opportunities is the opportunity equivalent of transferring risks. However in this case, if another party exploits the opportunity, both parties benefit. Enhancing an opportunity is attempting to increase the probability and the impact for maximum benefit. Finally, the 'ignore' response does not include managing it in an earlier stage, but instead requires a reactive, unidentified, approach. The one risk response that embraces instead of reduces is the 'accept' strategy. One accepts that some risks are unavoidable and therefore require risk monitoring and a reactive approach.

3.4. Dealing with uncertainty in different industries

As explained earlier in this chapter, the approach for dealing with uncertainties depends on the uncertainty's origin. This implies that uncertainty managements may vary in different industries. Considering this process in different industries may provide an insight in alternative ways of dealing with uncertainties.

In finance, a major uncertainty is the occurrence of volatility in market networks (Scoones, 2019) of which the effects are highly uncertain. Close feedback loops and identifying bottlenecks are mentioned to avoid systemic risks (Beale et al., 2011; Kambhu et al., 2007). Careful analysis of post-economic

crisis times showed the adaption of a more grounded and interdisciplinary approach (Scoones, 2019), which no longer focuses on overly simplified risk management models. Instead, uncertainty turned into something that was accepted as a ”subjectively constructed state of knowledge” (Haldane and Vasileios, 2012). This shift allowed for considering emotion and behaviours (Tuckett, 2011) and the implementation of adaptive management (Rammel et al., 2007).

The occurrence of a pandemic and especially when it will happen is something that is always uncertain in the medical industry. When it occurs, like COVID-19 did in the beginning of 2020, the situation is considered an emergency. All decisions and measures that need to be taken must be taken at a much higher pace than would be done otherwise. Richards (2016) studied the approach in the Ebola epidemic and observed that ”common sense, improvisations, distributed practical knowledge and collective action” from local professionals to be much more effective in limiting the number of deaths than the medical knowledge from outsider professionals (Hinchliffe et al., 2016; Lock and Nguyen, 2018).

The third and final example comes from the creative industry, the film industry specifically. This creative industry brings high levels of uncertainty for producer and consumer (Pokorny et al., 2019). Not knowing whether a movie will be a success, the demand for a film is highly uncertain. Pokorny et al. (2019) poses the question how firms can survive with such uncertainty with every movie they release. It appears that since the early 20th century, these firms opt for high levels of diversification of their portfolios in order to maximize portfolio return, rather than return on individual movies. However, a shift was seen towards decreasing portfolio size and diversity, aiming to develop optimally new content with each film (Thompson, 2017), allowing for charging higher prices for more popular films.

From these examples of uncertainty management in different industries, of the first two it can be said that ’project’ success was achieved through a flexible and adaptive approach. In both instances, standard procedures were let go of and intuition, emotion and common sense were used to respond. In the third example, diversification showed to be a successful way of dealing with uncertainty.

3.5. Human response to uncertainty

As discussed in section 3.3, there are many different ways of dealing with uncertainty. However, these approaches do not take into account the human factor of the decision-maker. Perminova et al. (2008) suggest Keynes’ literature showed there was a connection between human emotion and uncertainty which is established in three aspects that are analysed in a study by Al Hasani (2018): probability, delay and a lack of clarity . These aspects are touched upon in three traditional perspectives on human responses to uncertainty which are generally used to underpin psychological responses to uncertainties (Koleczko, 2012; Smithson, 2015):

1. The knowledge seeker
2. The certainty maximiser
3. The intuitive statistician-economist

A knowledge seeker develops new facts and skills, even though the uncertainty is on the short-term. They tend to have open communication, but generally, it is considered an idealistic view. Certainty maximisers seek to limit uncertainty as their sentimental, rational and functional abilities of a decision maker (Meng and Boyd, 2017). Another reason for wanting to limit uncertainty and therefore maximize certainty is the notion in literature that uncertainty is an equivalent of anxiety (Karimiazari et al., 2011; Keynes, 1936; Oliva, 2016). Finally, the intuitive statician-economist tends to focus on maximizing profits and minimizing loss (Bammer and Smithson, 2012). They carefully organize the different options and quantify each’ probability of occurrence. Combining this with the highest expected net benefit, a decision is made for the most favourable option.

3.6. Key takeaways and conceptual framework

Figure 3.7 illustrates the conceptual framework upon which this research builds. A lot has been written about the definition of uncertainty, the difference between uncertainty and risk and also the relationship between uncertainty and complexity. These elements are included in the left most part of the framework. The complexity element is linked to uncertainty with a two-way arrow, indicating their interrelatedness. From literature, the exact relationship could not be determined, however the relevance of the complexity element cannot be found in this exact relationship, but in the possible overlap of sources of complexity and uncertainty. This in its turn is of interest in finding a suitable way of managing the uncertainties.

Following the arrow down, as more information becomes available, uncertainty becomes a threat or an opportunity of which the probability of occurrence and/or impact can be quantified (Jaafari, 2001). This has also led to the definition of uncertainty which is leading in this thesis: *"Uncertainty is a lack of understanding which may grow to be a risk or an opportunity as more information becomes available. Risk is therefore a subset of uncertainty (Hillson, 2003) and is quantifiable as a result of knowledge and past experiences. For uncertainty, both the probability of occurrence, as well as the potential impact cannot be quantified (Daniel and Daniel, 2018; Koleczko, 2012; Mentis, 2015; Regan and Gold Coast, 2011)"*

Looking into the concept of uncertainty and also the management of it, it became apparent that uncertainty management is often considered an extension to risk management, thereby considering opportunity management as a separate process from risk management (Hillson, 2002; Ward and Chapman, 2003; Zheng and Monteiro De Carvalho, 2016). The management of uncertainties can be broken down into the identification of uncertainties, classifying them and consequently dealing with uncertainties with a suitable response. The identification of uncertainties can be done in different ways: using the six W's framework or a checklist, or through the process of a SWOT analysis, scenario thinking or performing interviews. Furthermore, the literature study showed that uncertainty sources can be identified as being internal or external (Hazir and Ulusoy, 2020; Kolltveit et al., 2005; Sicotte and Bourgault, 2008; Zheng and Monteiro De Carvalho, 2016), categorized in a general manner. One of the goals of the interviews is to learn about the uncertainties that Worley employees experience in this new industry, how they are different from uncertainties formerly observed and how these are dealt with. The source of these uncertainties is likely to be an important aspect in finding a suitable way of managing them (Cleden, 2017).

Classifying uncertainties is done for similar reasons. It looks at the cause and/or consequence of uncertainties (Zheng and Monteiro De Carvalho, 2016). More specifically, classifications are often done based on the identifiability, the potential impact, the type and/or amount of information available and finally, the source.

Finally, dealing with uncertainty requires three components according to literature. Understanding the concept of uncertainty is the starting point for dealing with it. For uncertainties that are known prior to occurrence or occur completely unexpectedly, responsibility should be allocated to the party most suitable to manage it. Thirdly, as uncertainty develops over time, flexibility is required throughout a project. Looking into the responses to uncertainty, literature provided three general responses: seeking knowledge, maximizing certainty and maximizing profits (therewith minimizing losses). Considering the examples from other industries, diversifying may also be added to that list. Generally, responses can be further categorized as being of a reducing or embracing nature.

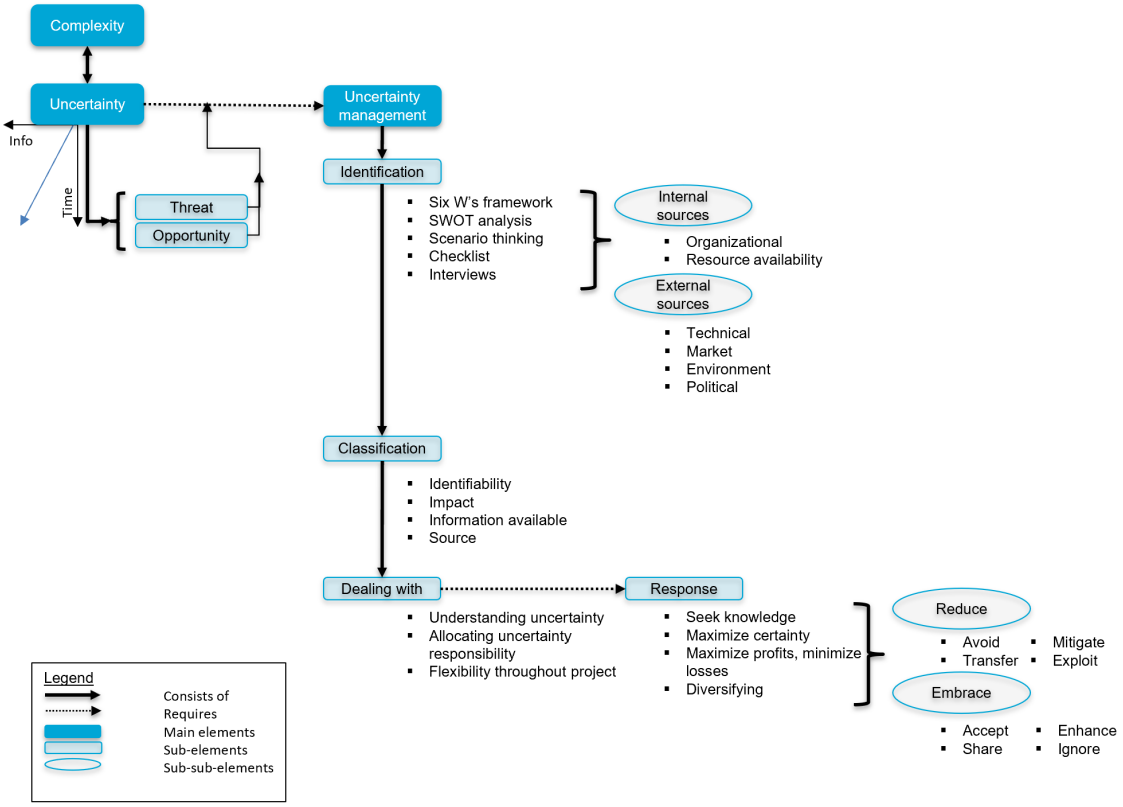


Figure 3.7: Conceptual framework

4

Worley: case description

Before moving on to the interview results, both for context and for reference this chapter provides a brief company description and background information on the steps and procedures that Worley utilizes, both on project level as within sales.

4.1. Brief company description

Worley is a global provider of project and asset services in the energy, chemical and resources sectors. In 2017 WorleyParsons Limited acquired Jacobs Energy, therewith taking over their business in the Netherlands among other countries. The company name then changed to Worley. Traditionally, Worley Netherlands' main business was in refining and (petro)chemicals. However, fueled by the global UN Sustainability Development Goals, Worley has set the goal of creating 75% of their revenue through sustainability related business by the year 2026. Nowadays, Worley Netherlands is one of the front runners within the company when it comes to more sustainable business, especially in the field of hydrogen.

4.2. Worley Ways of Working

In 2015, Worley started experimenting an agile and scrum way of working, which in this specific situation led to a decrease of average project duration from 60 weeks to 16 weeks. The company developed the Worley Agile Manifesto, comprising of four values and twelve supporting principles. The fourth value is 'responding to change', which is lived up to through increasing knowledge during the course of a project, allowing for fast and effective changes when necessary. Furthermore, Worley has developed process maps that are intended as guidance during project related processes. Worley's shared online environment 'Our Home' was consulted on the topics of relevance to this thesis: uncertainty, risk and opportunity. This was done for sales and project management as the interviewees originate from these two departments.

4.2.1. Sales

The sales team works to win projects. That process is divided into three phases: opening, middle and end game. The opening game contains marketing, campaigning and customer engagement, of which the latter contains 'customer evaluation and analysis' as a second step. In this step, the business potential is considered by looking at, but not limited to, the customer's needs, the available budget and the investment program. In addition to that, the customer's risk profile is determined. The middle game is made up of an exploration and differentiating phase. In the exploration phase, the opportunity of a potential project is explored. An important step in this is the assessment and classification of potential risks using the tool Risk Wizard in the Customer Satisfaction Program (CSP) and the initiation of appropriate response requirements. In the differentiation phase, mitigation strategies are evaluated for the identified risks. Finally, in the end game of the sales process, the proposal is reviewed by four different teams, in different stages of the proposal development. Right before the project handover, a Lessons Learned session is organized with all relevant stakeholders.

4.2.2. Project management
Worley identifies seven project phases that are used as common terminology for Worley and customers and also to identify the maturity of a project. These phases are: identify, evaluate, define, design, build, handover and asset management. The project management business process is divided into project management, stakeholder management, customer engagement, project organization, interface management, a project readiness review and advanced work package planning. The first always includes an analysis of risks and the incorporation of Lessons Learned of similar projects in accordance with Worley's Lessons Learned Standard. Within the interface management, project interfaces are identified as being technical, execution-related, organizational or communications. Another step entails the identification of interfaces that potentially impact the schedule or total cost.

4.2.3. Risk and uncertainty management
Worley defines risk as the effect of uncertainty on objectives and further divides risks into threats and opportunities. Both are considered in the risk management procedures. These procedures are based on the international standard ISO 31000. Uncertainty is not a concept that is defined within Worley and it is therefore not something that is treated as something separate: there are no processes in place for targeting uncertainty.

Within sales, the Risk Wizard should be completed in both the middle and end game. In a project, the risk management plan should be updated regularly and at the start of each new phase, a risk classification form must be completed. Furthermore, during monthly project reviews, the top threats and opportunities should be discussed. In both cases, additional risk analysis techniques (such as a SWOT analysis, CBA analysis and scenario analysis) can be used when deemed appropriate.

4.2.4. Lessons Learned
The main objectives of the Lessons Learned process are to:

1. Learn from events with unexpected and unfavorable outcomes and decrease the likelihood of repeating such events.
2. Recognize previous successes and opportunities, and increase the likelihood of repeating such successes and opportunities.

The Lessons Learned are classified as project, local or global lessons, depending on their relevance for potential other situations. The lessons are saved in a register open to all Worley employees and can be searched for on the basis of location, line of business, sector, customer, discipline or year completed. The register should be consulted at the start of a project and should be supplemented at the end of project.

4.3. Key takeaways
Based on the information in this chapter and several of Worley Ways of Working procedures, the conceptual framework from chapter 3 is supplemented with current processes in the company. In bold, all additional elements are shown. Lessons Learned is added as a means for identifying uncertainties. An additional basis for classification was also found, which is the required level of approval within the company. Finally, under dealing with uncertainty, determining cause and consequence, as well as monitoring and reviewing uncertainties were listed in Worley's 'Our Home' environment and now added to the framework. This framework can be seen in figure 4.1.

Altogether, the framework forms the starting point of the empirical research as it schematizes procedures and components that, based on literature and Worley Ways of Working, are important in managing uncertainty. Indicated in the figure in red are also the four elements on the basis of which the empirical results are analysed in the next chapter.

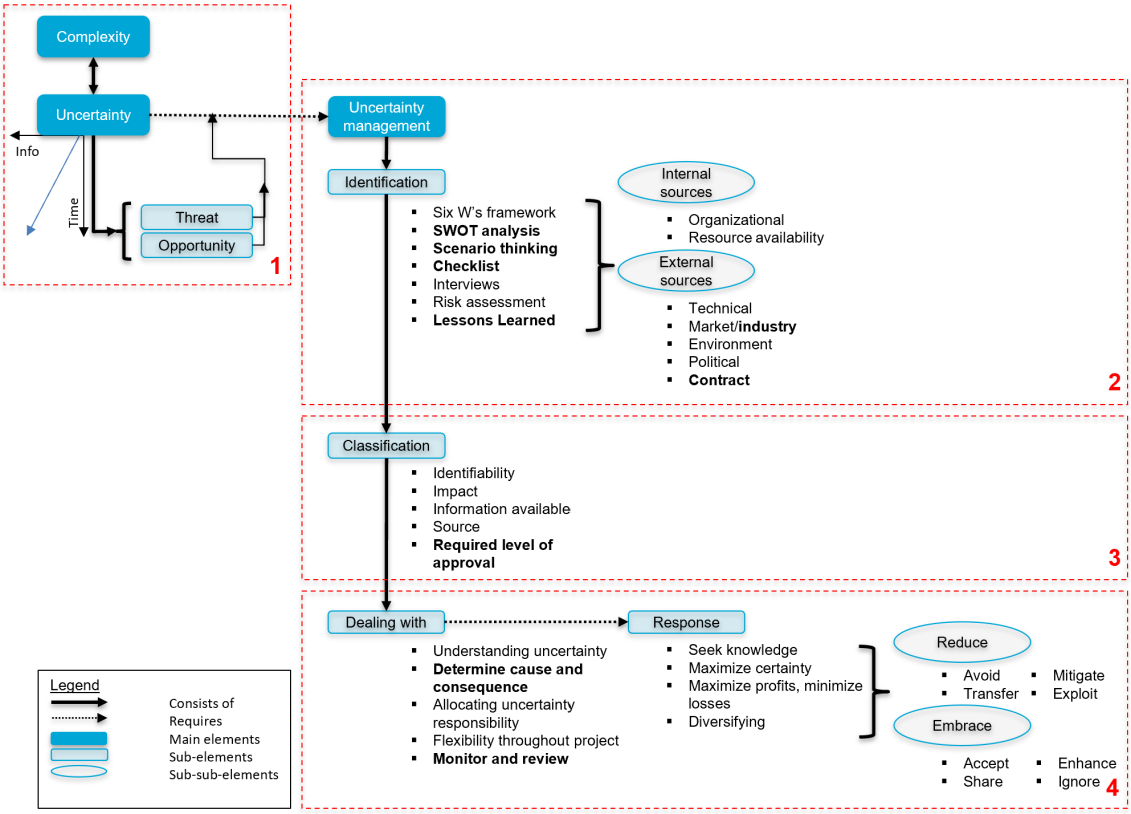


Figure 4.1: Conceptual framework including processes within Worley

5

Uncertainty management in practice

As explained in section 2.3.2, a total of twelve interviews were conducted with the goal of gaining information on differences between energy transition projects and more conventional energy projects, the way uncertainties are (possibly) dealt with and what changes may be needed to deal with uncertainties appropriately. This information is required for answering sub-questions 3, 4 and 5. The two groups that were interviewed consisted of project managers and sales managers. More information on the interviewees can be found in table 5.1. The interviews were of a semi-structured form and conducted in accordance with the interview guide which can be found in appendix A.1.

ID	Experience	Current ET project
PM1	Originally worked as materials engineer and operational solutions engineer with another company for over 17 years. Has been with Worley since 2019.	Sustainable aviation fuel
PM2	Project director and partnership alliance manager. Has been with Worley since 2001.	Green hydrogen
PM3	Grew into the PM role after working as an engineer and control systems engineer. With Worley since 2010.	Sustainable aviation fuel
PM5	Has been with Worley, formerly Jacobs in the role of project manager, and later project director, since 2008.	Green hydrogen
PM7	Worked in electrical engineering at first. Has been with different companies, each being taken over by another, of which Worley was the most recent. Has been in project management for about ten years now.	Biocrude oil & wind to hydrogen
PM9	Originally mechanical engineer, but has been in the petrochemical industry for most of his career. With Worley for nearly 25 years.	Blue hydrogen
PM10	Worked as a mechanical engineer at first, before taking on a role as project manager of chemical projects in 1994. Has been with Jacobs/Worley since 2015 as project director.	Biochemicals
S4	In sales since 2004, early on in contract engineering. With Worley since 2011 in inside sales.	N/A
S6	Moved into sales after working as a process engineer for six years. Has been with Worley, in outside sales, for the past 4.5 years.	N/A
S8	Currently in outside sales and has been with Jacobs/Worley since 2009.	N/A
S11	Six years of engineering experience, before moving into inside sales one year ago.	N/A
S12	Has been in the conventional energy industry for over 30 years. Currently in the role of inside sales.	N/A

Table 5.1: Interviewee description

After each interview, the results were summarized and presented in a format that corresponds with the interview design. These can be found in appendix **??**. The interviews consisted of three sections:

defining uncertainty, dealing with uncertainty and the difference between the conventional and energy transition industries. This chapter looks into the findings on the first two parts. These results were analyzed by means of a thematic and content analysis. The first order themes for the thematic analysis were deducted from the literature study and the second order themes match the themes in the interview guide, closely linked to the questions asked. Both are listed below in table 5.2. This analysis was done twice in order to perform a more complete analysis. The content analysis aims to identify the type of uncertainties that are now observed and the common sources from which these (new) uncertainties originate. The results of the analysis of the interviews can be found in appendices B and C for the project managers and sales group respectively.

First order	Second order
Defining uncertainty	Difference
	Association
Dealing with uncertainty	Identification
	Reaction
	Knowledge sharing

Table 5.2: First and second order themes of the thematic analysis

In this chapter, the interview results are presented and analysed alongside the theoretical framework. The choice for doing so is based on the fact that the structure of the interview guide, as presented in appendix A.1, was based on this framework and it helps to provide an insight into the overlap and gaps between literature and practice. To perform the analysis in a clear manner, the framework is split up into the four elements listed below. The first four sections in this chapter correspond to these elements. The fifth and final section presents the key takeaways of this part of the research.

1. Understanding of uncertainty
2. Identifying uncertainty
3. Classifying uncertainty
4. Dealing with uncertainty

5.1. Understanding of uncertainty

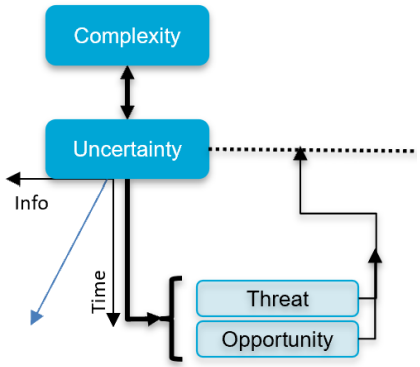


Figure 5.1: Part 1 of conceptual framework: understanding uncertainty

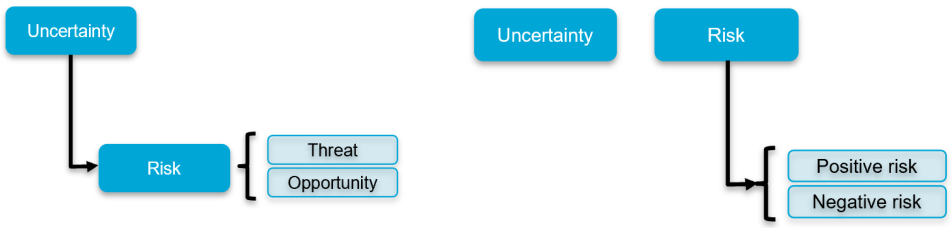
To start with the upper component of complexity, the interviews showed that just like in literature, the relationship between complexity and uncertainty is not clear. Where some say the more uncertainty in a project, the more complex it is, others say it's the other way around. Then there's also a small group that claims to not see a link between the two at all, therewith supporting the theory of Padalkar and Gopinath (2016). Three sources of complexity were mentioned for the energy transition projects. First of all, interviewee S4 states that a higher number of different elements or interfaces within a project

causes it to be more complex. Secondly, the presence of many different partners and stakeholders increase complexity significantly, so say interviewees PM2, S4, S11. A third source for project complexity is the project environment (interviewees PM2 and S8), which is said to be more complex now with energy transition projects when compared to the traditional energy projects. The latter is said to be the result of the novelty degree and will therefore grow less complex as more experience is gained in this industry. It not only refers to the technical environment, but also the regulatory environment within which projects need to be completed. Considering these limited sources of complexity, it would suggest the energy transition industry to be mostly structurally complex (Floricel et al., 2016). These sources can be placed in both the categorisation by the Project Management Institute, as well as the TOE framework as developed by Bosch-Rekveldt et al. (2011).

The definition of uncertainty proves to be inconsistent not only in literature, but also in practice. First of all, five of the twelve interviewees noted they do not make a distinction between uncertainty and risk in their work. From the interviews with the project managers, it did become apparent that also the project managers claiming to make a difference, in fact do not. This is concluded on the basis of the constant interchanging use of the terms risk and uncertainty and is supported by the theories by Koleczko (2012), Kolltveit et al. (2005) and Mentis (2015). However, most interviewees had said that in reality, within Worley as a company, uncertainties are translated into risks. They are therefore not considered as two separate aspects, let alone dealt with in different ways.

Not making a distinction in practice does not mean people don't see the difference. In fact, the difference is acknowledged by everyone but interviewee PM2, who considers both concepts to be negative, yet acknowledging opportunity as a positive risk. Risks are considered manageable through actions by seven interviewees and uncertainties are unknowns that simply happen. Regarding the latter notion, PM5, PM 9 and PM10 specifically named unknown unknowns.

Based on the interview results, the relationship between uncertainty, risk and opportunities was hard to find. When directly asked about the difference, as explained, most interviewees were able to motivate their consideration. Throughout the interviews, it became clear that when talking about uncertainties, people linked it back to risks on a very regular basis. The majority of sales managers and only one project manager, said to be neutral about both risk and uncertainty, stating it's a given and will always be there. However, whether risk is worse than uncertainty or the other way around is not something the interviewees agree on. Furthermore, the sales managers' association with both risk and uncertainty is predominantly neutral, it being associated with both positive and negative events. The positive side of it was however often scaled under (positive) risks rather than opportunities. For the project managers, this was considered the case for uncertainties, but risks were nearly always considered to lead to negative outcomes. Within this interviewee group, opportunities were noted four times of which two mentioned the concepts of value creation and sustainability plus, which both aim to create incentive for seeking opportunities. This differentiates the two groups in terms of acknowledging the positive element in uncertainty. The perceived relationship between risk and uncertainty for either group can therefore be schematized as shown in figure 5.2. These figures clearly show that the understanding of the concept of uncertainty is not uniform among the interviewees.



(a) By project managers (b) By sales managers

Figure 5.2: The perceived relationships between uncertainty, risk and opportunity

5.2. Identifying uncertainty

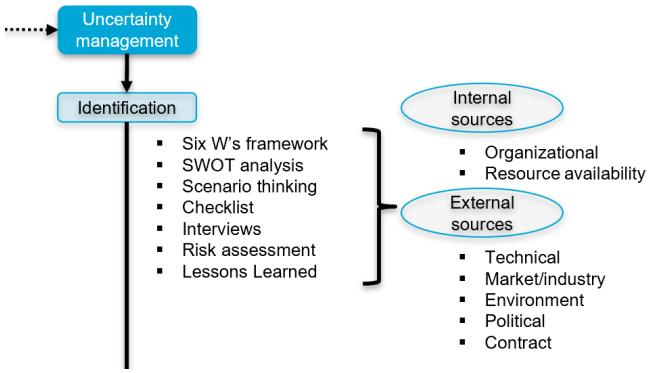


Figure 5.3: Part 2 of conceptual framework: identifying uncertainty

The second part of the framework is split into two sections. First, the methods for identification are looked into, after which the, in practice, identified uncertainties are elaborated.

5.2.1. Methods

None of the interviewees described a process for identifying uncertainties specifically. Several referred to the risk analysis process performed throughout the different phases of a project as described in chapter 4. Sessions in which a risk register is kept, were most often mentioned as the process in place for identification. These sessions are supposed to be held on a very regular basis, but in reality it varies a lot and may even be held only once per project phase as interviewee PM9 explained. Often, in a very early phase, the risk identification process is kicked off with a standard checklist of aspects prone to form a risk. In addition to this, a SWOT analysis may sometimes be performed to analyse how a stronger position can be gained. Finally, PM1 and PM5 mention scenario analyses as a means for dealing with uncertainty. PM1 explains pre-work is done for different situation in order to go ahead as soon as the necessary information becomes available. From literature we collected multiple methods for identifying uncertainties, namely the six W's framework (Chapman and Ward, 2003), SWOT analysis (Hillson, 2003), scenario thinking (Hillson, 2003) and checklists and interviews (Hillson, 2003). No additional methods were found from the empirical study, but the conclusion that can be drawn from these findings is that in practice, three (SWOT, scenario and checklists) methods for uncertainty identification are applied. However, within Worley this is done with a focus on risks. Since uncertainty management is the combination of risk management and opportunity management, including opportunities in a more prominent manner would complement the processes to be more comprehensive of a greater variety of uncertainties.

5.2.2. Characteristics

Literature showed that uncertainties are identified based on the sources they originate from. Asking the interviewees about examples from experience, uncertainties were discussed in the interviews. These examples, together with their sources are shown in table 5.3 and indicate contributors to uncertainty in energy transition projects. In addition to finding the common sources of uncertainties experienced in energy transition projects, the interviews aimed to identify what these uncertainties were typical for. The majority of the interviewees recognized that the uncertainties currently experienced in the energy transition projects are typical for a new industry with a new project environment, rather than typically for energy transition projects.

Uncertainty	Source
Industry environment	Market
Technology	Technical
Funding	Resource availability
Contract forms	Novelty of the market
Regulations	Political
New partners	Relationships

Table 5.3: Uncertainties and sources from the interviews

Due to the novelty of the market, the entire industry environment is uncertain. With different green energy concepts being developed and worked with at the moment, it is yet to be seen which one(s) will be applied at a large scale in the future. In addition to that, because of the application of new technologies, this new market requires a different kind of supply for which existing and new parties are responsible. A major uncertainty in this is whether these suppliers are able to match the demand. This is true for the supply and demand of green energy of course, but in this case, it concerns the supply and demand of materials and machinery needed for realizing the energy transition projects. Also resulting from the novelty aspect is the uncertainty regarding the technology. With little experience with some of these new technologies, knowledge is lacking. Interviewee PM3 describes the uncertainty about the knowhow of processes. Not yet knowing how things work requires flexibility to adjust as more information becomes available. In line with this is the uncertainty described by interviewees PM1 and PM5, namely that of the scalability of new (combinations of) technologies. PM5 describes that as a result of this uncertainty, projects tend to be over designed, therefore becoming more expense than needed.

With the gated work process with which Worley works, funding uncertainties on the client side may lead to having to hold on to a team without the security that the next phase will be entered. Despite getting paid for doing so, there is the uncertainty of the work continuing. Uncertainties regarding funding may also lead to spending time and resources risking not getting to the next step in a project, which according to interviewee PM2 is also a common effect that a project manager may have to deal with. Especially for new and smaller customers, the receiving of subsidies as additional funding may be a determining factor in whether or not a project will reach the actual engineering phase.

The sales department sees a client's desire for new or different contract forms for projects. Not only contract forms, but also financial models are often proposed as such that Worley carries more risk than what they used to in the conventional projects. This may be attributed to the fact that clients are also new to this industry and may have less in-house knowledge on topics such as hydrogen than they used to have with oil and gas. At the same time, regulations in this industry are often still being developed and are subject to constant change still. The awarding of subsidies is impacted by this. The way that this is incorporated in contracts and financial models is often new and leads to uncertainty.

Furthermore, new partners examples were mentioned a lot. These uncertainties were said to influence the sales process in a number of different ways. However, different results of these uncertainties were named. Working with new partners, whether they be clients, suppliers, or other, make it harder to make value propositions as little information about market and competitors is available. Also, more effort must be put into building relationships, which is something that Worley has relied on in the conventional industry. This relates also to Worley's social license to operate which not only depends on relationships with stakeholders and this new business community, but also having to prove all over again their capability in this new energy industry. For the market uncertainty, a question raised is 'which way to go?' as a result of uncertainty about what direction the market will head. Currently, a number of different green(er) energy products is being worked with; hydrogen, sustainable fuel and wind among other things. However, it is still uncertain what will be the future and as Worley remains a business with the goal of earning money, the uncertainty of future market is closely related to the business uncertainty for Worley. Potential supply chain constraints are also named as an uncertainty. Especially when this industry further develops, projects are up-scaled and more parties enter the market, interviewees

expect a spike in projects brought to realisation and therefore orders to be placed. Before a demand and supply balance is found, potential constraints are likely to become a problem in this industry. One element, placed in the 'market' category sees quite an overlap with the uncertainties in new partners. From current projects related to the energy transition one can say that these projects will not only be brought by new clients, but also long-term clients. These clients however are also new to this energy transition market and what is seen as interviewee S11 describes, is that they reevaluate their strategies.

Most of the uncertainties named by project managers and sales managers could be placed in the same categories. The two groups interviewed are very different in their role within the company. Therefore, the expectation was to see a difference in this and therefore see more clearly what uncertainties are specific for project managers and what is telling for the sales department under these new industry circumstances. Of all seven categories, only one has an internal source, whereas all the others are external. This places Worley in the top left A2 quadrant of the uncertainty profiles developed by Kolltveit et al. (2005). This quadrant suggests that stakeholders are well-versed in the project itself, but lack understanding about the external context. Four strategic options can be considered when dealing with uncertainty. According to the authors, the goal is to choose the strategic option that best facilitates the exploitation of uncertainty opportunities.

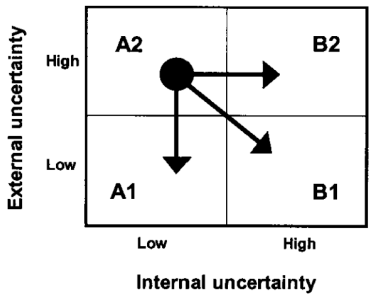


Figure 5.4: Strategic options from an A2 uncertainty profile

5.3. Classifying uncertainty

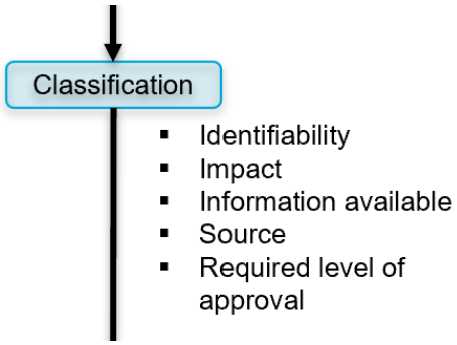


Figure 5.5: Part 3 of conceptual framework: classifying uncertainty

As described before, one of the conclusions from the interviews is that uncertainty management is not actively done within Worley. Classifying uncertainties is something that is not done at all. Talking about classifications, this is only done for risks and it is done based on the level of risk. In hindsight, a classification may be made based on the achieved degree of project success. Depending on that risk category, the required level of approval within the company is determined. However, in the first part of the interviews in which the interviewees were asked about the difference between uncertainty and risk, a number of characteristics for uncertainty were named that could function very well as classification properties. This includes the quantifiability of an uncertainty for instance. If it it quantifiable, how detailed can that be done? In other words, how uncertain is the uncertainty? Also the influenceability of an uncertainty; creating a categorisation based on this property could be interesting when deciding on

approaches for specific uncertainties. For instance if an uncertainty can hardly be made less uncertain by making an extra effort, one may be likely to choose a different response when compared to an uncertainty that could be made a lot less uncertain with the right efforts.

Despite the unclear relationship between complexity and uncertainty, literature clearly showed that they are related concepts. Therefore, one could argue that categorisations similar to those for complexity could also be included for the categorisation of uncertainty. This would then lead to an overview of all types of classification as depicted in the table below.

Classification types (literature)	Additional classification types (practice)
Identifiability	
Impact	
Information available	
Source	
	Quantifiability
	Influenceability
Human behaviour	
System behaviour	
Ambiguity	
Technological	
Organizational	
Environmental	

Table 5.4: Different bases for classification of uncertainty

5.4. Dealing with uncertainty

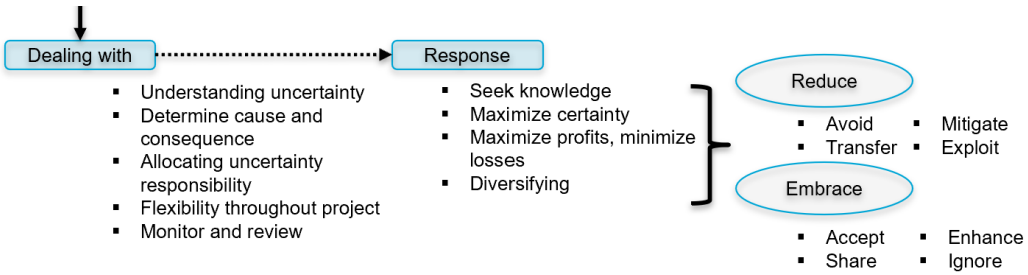


Figure 5.6: Part 4 of conceptual framework: dealing with uncertainty

The final element of managing uncertainties is the part in which the uncertainty is actually dealt with. As explained before, the terms risk and uncertainty were constantly interchanged throughout the interviews. While, except for one, all interviewees acknowledge the difference between risk and uncertainties, only a very limited number of interviewees said to consider uncertainties as something separate in practice. Nevertheless, uncertainties are not actively dealt with and from the interviews it did not appear that the respondents experienced the need to manage uncertainties. Based on these two observations, Worley classifies as a novice organization according to Hillson (1997)'s four-level uncertainty maturity model.

This section is further subdivided into three sections: methods, goals and characteristics.

5.4.1. Methods

From literature, three elements show to be important in dealing with uncertainty. Understanding uncertainty (Atkinson et al., 2006; Perminova et al., 2008; Ward and Chapman, 2003), allocating uncertainty responsibility (Atkinson et al., 2006) and flexibility (Jaafari, 2001). The understanding of uncertainty was looked into in the first part of the interviews of which the results are discussed in section 5.1. The divergent perceptions of uncertainty make it harder to manage uncertainty as an organization and therefore increases the chance of missing opportunities and inconsistent responses. Secondly, the allocation of uncertainty responsibility is something that was also described in the interviews. Especially regarding the desired new contracts and financial models that place additional uncertainty responsibility with Worley, extra efforts are made to 1) limit or simply not accept this, 2) help the client reduce their own uncertainty and 3) involve specialists and/or key players in the relevant field from an early stage. Finally, similar to literature, the interviewees described flexibility as one of the methods for dealing with uncertainty. One interviewee for instance describes that a more flexible attitude, combined with the awareness of the increased potential for a project to be put on hold is required. Another describes his process under a specific uncertainty to be more free, allowing for responding to the situation. Both contribute to limiting the chances of overlooking potential risks and opportunities in a later stadium.

From the uncertainties that were named in the interviews and the responses to these examples, the following list of (type of) responses could be assembled:

1. Await information
2. More tolerable to risk
3. More flexible/adaptive
4. Turn uncertainty into a positive
5. Incorporate contingencies
6. Involve key players early on

Something that did not come up in the literature study was the incorporation of contingencies as a method for dealing with uncertainty. Contingencies can be included for cost and time and allow for unexpected events to happen without direct negative impact on the project outcome. However, while including contingencies does serve this purpose, it may be considered more of a tool rather than a method. It can therefor be argued that the sole application of cost and planning contingencies would not suffice. A combination of a flexible approach and the allocation of responsibility is likely to contribute to the successful managing of uncertainties with the potential side-effect of needing only limited amounts of the predetermined contingencies.

Furthermore, waiting for more information to become available and being less risk averse are actions rather than methods, so will not be considered as such. Similarly, turning uncertainty into a positive is not a means, but rather a goal.

Finally, throughout the interviews, the importance of sharing knowledge and experience was considered very important, especially in a new industry. However, often, the current processes for doing so, through knowledge sharing sessions and Lessons Learned, are not performed optimally and lesson are not captured. Improving and including this process in the framework would help to decrease uncertainties in a new industry faster over time. For uncertainties not specifically related to a new industry, it would help to prepare accordingly and potentially seek more opportunities because of it.

5.4.2. Goals and characteristics

The final two parts of the framework concern the goal and nature of the response. The responses described in the previous subsection can be linked to a goal and that is shown in table 5.5. Whether the chosen response is cause-driven or consequence-driven is linked by Zheng and Monteiro De Carvalho (2016) to the ability to influence different types of uncertainty. This typology on which this is based is

internal/external uncertainty. When asked about the goal of people's response, the interviewees found it hard to put that into words. It shows that dealing with uncertainty in practice is not a well thought through process.

Response	Goal
Await information	Seek knowledge & maximize certainty
More tolerable to risk	Maximize profits, minimize losses
More flexible/adaptive	Maximize profits, minimize losses
Turn uncertainty into a positive	Maximize profits, minimize losses
Incorporate contingencies	Maximize certainty
Involve key players early on	Seek knowledge

Table 5.5: Goal of response

For the nature of the responses, nearly all interviewees claimed to be embracing. However, among the two groups interviewed the definition of embracing appeared to be different. When describing an embracing attitude, the sales managers referred to both potential positive and negative outcomes. They implied a broader way of embracing uncertainty. The project managers on the other hand described reactions to uncertainty as embracing, but with the side-note of referring to the positives only. The potential negatives would be mitigated, which under Hillson (2002)'s theory is categorized as being reducing.

5.5. Key takeaways

First of all, among the two groups interviewed, there is a different perception of the uncertainty, risk and opportunity. Uncertainties are currently not considered as a standalone concept in practice at Worley. Furthermore, with the findings from the interviews, the conceptual framework is supplemented to display the results in a clear, schematic way. All phrases coloured red were added to the framework.

First of all, the interviewees explained they consider sharing experience to be an important process in identifying uncertainties. This can be done through organized sessions or by properly maintaining a clear and easy to use database. Then, in addition to the uncertainty sources found in literature, from interviews followed another source, namely 'relationships'. Especially in new markets this is a source for several new forms of uncertainty. Under classification, several points were added on the basis of which uncertainties could be categorized. In addition to the complexity categorization of human and system behaviour, ambiguity and the TOE elements, quantifiability and influenceabiltiy were added as possible bases for classification. Finally, in dealing with uncertainty, including cost en planning contingencies was mentioned in the interviews, but not found in literature. However, doing so allows for more room for unforeseen events. With regards to the responses, awaiting more information to become available is included as a cause driven response. Under consequence driven responses, turning uncertainties into a positive is included as a response goal. The complemented framework can be found in figure 5.7.

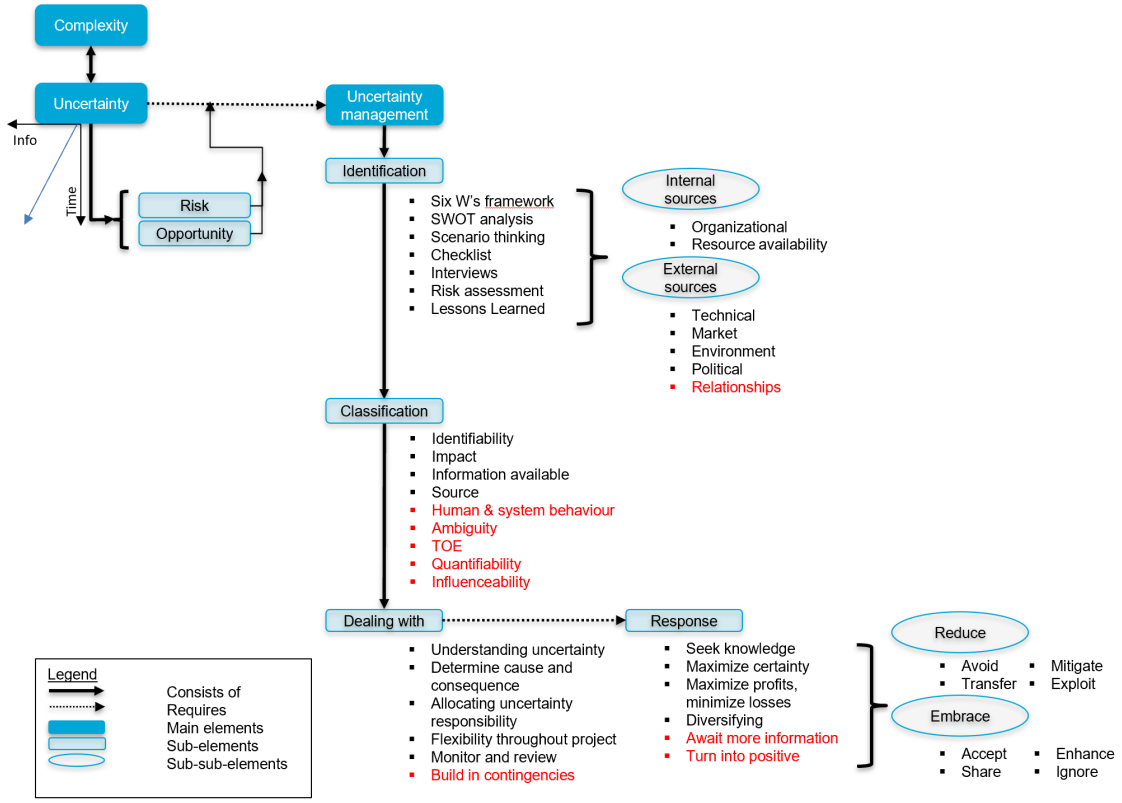


Figure 5.7: Revised framework

6

The difference between conventional and energy transition projects

The third part of the interviews concerned the difference between the new and conventional energy industries. Different from the other part of the interview as discussed in the previous chapter, these questions zoomed out, aiming to gain a broader understanding of the differences between the projects in the two industries. Comparing the conventional oil and gas industry with the energy transition industry provides a base-case and thus potentially an insight into what contextual elements play a role in the (different) uncertainties in energy transition projects.

This chapter elaborates on the differences as experienced in practice by both the project managers and the sales managers. For the analysis of these results, a thematic analysis was performed. The first order theme is the difference between the new and conventional energy industries and contains the sub-themes: the industries, the uncertainties in both industries, the project and sales management approaches and the responses to risk and opportunities. Section 6.1 discusses the first two sub-themes and section 6.2 elaborates on the final two sub-themes. Section 6.3 presents the key takeaways from this part of the study.

First order	Second order
ET vs conventional projects	Industry
	Uncertainties
	Approach
	Risk/opportunity response

Table 6.1: First and second order themes of the thematic analysis

6.1. Industry and uncertainties

Looking at the difference between the traditional oil and gas industry and the energy transition industry, the biggest differences between the two can be found in the following elements:

- Novelty
- The business case
- Different and new relationships
- Time pressure
- Subsidy component

With regards to uncertainties in both industries, one project manager specifically mentioned more uncertainties to be present in the energy transition projects. PM3 claimed however to not necessarily see more uncertainties, but attributes the difference to the sources from which the uncertainty arises. Generally, the interviewees were quite aligned in the uncertainties that they said to be different in the energy transition industry. They could be categorized as follows:

- Legislation
- Industry landscape
- Financial and technological feasibility

First of all, with the transition to green energy projects, the novelty aspect is what makes the industries most different from one another. The lack of both familiarity and experience results from this directly. Regarding the quality aspects of the traditional project controls, interviewee PM1 states that the importance of 'everything right the first time' has slightly shifted as a result of the novelty of these projects. This is likely to be linked to the fact that many of these projects are trial projects, now at a smaller scale for trial purposes to be up-scaled when possible. Resulting from the novelty degree of the new energy industry is the fact that regulatory frameworks are still being developed on a continuous basis. Because of this, both clients and engineering companies cannot know what the boundaries are within which they need to work. This relates to laws and regulations, product requirements and more and bring significant uncertainty to a project.

Furthermore, the business case has changed, so say four of the five sales interviewees. The need to gain market share in a developing market, different drivers and more risk that needs to be accepted are provided as reasons for what makes the business case different. This brings the uncertainty of which market position is going to be taken: what direction within energy transition is best to pursue and will eventually be applied at a large scale? Not only that, but decisions ought to be made on what position Worley takes on as a company in this new industry. This new aspect to the energy transition industry is accompanied by the uncertainty regarding future business. The final category of new uncertainties relate to the industry landscape. Questions such as 'who will be the suppliers?', 'will they be able to match supply to the demand?' and 'what direction will the market go eventually?' are asked in relation to these uncertainties. In addition to that is the development of oil and gas prices and the influence of that on developments in the energy transition industry. Interviewee PM5 explains that if oil and gas prices are low, energy transition projects tend to be put on hold, whereas when prices rise, these projects are pushed a lot more.

Thirdly, as a result of the novelty aspect, as well as the different business case in the energy transition industry, new relationships need to be built and existing relationships change. The former is simply the result of new parties entering the market, both on the demand and supply side of business, so interviewees S4, PM9, S11 and S12 explain. The latter refers to changing relationships in terms of different ways in which parties work together. With less experience available, a higher level of collaboration and more intensive early-on involvement were named multiple times as examples for this.

Despite the standard project controls are still the same in these new projects, a shift can be seen in the importance of time. As a result of the sense of urgency regarding the energy transition, the sales department experiences a higher time pressure in projects related to the energy transition. As interviewee PM3 puts it: "we're trying to catch up with the Paris Agreement and projects need to be finished tomorrow rather than later". This saving of time can especially be observed in the shortening of the bid phase as interviewee S4 explains. A shift in focus on cost is also seen as a result of a change in desired financial models, namely that of a lump-sum nature.

Finally, the subsidy component is a new element in the energy transition industry, which comes with the uncertainty of project continuance. Namely, especially for new, smaller clients who have just entered the market, these subsidies may be deciding in whether or not projects are continued. Besides that, subsidies allow for more push to get fixed price contracts for instance, which places more financial risk with Worley, so interviewee PM2 explains. When a potential client depends on a subsidy for being able

to move forward with a project, it will influence the uncertainty for Worley regarding work to become available. In addition to uncertainty regarding financial feasibility, there is also that of technological feasibility. This results from not only the new (combinations of) technologies, but also the scalability of projects or concepts. The uncertainty in that is how combinations of technologies will work when combined.

6.2. Approach and response

Despite the acknowledgement of differences between the industries and also the recognition of different types of uncertainties, six of the seven project managers indicated that there is no difference in their project management approach. The seventh interviewee, PM3 describes the processes to have become much more agile. However, this comment referred to a specific situation and can therefore not be generalized for the industry. However, this does show the team acted in a flexible manner for this instance of uncertainty. Project manager PM1 acknowledges that there does seem to be more flexibility in projects and attributes this to a shift in what's considered important, referring to the cost, time and quality aspects of projects. In the sales processes, a different makeup of teams and their functioning is seen in energy transition projects. A higher level of collaboration is needed between team members. Other disciplines play a bigger role in these projects than before and a higher degree of multidisciplinarity is desired. Furthermore, the clients require more detailed and in-depth knowledge of the company they decide to work with. As a result, more time is required in the study phase in order to prove to the client that they possess the required knowledge. Besides this, a difference in sales procedure between the two industries is seen in time spent on different phases. For the reasons desribed above, interviewee S8 explains the front-end sales process is much more intense. S4 supports this notion when saying more time is spent on the study phase and less time is available for making a bid.

Finally, comparing the risk and opportunity responses, many interviewees indicate the energy transition projects lead to a more embracing attitude towards uncertainty. Several mention that in the energy transition projects, there is generally a higher level of risk acceptance. PM3 and PM5 added to this the observation that a greater effort is made for finding risks and opportunities. PM10 specifically linked it to the chosen contract model and interviewees S6 and S12 attribute it to a natural result of wanting to gain market share in this new industry and therefore having to be more embracing. S12 says it's the result of the time pressure behind this transition and states that this "forces us to embrace or accept both uncertainty and risk in ways in which we may not have done in the past". He illustrated this with an example that in a partnership deal, transferring risk may become more appropriate than mitigating it. Furthermore, the project managers do say that being more accepting to risk is necessary if you're part of a developing industry with a higher novelty degree. However, first and foremost, the main drivers of a project remain to be profitable for the organization and to satisfy the customer's needs as agreed upon, thereby increasing the chances for more business with this client. Whereas the latter may be positively impacted by a more accepting attitude towards risk, the former could be jeopardized when accepting risks without a plan for managing them.

6.3. Key takeaways

Part of the empirical research looked into the differences between the conventional energy industry and that of energy transition. Interviewees were asked about how the industries, uncertainties, project/sales approach and risk/opportunity responses are different for conventional energy and energy transition projects. It showed that the novelty character is one of the biggest differences between the two industries, not only for the type of projects, but also with regards to new players entering the market, requiring a new buildup of relationships. Partly as a result of the novelty, but also the sense of urgency regarding the energy transition, the business case for Worley is different, time pressure is higher and a component of subsidy is included. These characteristics lead to new uncertainties as well, namely legislative, financial feasibility and the industry landscape. While these are provided as differences between the two industries, the uncertainties are linked to a new industry instead of to energy transition specifically.

The project and sales management processes have not officially changed for this new industry. However, a higher degree of flexibility and a shift in composition of teams, combined with a higher level

of collaboration, is implemented to compensate for the lack in individual experience with the new type of projects. Furthermore, generally a more embracing and less risk averse attitude is observed in the new energy industry which is said to be needed if the goal is to gain market share in this new industry. In the table below, observed properties of managing projects are linked to differences between the conventional and energy transition industry.

Difference conventional & ET	Properties of management approach
Novelty (lack of experience)	More flexibility
	Shift in team composition
	Higher level of collaboration
Changed business case	Less risk averse
	Shift in team composition

Table 6.2: Relation between properties of management approach and differences between conventional energy and energy transition projects

7

Broader perspective of research findings

The interviews have led to a variety of findings described in chapters 5 and 6. A number of things stood out in specific. First of all, the interviewees generally aim to reduce risks and embrace opportunities. The way they described their approach for managing a project is often linked to the chosen strategy for a project. In sales, risk and opportunity responses were more often described as embracing. It was also observed that sales more often spoke about being more adaptive in seeking opportunities. Secondly, everyone acknowledges that there are tools and processes in place for sharing knowledge and experiences. However, most people say this is not done enough. In addition to that, sharing knowledge seems to be done differently on project level and in sales. Sales was generally more positive on the effectiveness of sharing knowledge in comparison to project managers. Finally, despite acknowledging a great variety of characteristics and uncertainties being different in energy transition projects compared to conventional projects, nearly every PM claims that the ways of approaching and/or managing a project has not changed. In sales, the processes seem to be adjusted to the new project circumstances observed in relation to the energy transition. Interviewees did have thoughts on what could be changed for better matching the new project circumstances (e.g. more agility, different team composition).

These three sets of observations were each composed into statements that were presented during the expert panel. The statements are as follows:

1. ”The reaction towards uncertainties is mostly of an embracing nature, allowing for a pro-active approach towards both risks and opportunities.”
2. ”At Worley, we learn from each other’s experiences and are not surprised by the same sort of event more than once.”
3. ”The projects related to energy transition are different from the conventional projects, but the approach in these projects can remain the same.”

Project managers and sales managers naturally gave answers within the boundaries of their own roles, so with the goal of putting the results in a more holistic frame, two additional research steps were taken. First an expert panel was organized where members of the management team were invited to put findings into perspective from a broader Worley perspective. These findings are presented in section 7.1. Secondly, a client was interviewed to get an outside view of on uncertainty in the energy transition industry. The conclusions on this are discussed in section 7.2. Finally, section 7.3 presents the key takeaways of this chapter.

7.1. Expert panel

During the expert panel, three statements were presented to five members of the Worley Netherlands management team. Information about the panel members can be found in table 7.1. These statements were accompanied by a brief description of the findings from the interviews to give the panel members

a chance to react or put into perspective. The set-up and transcript of the panel session can be found in appendices D and **??** respectively.

ID	Role
ST	Chair and initiator
EP1	Director business improvement
EP2	Manager of engineering
EP3	Director of projects
EP4	Business development manager
EP5	Director Advisian, advisory organ within Worley

Table 7.1: Description of members expert panel

1. The reaction towards uncertainties is mostly of an embracing nature, allowing for a proactive approach towards both risk and opportunities.
First of all, all members agree on the fact that Worley knows how to manage risk, but not how to manage uncertainties. Only one of the members agreed with this statement saying that Worley's proactive approach can be seen in the fact that the company is willing to pick up financial and technological uncertainties in this energy transition industry. Member EP2 is seeing that the company is definitely moving to be more embracing, but would not yet say it's 'mostly' the case. Members agree that generally, the recognition for having to participate in the energy transition is there, so that's part of being more embracing already. Furthermore, this claim was supported multiple times by the example of a model that's currently being developed to standardize Worley's way of working in hydrogen projects. Spending time and resources on this shows the will to transform uncertainty of new technologies into a positive, namely a business opportunity.

At the same time, EP3 mentions that everything in the traditional energy industry is focused on certainty and mitigating risks. It is a complex task to get employees to let go of that focus and embrace uncertainties, which especially among the project managers appeared to be the case. EP4 claims that for specific opportunities however, the company is willing to accept more technology related risk and is also prepared to make additional efforts to understand what that risk is.

2. At Worley, we learn from each other's experiences and are not surprised by the same sort of event more than once.
All members of the expert panel strongly disagreed with this statement and therewith agree that lessons are not learned in an optimal manner. The difference in success between sharing knowledge and experience in the sales department and at project level is said to be the result of a higher level of interaction within sales. The fact that the process of sharing knowledge and experiences are not as successful as they could be is dedicated to the fact that talking about mistakes is wrongfully considered a weakness instead of a lesson. Towards the end of a project a Lessons Learned session is organised, but despite the Lessons Learned procedure requires project teams to look for relevant lessons at the start of a project, panel member EP2 acknowledges that it's never done. Similarly, EP5 states that if you really want to be a learning organization, you should already at the start look at what can be learned instead of only reflect and share afterwards. In addition to that, Lessons Learned should not only be negatively associated, but also positive: what was done differently and went well and how can that be applied in a next project?

3. Projects related to energy transition are different from the conventional projects, but the approach in these projects can remain the same
Again, all members disagreed with this statement. EP1 even describes the absence of an amended approach to be one of the biggest risks to the sustainability and credibility of Worley as a company. He claims this risk is mostly present with respect to clients who have not been in the oil and gas business and therefore develop their ways of working for this energy transition industry specifically. However,

EP3 says that in pockets, one starts to think differently about things. EP5 agrees and approves of this and also says that that's where you have to start. Once you find a way of doing things differently on a smaller scale you look at increasing the pockets and broadening implementation.

However, when changing processes, the client also plays a role. With bigger, long term, customers, your ability to change your ways of working as a company depends on the acceptance and/or adaptability of that client as well. With the newer clients, there is more possibility to change your ways of working. EP3 describes seeing a change in the client's request. Before, the client used to tell the contractor what they wanted. However, nowadays clients know what they want to develop, but ask the contractor how they can help with that. As EP3 describes, Worley currently doesn't know how to deal with that question and processes should therefore be altered to comply with those types of requests.

7.2. Client perspective

In addition to an expert panel, a client was interviewed, providing an outside view on the concept of uncertainty and how to deal with it in this new industry of energy transition. In table 7.2, the client profile can be found. Just like the other interviewees, the client was asked about his perception of uncertainty and the difference between energy transition projects and conventional energy projects. In addition to that, four client-specific questions were asked about uncertainty management within their company. The interview guide can be found in section A.2 and the summary of the interview in appendix **??**.

ID	Role
C1	A client with whom Worley has had a long-term relationship in conventional project initially, now moving to energy transition projects. Contracted Worley for a program of five new energy projects in three different, consecutive phases.

Table 7.2: Description of client

Asked about uncertainty and risk in a project, client C1 says to absolutely make a difference. Uncertainty he considers to be a range of outcomes around a given expectation and something that will always be there. Different from both the Worley interviews and the provided definition, this interviewee does say that uncertainty can be quantified; namely in terms of a range. Risk on the other hand is the possibility of the expected outcome and is something that can be mitigated. Just like the Worley interviewees, the client associates risk with an action or reactive plan. Much unlike Worley, the client formally recognizes the difference between risk and uncertainty, but despite that there is no uncertainty management plan.

From the client perspective, the conventional and energy transition industries differ from one another in terms of being driven by public demand, something that was not experienced by the sales and project managers. Furthermore, the client sees a number of uncertainties, which can be categorized as follows:

1. Technology
2. Resource availability
3. Difference in projects
4. Market

The only new category without overlap with the uncertainties raised by Worley interviewees is the uncertainty regarding the difference of these new projects. The client recognizes that it is still uncertain how these projects actually are different from the conventional energy projects. Despite the slightly different angles from which the shared uncertainties are perceived, it shows that Worley and the client consider the same elements of projects to be uncertain. When managing these uncertainties, this is likely to be beneficial in the understanding of the uncertainties, the allocation of responsibility and the

agreement on the size of contingencies; three methods included in the framework for dealing with uncertainties.

The influence of the uncertainties on project management and sales approach is limited, client C1 explains. However, the uncertainty around technology influences the client's choice for who he decides to work with. The higher the uncertainty, the smaller the chance a less established player is considered for the job. In that sense, Worley has the benefit of being an established player in the energy section with a record of successfully doing their job. Furthermore, the resource availability regarding knowledge of the new industry leads to an increase in necessary effort for finding people with the relevant experience or knowledge. Both of these uncertainties Worley can respond to. Worley can decrease both uncertainties for the client by proving experience and/or showing they have access to people with the right experience and knowledge.

The client describes three areas in which the company is most actively trying to reduce uncertainty: feedstock supply, pricing and general regulation. These efforts do not seem to play a role in the client's choice for who to work with. Furthermore, from the contractor they work with, Worley in this case, they don't request any differential knowledge in project delivery and carrying out the project for energy transition projects compared to the traditional projects. What does play a much more important role is the familiarity with technology providers. The client sees a major uncertainty in this en looks to reduce that uncertainty by choosing the right party to work with.

Finally, something that the client finds really important is learning from experience. Especially in a program collaboration, with similar, consecutive projects, the goal is to transfer learnings to the following project directly. The fact that within Worley, learnings are not captured the way they should does not align with the wishes on this of the client.

7.3. Key takeaways

This chapter provides a broader and outside perspective and view on the uncertainties in energy transition projects and their management. The expert panel confirmed a change towards more uncertainty embracing approaches, which they supported with the claim of a higher acceptance of technology-related risk. The panel recognizes that processes are not different, but acknowledges the need for that. However, the adaptability of the client is said to complicate this matter. Furthermore, the panel confirmed the lacking implementation of the Lessons Learned procedure, showing that this is a company-wide problem and not individuals' experiences.

The client interview brought an outside view on the topic. It showed that a number of perceived uncertainties overlapped with those mentioned by sales and project managers. For later dealing with uncertainties, this is of interest for a number of reasons. First of all, when different parties consider the same things to be uncertain, communication about these uncertainties is likely to be a lot easier. In addition to that, it's more likely to be on the same page with regards to managing the uncertainties. The allocating of uncertainty responsibility and deciding on size of contingencies may become easier when finding yourself on the same page as your client. Furthermore, the client stresses the importance of capturing learnings to be applied in a next project. In this case he referred to different projects within a program, but considering the long-term relationships that Worley aims to keep with their clients, it can be considered to be just as important for different projects outside of a program. Capturing Lessons Learned in an effective way not only lowers Worley's uncertainty, but also that of the client and that is something that the client looks for in this new industry.

8 Discussion

Before moving to the conclusions of this thesis, the research is evaluated and both the research contributions, as well as the limitations are discussed.

8.1. Evaluation of the research

8.1.1. Scope

The research gap this thesis aims to fill concerns the potential new kind of uncertainties that come with the energy transition and what project management features are required to deal with these appropriately. That means that the scope of this research is set by the energy transition specifically. Considering the newness of the industry, the assumption was made that in line with Williams et al. (2021)'s theory, this industry would see more and/or new uncertainties, which the empirical research indeed confirmed. However, unlike the defined research gap suggests, most of these new uncertainties described were not specific for the energy transition, but were linked to simply any new industry. For the research this means that if the gap referred to uncertainties in new industries in general, the literature study could have been extended with a section on the effect of different novelty characteristics on uncertainty in projects. In the case for energy transition projects specifically, there was little to no literature available on the differences between energy transition projects compared to conventional energy projects.

From the literature review could be concluded that uncertainty doesn't quite have an unambiguous definition. For that reason, in the scope demarcation, a definition for uncertainty was formulated, based on the literature review, that would be leading throughout the research. Especially for the empirical study phase of the thesis, the formulated definition was intended to gather information about uncertainties of a comparable nature. However, it appeared that people's personal perception of the uncertainty definition was the one that they fell back on when answering questions throughout the interviews. In hindsight, it should therefore be concluded that it was virtually impossible to stick to one unambiguous definition throughout the interviews.

8.1.2. Methods

Literature review

Two elements, namely 'capturing and sharing learnings' as a means of identifying uncertainties and 'building in contingencies' as a means of dealing with uncertainties, were not encountered in the literature review. The first element is specific to a new industry with a higher degree of uncertainty, like the energy transition industry. The latter, the use of contingencies, should have been encountered during the literature review phase.

Similarly, in the interviews, the complexity component didn't come up as clearly as would have been expected based on the literature and the questions asked about it. The goal was to identify overlapping sources of complexity and uncertainty in order to determine the relationship between complexity of a project and uncertainty. These were found in the literature review. However, in the interviews, the link

between complexity and specific uncertainties was often not even recognized. And when it was, no specific sources of complexity could be named.

Empirical study
The empirical study consisted of interviews and an expert panel. The intention was to interview 13 people. However, during the final interview, it was not possible maintain a leading role as interviewer. The interviewee had a lot to tell, but due to loosing the possibility to ask questions, it was not possible to move through the interview guide. The results were not usable and therefore the choice had to be made to eliminate this interview from the results.

Furthermore, the conceptual framework formed the basis for the empirical study. However, while some conceptual elements were also found in the interviews, some were not. That could either mean that these are relevant but were simply not named, or that they were not relevant for this instance in practice and could therefore be excluded from the framework.

8.2. Contribution to research

The research provides information on the uncertainties that are identified in energy transition projects. It also finds differences between the conventional energy and energy transition industry. Another part of the research looked into the ways these uncertainties are dealt with. Combining these three aspect of the research facilitates the analysis of what features a management approach needs for dealing with uncertainties in energy transition projects. The empirical results resonate largely with the literature on the topic of uncertainty. Overlap between the interview replies and the conceptual framework showed that many of the theoretical uncertainty concepts also apply in practice. In addition to that, numerous uncertainty identification and classification methods were found in the interviews, such as lessons learned and the application of contingencies.

8.3. Limitations of research

Limitations of the conducted research lie within the case study and the outside view.

First of all, with Worley providing the case, the empirical research was limited to one company. Considering only one (company) perspective, limits the research in the sense that it may not be representative for the entire industry. However, Worley is a large company with experience in both the conventional and energy transition industry. In both, Worley has a lot of projects and thus ensures sufficient comparison material within the defined scope of this research. At the same time, considering only one company with a lot of project history in the conventional industry comes with the potential limitations of not being able to adjust procedures and approaches to a new project environment.

The outside perspective is a limiting factor due to the single client perspective. Including this outside view was not one of the main objectives of this research, but was deemed interesting for putting empirical results into perspective. For that reason, one client was interviewed. That interview did turn out to provide an additional insight into what is important in managing uncertainties in energy transition projects. It therefore shows that this perspective is one that would be interesting to be researched further on a broader scale, thus including more clients.

A final limitation of the research is that the framework was not tested for industry specific relevance. The revised framework contains both literature findings as well as empirical findings. The latter are clearly relevant for the energy transition industry, but the former were not specifically tested. In the interviews, several, but not all elements from literature were mentioned. For the ones that were not, their relevance in the context of the energy transition industry remains unclear.

9 Conclusions

This research was driven by the interest in how uncertainties can be dealt with in a way in which the focus is not solely placed on mitigating the potential negative effects. In this chapter, the research questions are answered. The main questioned to be answered in this thesis is:

"What features does a management approach need in order to deal with uncertainties in energy transition projects?"

In order to find an answer to this question, five sub-questions were defined. Through a literature study, followed by an empirical study with a focus on the energy (transition) industry, information was gathered on the concept of uncertainty and its management. Before coming to the answer to the final research question, the sub-questions are answered one by one.

SQ1 - What are uncertainties in projects?
Above all, it's important to be aware of what uncertainties are in projects. A lot has been written about what uncertainties are. First and foremost, uncertainty is an unavoidable element of project management. It is a lack of knowledge about something and its probability of occurrence and potential outcome are usually unquantifiable and immeasurable. Categorized into internal and external uncertainties, uncertainty can originate from a great variety of sources. It can have potential positive or negative outcomes which can be influenced through the chosen uncertainty management approach.

Uncertainty is a dynamic concept of which the magnitude decreases over time as more information becomes available and can be influenced by many different variables. Generally, the more variables present, the higher the uncertainty. The presence of uncertainty complicates the management of projects as this means choices need to be made without all relevant information.

SQ2 - How can uncertainties be dealt with from a broad project management perspective?
The complicating effects of uncertainty on the management op projects make that people want to deal with it. Uncertainty management goes further than risk management as it places extra focus on opportunity management and considers it a separate process from risk management. This is said to avoid missing out on opportunities as a result of a disproportionate focus on risks.

The framework in chapter 3.6 illustrates different elements of uncertainty management: the identification, classification and the act of dealing with uncertainties. Identifying possible uncertainties and their sources is the start of dealing with uncertainties. You must know what you're dealing with as best as possible to respond to it in a well-considered way. Similarly motivated is the identification of uncertainty sources. Namely in the 'dealing with' part of uncertainty management, this information is needed when deciding on a cause- or consequence-driven response.

The classification of identified uncertainties must be done to prioritize the uncertainties, find possible inter-relatedness and decide on a method for dealing with uncertainties. In that final element, the

understanding of uncertainty is a starting point. This implies understanding of the concept, but also of specific uncertainties as perceived by your own company as well as partners. In the latter case, aligning that understanding could end up to be important when developing a shared uncertainty management plan for a project. (Mutual) understanding is also needed for allocating uncertainty responsibility in a successful manner. Placing responsibilities with the right parties can decrease the overall uncertainty of a project. Finally, a flexible attitude is required when dealing with uncertainties. Especially because of the fact that uncertainty is characterized by turning less uncertain over time. A flexible approach allows for optimal adaptability towards these changes. For the response to a specific instance of uncertainty, the driver should be considered: cause or consequence.

SQ3 - How are uncertainties currently handled in energy transition projects?
Currently in practice, uncertainties are not actively dealt with. Often no distinction is made between risk and uncertainty and therefore both are included in one risk management process. Combined with the fact that in practice the focus tends to be placed on mitigating risks, potentially interesting uncertainties may be overlooked. However, despite not actively managing uncertainties, a number of elements of the uncertainty management process as schematized in the framework in figure 3.7 are executed or applied as part of the risk management processes. SWOT analysis, scenario thinking and completing a (risk) checklist are three methods that are already currently applied for identifying uncertainties. In addition to that, procedures for capturing learnings exist, which would also successfully contribute to identifying uncertainties if applied efficiently. Non of these methods were new or specifically applied for the energy transition industry.

Furthermore, the empirical study shows that in the energy transition industry, more effort is made to allocate uncertainty with the responsible party. Because the energy transition industry is new for everyone, the client aims to shift the responsibility for uncertainties to the contractor. In response to that, the contractor makes more effort to allocate it with the best party. In addition to that, more room is left for flexibility in managing projects because of the realisation and acceptance of a higher level of uncertainty in the new industry. Finally, not specific to the energy transition, but applied in projects in general is the method of building in cost and planning contingencies.

Looking at more direct responses to instances of uncertainty, a number of ways of handling uncertainty were found:

1. Await more information before making decisions
2. Turn uncertainty into a positive, for instance a business opportunity
3. Seeking knowledge prior to having to make a decision
4. Minimizing losses, while maximizing profits

SQ4 - What makes energy transition projects different from conventional projects?
There are a number of aspects which make the energy transition industry different from the conventional industry. First of all, there is an increased pressure on time, which is reflected in especially the shortening of the bidding phase for projects. Secondly, the novel character of the energy transition industry makes the projects different and requires new relationships to be built. Furthermore, at a higher level, the business case is different in the new energy industry. Partially driven by the new subsidy component, this brings uncertainties for the projects in terms of financial feasibility, legislation that is still being developed and overall industry landscape. It also leads to regulations that are still being developed, which complicates the understanding of legislative boundaries within which projects can be developed and results in a lack of guidelines.

SQ5 - What changes in management methods could be implemented to deal with uncertainties in energy transition projects?
The empirical study showed that uncertainty management is not included in the business processes. So that would be a first major change that is needed, to at least start dealing with uncertainties in a more pro-active manner. Therefore, the current processes could be complemented with a more thorough uncertainty management framework as presented in chapter 5. A six W's framework could be

implemented to better identify uncertainties and the checklist should be amended to more specifically include opportunities next to risks and also consider those potential events that are unquantifiable. Furthermore, considering the presence of new partners and suppliers, the uncertainty regarding technology and also that of financial feasibility, the method of risk interviews could be implemented and expanded to cover uncertainties instead of risks. Finally, besides changes with respect to the identification of uncertainties, classification could be included as it's currently not being done.

Finally, after having answered all the sub-questions, the main research question can be answered:

What features does a management approach need for dealing with uncertainties in energy transition projects?
Uncertainty has proven to be a complex concept and is, despite increased levels of uncertainty in the energy transition industry, currently not something that's being managed. First and foremost, the management approach should therefore be complemented with an uncertainty management plan that extends current risk management practices. In addition to focusing on potential negative outcomes, potential positives should not be overlooked. Wanting to implement such uncertainty management at a (company) wide scale, uncertainty must first be understood. For optimal efficiency it is important for all the people involved to work with a common understanding of the concept.

The management of uncertainties should include an identification and classification procedure before deciding on the response for dealing with uncertainties. Identifying uncertainties can be done in different ways. Some of which are specifically focused on uncertainties, whereas others are traditional risk identification methods. With slight amendments, the latter could be made suitable for the purpose of uncertainty identification as well. The classification of uncertainties can be done on the basis of any characteristic of uncertainties.

Finally, dealing with uncertainties requires an appropriate response. As uncertainty develops over time, the monitoring of uncertainties should be done on a regular basis. The overall management approach thus requires a flexible attitude so that management alternations can be chosen if deemed suitable or necessary. At last, to bridge the knowledge gap for technologies and reduce the client's uncertainties, early involvement of specialists is desired.

10 Recommendations

As closing part of this thesis, building upon the conclusions from the previous chapter, recommendations are developed. First the recommendations for practice are laid out, followed by recommendations for future research.

10.1. Recommendations for practice

Based on the final results of this thesis, the following recommendations can be made for practice. First of all, incorporating an uncertainty management plan should become standards practice. The starting point for that is to introduce the concept of uncertainty and ensure everyone involved is familiar with the rough definition to establish a shared understanding. The project management features that are needed for dealing with uncertainties should be further developed so that they can be incorporated into existing standardized process flows for project management. After having done that, an uncertainty management plan should be developed to establish these procedures and possible strategies for dealing with and responding to uncertainty. This plan and these procedures should accommodate the desired features as described in the answer to the main research question of this thesis.

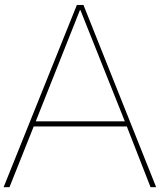
For Worley specifically, it is recommended to extend the Worley Ways of Working with uncertainty management practices. This means that in addition to risk management, opportunity management should be actively done as well. A starting point for doing so would have to be to create a shared understanding of uncertainty, of what is required to deal with uncertainty and the importance of doing so. The empirical study showed numerous uncertainty management components to subconsciously be applied in practice. This should become common knowledge and/or practice for all employees and should not depend on individuals' ways of working. The managing of projects at Worley should start with identifying and classifying uncertainties to create awareness of potential risks and opportunities. With regards to the identification of uncertainties, Worley has the organization to do that. Lessons Learned is an important process within Worley, but as revealed in the interviews, there is still a lot to gain if done more efficiently. In addition to that, during the course of a project, a flexible approach is recommended to be implemented to respond to a changing project environment. Not only the sales managers, but also the project managers are recommended to take on a more flexible attitude in projects.

10.2. Recommendations for future research

First of all, it would be of great value if this research would be scaled up by turning it into an extensive case study of similar companies. The goal of such a research design would be to get a more comprehensive view of managing uncertainties in energy transition projects. The conceptual framework could then be appropriately tested to practice as well. Similarly, a larger client pool should be interviewed to get a more complete pictures of both sides of the projects.

A subsequent recommendation would be to further develop the framework and to also test the suitability of all separate elements for practice. Having done that and developing a final framework, follow-up research could look into developing more standardized processes for dealing with uncertainty on the basis of that framework.

A final recommendation would be to perform similar research in other industries, all with the goal of finding suitable features for a management approach for dealing with uncertainty. Comparing these results would allow for insights into how uncertainties are dealt with in other industries. Considering also the differences between the industries could tell something about the influential components of these industries on the project uncertainty. Gaining insight into the role of these components should help to better understand and manage uncertainties in all sorts of industries.



Semi-structured interview guides

A.1. Worley

1 - General: Defining uncertainties

1. Do you make a distinction between risk and uncertainty?
   (a) Why (not)?
   (b) What is your perception of the difference between risk and uncertainty?
2. Do you associate uncertainty with negative or positive events or both?
3. And what do you associate risk with?
   (a) Follow-up if answer is different: Then what is the reason for (not) making a distinction in the identification (and the management) of the two?

”Uncertainty is a lack of understanding which may turn out to be a risk or an opportunity. Risks are quantifiable as a result of past experiences and for uncertainty, the probability of occurrence cannot be quantified.”

- Does this change anything about your perception on risk and uncertainty?

2 - Example specific: Dealing with uncertainties

1. Can you give an example of an (event that resulted from) uncertainty in an energy transition project?
   (a) Is this uncertainty typical for energy transition?
   (b) What do you believe to be the source of this uncertainty?
      i. What would be the source if the context were a traditional project rather than energy transition?
   (c) To what extent was the uncertainty the result of the project’s complexity? What complex element?
   (d) How did you and your team react to this occurrence of the uncertainty?
      i. What was the goal of this reaction?
   (e) What was the result of this occurrence?
      i. If negative: In hindsight, could this uncertainty have been made into an opportunity instead, if dealt with differently? If so, how?
   (f) What was done to identify and manage uncertainties prior to the start of this specific project?
      i. How was the uncertainty classified? (Based on what?)

ii. Is this different from what is done in traditional projects?

(g) Would you characterize this way of reacting to this uncertainty as reducing or embracing uncertainty?

i. Does this differ for risks and opportunities?

2. What was done to make sure to learn from the event?

3. Can you give me another example?

(a) Did you act the same way in this situation? If not, how did you or your team act differently?

3 - General experience: Energy transition vs conventional projects

1. In what way (characteristics, challenges, problems, opportunities) are energy transition projects different from conventional projects you have worked on?

2. What kinds of different uncertainties in energy transition projects as opposed to conventional projects do you observe?

(a) How does this influence your decision making during a project?

3. In what way is the project management/sales approach for energy transition projects different from conventional projects?

(a) If not different: in what way should it be different to adjust to this new type of projects?

4. Is the risk and opportunity response different in energy transition projects compared to conventional projects?

A.2. Client

1 - General: Defining uncertainties

1. Do you make a distinction between risk and uncertainty?

(a) Why (not)?

(b) What is your perception of the difference between risk and uncertainty?

2. Do you associate uncertainty with negative or positive events or both?

3. And what do you associate risk with?

(a) Follow-up if answer is different: Then what is the reason for (not) making a distinction in the identification (and the management) of the two?

”Uncertainty is a lack of understanding which may turn out to be a risk or an opportunity. Risks are quantifiable as a result of past experiences and for uncertainty, the probability of occurrence cannot be quantified.”

2 - General experience: Energy transition vs conventional projects

1. In what way are energy transition projects different from conventional projects?

2. What kinds of different uncertainties in energy transition projects as opposed to conventional projects do you observe?

3. In what way is the project management approach for energy transition projects different from conventional projects?

(a) If not different: in what way should it be different to adjust to this new type of projects?

4. Is the risk and opportunity response different in energy transition projects compared to conventional projects?

3 - Client specific

1. Is it a worry of you or your company that you might be caught up by companies that don't have the ballast of oil and gas business?
2. Do you set different requirements when working with parties such as Worley? Both in terms of the sales process and in the management of projects?
3. Are there ongoing discussions about dealing with uncertainties within your company?

B

Results project managers

Results thematic analysis

First order theme	Second order theme	Codes
Defining uncertainty	Difference	Uncertainties are unknowns (PM1, PM3, PM5, PM9)
		Risks are manageable (PM1, PM3, PM5)
		No distinction made in practice (PM2, PM7, PM10)
		Risks are quantifiable (PM7, PM9)
		Unknown unknowns (PM5, PM9, PM10)
	Association	Risk: both negative and postive (PM1, PM5)
		Risk: negative (PM2, PM3, PM9, PM10)
		Unc.: both negative and positive (PM1, PM5, PM10)
		Unc: negative (PM2, PM3, PM9)
		Neutral (PM7)
Dealing with uncertainty	Identification	Scenario analysis (PM1, PM5)
		Risk sessions (PM1, PM5, PM9, PM10)
		SWOT analysis (PM2)
		Checklist (PM7)
		Level of approval (PM2)
	Reaction	Embracing (PM3, PM5, PM10)
		Wait for information to become available (PM1, PM9)
		Less risk averse (PM2, PM3)
		Flexibility (PM3, PM5)
		Turn uncertainty into a positive (PM1)
		Contingency plans (PM5)
		Involvement of key players (PM5, PM10)
	Knowledge sharing	Lessons Learned (PM1, PM3, PM5)
		Organized sessions (PM3, PM5, PM10)
		Inform yourself (PM3, PM7)
		Subsequent projects (PM1)
Energy transition projects vs conventional projects	Industry	Novelty (PM7, PM9, PM10)
		New contracts (PM2)
		Scheduled driven (PM3)
		Change in people's motivation (PM7)
		Importance of appearance (PM5)
		New parties (PM9)
	Uncertainties	More/different uncertainties (PM1, PM5)
		Same uncertainties, different source (PM3)
		Subsidies (PM2, PM5, PM7)
		Legislation (PM5, PM9, PM10)
		Feasibility (PM3, PM7)
		Industry lancscape (PM5, PM7, PM10)
	Approach	More flexibility (PM1, PM3)
		Different team composition (PM5, PM 10)
		No difference (PM1, PM2, PM5, PM7, PM9, PM10)
		More agile (PM3)
	Risk/opportunity response	Higher level of risk acceptance (PM2, PM3, PM5, PM10)
		Greater effort for finding risk/opp (PM3, PM5)

Figure B.1: Results project managers

Results content analysis

Examples

Examples			Example, typical for:	PM1	PM2	PM3	PM5	PM7	PM9	PM10	Total
New Partners	Will there be sufficient financial backup?	PM2	**New industry**	3	4	1	4	2	1		15
			New market								0
Funding	Will a project be realized?	PM1, PM2, PM7	**New environment**								0
	Will subsidies be awarded?	PM1	**Energy transition**	1							1
			No link	1		1				1	3
Market	Public acceptance	PM7									
	What will be the demand?	PM1, PM5									
	Will demand be able to be matched with supply?	PM1, PM5									
Technology	What is the best technology?	PM9									
	Is it possible/will it work?	PM1, PM2, PM3, PM5									
Regulations	Effect on awarding of subsidies	PM5									
External events	Ukraine war	PM10									
	Ground bearing conditions	PM3									

Sources

Source:			PM1	PM2	PM3	PM5	PM7	PM9	PM10	Total
Project parties			1	1						2
Market						3	1			4
	Novelty				1					1
	Demand		1							1
	Supply		1							1
	Political								1	1
Organizational				1		1	1			3
Resources										0
	Financial		1	2			1			4
	Human/knowledge		1		1	1		1		4
	Material		1		1					2
Technology			1	1	1	1				4
Third parties				1						1
Human element										0

C

Results sales

Results thematic analysis

First order theme	Second order theme	Codes
Defining uncertainty	Difference	Uncertainty as subset of risk (S4)
		Difference is made (S6, S8, S11)
		Risk is related to actions (S6, S8, S11, S12)
		Uncertainty happens (S6, S8, S11)
	Association	Both negative and positive (S4, S8, S12)
		Positive (S6)
		Neutral (S11)
Dealing with uncertainty	Identification	No identification of uncertainties (S4, S8,11)
		Risk analysis (S4, S6, S11)
		(Business) Opportunities (new projects) (S4, S6, S8, S11)
		Classification: level of approval (S4, S6, S11)
	Reaction	Flexible (S4, S6)
		Help client to reduce own uncertainty (S8, S11, S12)
		Embrace (S6, S8, S11, S12)
		Accept (S4)
	Knowledge sharing	Discussions (clients and previous teams) (S4, S6, S8)
		Collaboration (S11, S12)
		Cold eyes view (S6)
		Lessons learned (S6, S8)
		No/little structure (S4, S12)
Energy transition projects vs conventional projects	Industry	Business case (S4, S6, S11, S12)
		Time pressure (S4, S8, S12)
		Lack of experience (S4, S8, S11, S12)
		Different relationships (S8, S11, S12)
		Subsidy component (S6)
	Uncertainties	Unproven technology (S4, S6, S11)
		Market position (S8)
		Underdeveloped frameworks and models (S4, S11, S12)
		Same type, different degree (S12)
	Approach	Time (S4, S8)
		People (S6, S11)
		More collaboration (S11, S12)
		More detailed knowledge (S4, S8, S11)
	Risk/opportunity response	More embracing (S6, S12)
		Strategy related (S4, S8, S11)

Figure C.1: Results Sales

Results content analysis

Examples

Examples			Example, typical for:	S4	S6	S8	S11	S12	Total
New Partners	Harder to make value proposition	S4	**New industry**	1	3			3	7
	More effort on building relationships	S4	**New market**				1		1
	Joint ventures	S8	**New environment**	2					2
	Social licence to operate	S12	**Energy transition**			1		1	2
			No link			2		1	3
New/different contract forms	More risk placed with Worley	S4, S6, S8							
Funding	Will project be realized?	S4, S6							
Market	Opportunity: which way can you go?	S6, S11							
	Clients reevaluate their strategies	S11							
	Third party events	S12							
	Supply chain constraints	S12							
Technology	Feasibility	S8							
	Feedstock availability	S12							
Regulations	What are the requirements?	S12							

Sources

Source:		S4	S6	S8	S11	S12	Total
Project parties		2		1		1	4
Market			1	1	1	4	7
	Novelty	1					1
	Demand	1					1
Organizational			1	1		1	3
Resources						1	1
	Financial	1	1				2
	Human/knowledge		1				1
Technology				1			1
Third parties						1	1
Human element						1	1

D

Set-up expert panel

The statements and preliminary results as presented in the expert panel are listed below:

1. **"The reaction towards uncertainties is mostly of an embracing nature, allowing for a proactive approach towards both risks and opportunities." -** The replies varied a lot. People generally aim to reduce risks and embrace opportunities. The way the overall approach is described is often linked to the chosen strategy for a project. In sales, risk and opportunity responses were more often described as embracing. It was also observed that sales more often spoke about being more adaptive in seeking opportunities.
2. **"At Worley, we learn from each other's experiences and are not surprised by the same sort of event more than once." -** Everyone acknowledges that there are tools and processes in place for sharing knowledge and experiences. However, most people say this is not done enough. Sharing knowledge seems to be done differently on project level and in sales. Sales was generally more positive on the effectiveness of sharing knowledge in comparison to project managers.
3. **"The projects related to energy transition are different from the conventional projects, but the approach in these projects can remain the same." -** Despite acknowledging a great variety of characteristics and uncertainties being different in energy transition projects compared to conventional projects, nearly every PM claims that the ways of approaching and/or managing a project has not changed. In sales, the processes seem to be adjusted to the new project circumstances observed in relation to the energy transition. Interviewees did have thoughts on what could be changed for better matching the new project circumstances (e.g. more agility, different team composition)

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