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Measuring R&D in a multinational company

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Submission date: June 2013
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PREFACE

This thesis is prepared in the department of Industrial Economics and Technology Management (IØT), at the Norwegian University of Science and Technology (NTNU). It constitutes to the final Master of Science within the specialization Strategy and International Business, and was carried out during the spring semester 2013.

This thesis has been written for, and conducted in collaboration with, Statoil´s TPD RDI FC department. It has been challenging to go outside the standard list of master thesis topics, but it has been very rewarding to work with ideas that are my own to create a useful model for a multinational company.

I would like to thank my supervisor Arild Aspelund for excellent guidance and valuable feedback throughout the entire preparation of this thesis. I would also like to thank Statoil and especially the TPD RDI FC staff-members at Rotvoll in Trondheim, for support and help during the work.

A special thanks to Ida, without your support and engagement, this thesis would not have been possible.

Thanks to family and friends for all support throughout my long study period against the aim to become a civil engineer. I am forever grateful.

Trondheim, June 2013

Kristin Mürer Stemland

SAMMENDRAG

Forskning og utvikling er essensielt for en bedrift som ønsker å overleve i dagens samfunn. Med blant annet økt konkurranse og sterkere kundekrav er det viktig at bedriften hele tiden utvikler nye teknologier og starter nye prosjekter. For å kunne fordele ressursene riktig, er det viktig for en bedrift å ha ett system for å kunne evaluere, prioritere, og velge de riktige prosjektene for å kunne oppnå sine strategiske mål og få en optimal portefølje.

Forskning og utvikling er fremtidige hendelser som det er vanskelig å anslå utfallet av. Alle prosjekter har sine styrker, og kan bidra til at bedriften oppnår suksess. Det er ikke mulig å estimere representative finansielle verdier for alle prosjekter, for å muliggjøre sammenligning og evaluering. Prosjekter er viktige innenfor ulike områder, og noen har krav om å bli gjennomført. Det er derfor viktig å utvikle ett system som får frem den reelle verdien av ett prosjekt, og gir alle typer prosjekt en mulighet til å bli evaluert på samme grunnlag. Dette for at alle skal få en rettferdig sjanse til å bli prioritert og valgt av bedriften.

Denne masteren er utført for, og i samarbeid med, Statoil sin forskningsavdeling. Statoil er en stor multiinternasjonal bedrift innen olje- og gassindustrien med en stor forskningsportefølje bestående av mange ulike teknologier og prosjekter. Denne studien skal finne ut hvordan Statoil skal gå frem for å finne en optimal forskningsportefølje, hvilket system som anbefales, hvordan det skal brukes og hva det skal inneholde. Det er gjort en studie av relevant teori, bedriften, industrien, miljøet, markedet, og intervjuer og gruppe diskusjoner med ansatte i Statoil er gjennomført.

Hovedfunnene i masteren er at prosessen må skje på porteføljenivå. Dette fordi mange prosjekter hører sammen og man må se den totale balansen av alle prosjektene i porteføljen. En optimal portefølje består av optimale prosjekter som passer sammen, som har strategisk forankring og bidrar til maksimal verdi. Det må brukes en felles modell, for å kunne ha samme utgangspunkt for diskusjoner, og ha mulighet til å evaluere og prioritere på tvers av ulike porteføljer. Modellen som anbefales er ett evalueringskort som består av ulike evalueringsområder med tilhørende utsagn der det som passer best skal velges. Kortet benyttes som ett informasjonsdisplay som utgangspunkt i diskusjoner, men med en totalevaluering i form av ett trafikklyssystem for å vite hvor diskusjonen skal begynne.

Resultatet av denne masteren er ett evalueringskort som er tilpasset Statoil, for å få frem hver teknologis verdi i lys av hva som er viktig for Statoil. I tillegg er en generell modell med stegvis beskrivelse for hvordan en bedrift kan gå frem for å finne sin optimale forskningsportefølje laget. Denne har fått navnet Mürer Stemland´s R&D portefølje optimaliseringsmodell.

Nøkkelord: optimal portefølje, portefølje ledelse, evaluering, prioritering, forskning og utvikling.

SUMMARY

Research and development (R&D) is essential for companies that wish to survive in today´s community. With increased competition and stronger customer demands, it is important to develop new technologies and start new projects. To be able to allocate the resources right, the company has to have a system for evaluation, prioritization and selection. This will help reaching the organizational goals and to obtain an optimal portfolio.

R&D is future happenings it is difficult to predict the outcome off. All projects have its strengths, and can contribute to success for the business. Not all projects are able to estimate representative financial values to be compared and evaluated after. Projects are important in different areas, and some just have a requirement to be performed. It is therefore important to develop a system that highlights the real value of a project and gives all types of projects the opportunity to be evaluated on the same basis, so that all have a fair chance to be prioritized and selected.

This thesis is written for, and in collaboration with, Statoil´s TPD RDI FC department. Statoil is a big multinational company within the oil- and gas-industry, with a large R&D portfolio consisting of different technologies and projects. This study is going to find out how Statoil must proceed to obtain an optimized R&D portfolio, what system that is recommended, and how to use it. The methodology used to solve this has been qualitative research of relevant theory, the company, the industry, the environment, the market opportunities, and interviews and group discussions with employees in Statoil.

This thesis found out that the process must be conducted as a portfolio review. This is because there are interrelationships between projects, and there are needs to see the total mix of all the projects in the portfolio, which give maximal value and have strategic alignment. Optimal portfolios consist of optimal projects that fit together. There must be a common system, to have the same basis for discussions, and to be able to evaluate and prioritize across the different R&D portfolios. The model recommended is an evaluation card that consists of multiple evaluation areas with a set of associated statements. The statement that fit the most must be chosen. The card should be used as an information display, as basis for discussions, but with a total evaluation included, by use of a traffic-light system, to know where to start the discussion.

The result of this thesis is an evaluation card adapted to Statoil, to be able to highlight what are important to them. In addition, a general model, with a stepwise description of how a general company can proceed to find their optimal portfolio, is made. This model is named Mürer Stemland´s R&D portfolio optimization model.

Key words: optimal portfolio, portfolio management, evaluation, prioritization, and R&D.

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LIST OF ABBREVIATIONS

FC	Finance and Control
HID	High Impact Delivery
HSE	Health, Security and Environment
IRR	Internal Rate of Return
NCS	Norwegian Continental Shelf
NPD	New Product Development
NPV	Net Present Value
P	Project
PM	Portfolio Management
PPM	Project Portfolio Management
R&D	Research and Development
RDI	Research Development and Innovation
ROI	Return of Investment
TDG	Technology Decision Gate
TDI	Technology Development and Implementation
TDP	Technology Development Plan
TPD	Technology Projects and Drilling
TRL	Technology Readiness Level

1 INTRODUCTION

In this chapter a short presentation of the introduction and motivation behind this thesis are given. Then the research questions that are going to be answered are presented. Finally, the structure is described.

1.1 INTRODUCTION

Every company with an R&D department must be able to set a value on their R&D project that is as reliable as possible, to be able to evaluate and prioritize between different projects, and to choose the right projects with the scarce resources available.

An earlier literature study on what the theory recommends, regarding how to set a value on an R&D project, showed that there are a lot of different factors that have an impact. A framework that need to be adapted to fit each company´s; objectives, strategy, organizational structure, resources available, type of project and type of industry, was proposed so that a company can be able to measure the value of R&D in a way that is best for that specific company. The implementation of strategies in the measurement system requires consideration regarding both financial and non-financial measurements. The basis of a measurement system should be the alignment to the corporate strategy and the organization´s missions and goals. To be able to obtain balance, several evaluation areas that are determinants of growth, have to be included to cover all demands provided by stakeholders and markets.

A big company like Statoil have several different R&D technologies or projects at the same time. To manage to choose the right projects within the limited resources, they must evaluate and prioritize among all the projects in the portfolio. A way to achieve the right balance, a strategically aligned portfolio, and to obtain maximized value of the portfolio, is to use portfolio management for R&D projects. Portfolio management handles resource allocation, funding decisions, top priority decisions, and strategically decisions. Finding the right balance means finding the optimal investment mix between low versus high risk, incremental versus radical new technologies, and short-term versus long-term new projects.

Today Statoil are in a process for setting a more reliable value on their R&D projects. A new method regarding how to set the quantitative net present value (NPV) on each projects is being implemented, with decision-analysis including decision trees. This is a method that gives a good view on the opportunities that lies in each project, and can help getting a financial NPV value on the project. But this is not enough. Since R&D projects are future events, these values become highly unreliable. The estimates are given by the scientists, and many of them do not want to give these numbers because they feel they give a wrong picture of their project.

To get the right value, the earlier study recommends that several evaluation areas have to be included in the total score. If it is possible to put a more reliable score on each project, it can be used in evaluation to compare them against each other to find out which mix of technologies and projects that can optimize the company's portfolio. One method proposed for this is use of a scorecard. Here the decision makers rate the projects on a number of questions that distinguish superior projects, typically on 1-5 scales. These ratings are then added to get a score that is a proxy for the score of the project to the company. But this may not be the best way possible. Within R&D, exploration and new ideas are the essential. The research has to be maintained, and failure has to be allowed. It is possible that a mechanical value on a project not is the right way of doing it. Many of the needed factors that are important and have to be taken into consideration, to be able to evaluate the portfolio, are difficult to rate.

The problem is to configure the portfolio in order to obtain the highest possible profit in a reliable way. There are challenges due to the presence of uncertainty, the interdependency between projects, the limited available resources, the combinatorial nature of a portfolio, and the climate considerations, to mention some of them.

1.2 RESEARCH QUESTIONS

The goal is to propose an optimization system that can help Statoil to select a set of R&D projects from a pool of available projects, in order to maximize the expected benefits and finding the right mix of projects, while coping with the uncertain nature related to R&D. The selected and prioritized technologies or projects must be implemented to the company's strategy, and its scarce resources must be allocated right. This means that the company must decide which projects to select, pursue, set on hold, or kill. This thesis should propose the best way for the managers to be able to see what is in the project, and give a good view on each portfolio, to make it possible to evaluate, prioritize and select the right projects according to the company´s needs. This leads to the first research question:

Q1: How can a large company, like Statoil, proceed to optimize their R&D portfolio?

In the theory, many systems are proposed for this purpose, but no one is good enough to cover all the goals and needs to obtain an optimized portfolio. This thesis is going to find this optimal system. There is also a question of what the best way to use the system is. It can be used as an information display, without weighting of the evaluation areas, or it can be used like an scoring model that produce a prioritized list of projects. The display approach means that the managers must review the various results, integrate and assess the information, and then make prioritized lists themselves. By contrast, the scoring model approach provides the management with a first-

cut list of projects, weighted and prioritized according to certain criteria. Management then reviews and adjusts the list as needed. This dilemma results in the next research question:

Q2: What method should be used, and should it be an information display or a scoring-model?

The chosen method must be adapted to the company. What evaluation areas to be included in the system and which set of associated statements, are the key problems that have to be solved. This leads to the last research question:

Q3: What should be included in Statoil´s evaluation card?

1.3 STRUCTURE OF THIS THESIS

The first chapter of this thesis is the introduction, which includes a short introduction and research questions that are going to be answered. All the relevant theory about the topic is presented in chapter two. The methodology, chapter three, describes the research method used to find the solutions of the research questions, the methodology limitations, followed by an evaluation of the qualitative validity to the findings. Also introduction and information about the interviews and group discussions are included in this chapter.

Chapter four presents the empirical findings. The main findings in the oil and gas industry, the environment and market opportunities are presented, together with information about Statoil, and useful information regarding the company used to answer the research questions. A summary of the interviews and discussions are presented at the end of the chapter.

The next part is the discussion. In this chapter each research question is discussed separately. The result from the discussions ends up in Statoil´s evaluation card. Then implication for theory is discussed. The result of this is a general evaluation card that can be used as a guideline for other companies. This is also input to the final results, the Mürer Stemland´s R&D portfolio optimization model, which is described in a stepwise process. At the end of chapter five, recommendation for the managers and further research, and limitations are given. Finally, the thesis ends with the conclusion that is presented in chapter six.

2 THEORY

In this chapter the relevant theory used to answer the research questions together with the empirical findings are presented. First a short introduction about why R&D projects are important is given. Then the main concepts of R&D project management are described, to be able to develop the most optimal projects possible. Also a section of project performance is included, to be able to determine what factors that project success is determined of. At the end of the section definition and theory of project portfolio management is presented. This is followed by the next section which presents the main topic of portfolio management of research and development projects and its goals. Once the main concepts and definitions are introduced, the evaluation, selection and prioritization process are looked deeper into. This includes how to evaluate, prioritize and find the right mix of R&D projects, and what a method should consist of.

2.1 THE IMPORTANCE OF MEASURING R&D PROJECTS

Over the last decades there has been an increased focus on innovation and its importance for nations, society, and companies to survive and obtain economic growth. A company needs to be innovative to gain competitive advantage. Innovation generally refers to changing or creating more effective processes, products, and services. (Trott 2008)

Innovation is about opening up new markets, and new ways of serving established and mature ones. There is a strong connection between innovation and R&D. Corporations must be able to adapt and develop if they want to survive and increase the probability for success. Companies with a strong R&D base are constantly looking for opportunities to diversify horizontally into new product markets, and their strategic management activities seek to mobilize complementary assets to successfully enter those markets. (Trott 2008)

Today's market is characterized by increased globalization, strong competition, high cost pressure and increased demands from the customers. To ensure economic growth and sustain competitive advantages, the society has to keep up with developments, and invest its money in new technology wisely. If a company wants success with new technology developments, they have to allocate their resources right. If they could put a value on the projects, it will be easier to compare and know how to prioritize. If the company prioritizes the right project there is increased possibility for success, which again can result in increased profitability, reduced costs, good reputation and organizational environment, and motivated personnel.

2.2 R&D PROJECT MANAGEMENT

This section describes first a model for how to best get a new development project from idea to market. Then some best practices are presented to be able to ensure superlative development results. This is followed by theory about project performance and the three direct project goals. At the end, theory and definitions of project portfolio management are introduced.

2.2.1 FROM IDEA TO MARKET

The Stage-Gate concept and techniques, that provides structure, order and control to the entire new product development (NPD) process, is a valuable tool for developing ideas into projects and maintenance of the portfolio.

According to Cooper (2001) are new products critical for the survival and prosperity of the modern corporation. Innovation is no longer seen as an optional investment, but as a major instrument of company growth and very critical for future business success. In this thesis, new products are defined as:

> *"Anything that the organization offers to its marketplace for use or consumption and is new to the selling organization"* (Cooper 2001)

Even though innovation and new products are important, the problem for the managers is that approximately just one in ten new product concepts succeed (Cooper 2001). One way for reducing the failure-rate is to use Cooper´s Stage-Gate framework. The thought is to guide new product projects from beginning to end, and drive the projects from idea to market effectively and quickly. Stage-Gate new product approach is a conceptual and operational model that can be used for this. The model breaks the innovation process into predetermined set of stages. The model is viewed in figure 1.

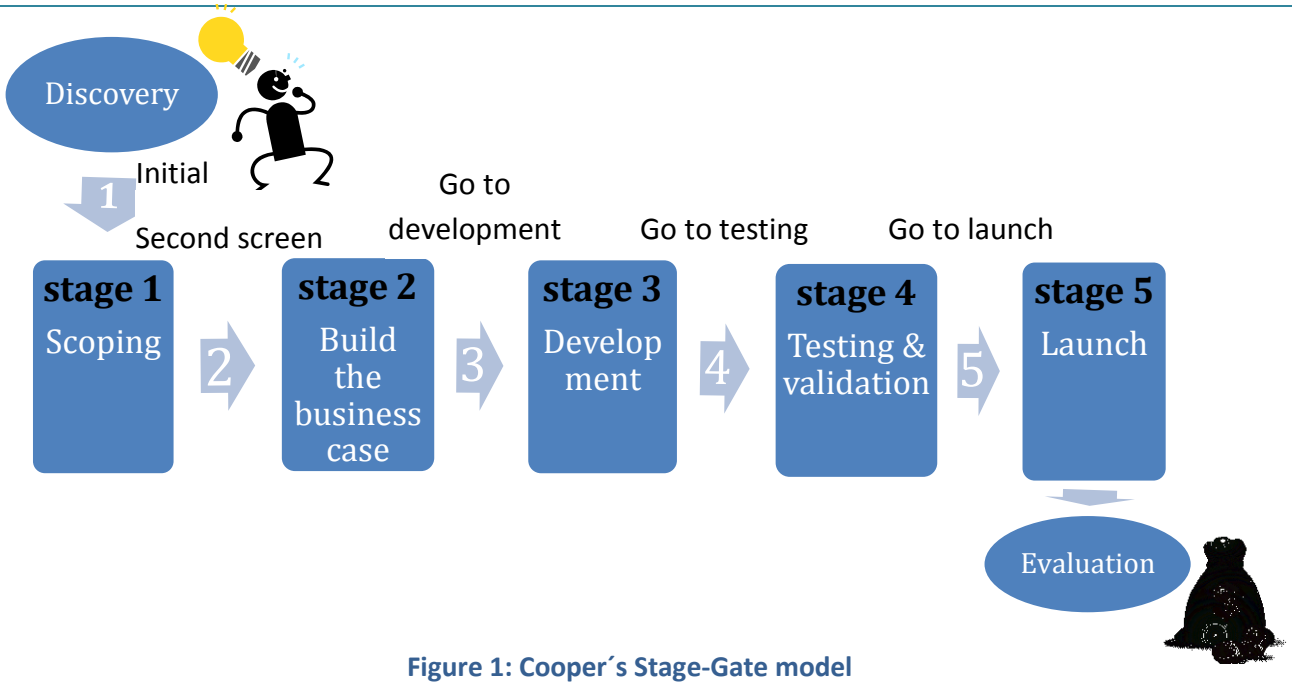

Figure 1: Cooper´s Stage-Gate model

The stages:

The stages are where the action occurs. It consists of a set of prescribed, cross-functional and parallel activities, adapted to the business. The activities are specified to answer questions about what the managers need to know at the end of that stage to make an informed decision to move forward. An overview of each step, according to what Cooper (2001) recommends, is given in the following:

- Discovery or the idea-phase is for pre-work, designed to discover opportunities and generate new product ideas, both intern in the company and extern. The goal for each company is great ideas and a lot of them. This is so important that many companies handle the discovery stage as a formal stage. Activities in this stage can be technical research, seeking new technical possibilities and product value analysis, to mention some. A close relationship with the leading users is important.
- The scoping stage has the objective to determine the project´s technical and marketplace merits. Stage 1 is a quick scoping of the project, involving research based on already existing information. Preliminary market and technical assessment are carried out, at a low cost and in short time, to enable a superficial financial and business analysis.
- Building a business case is a much more detailed investigation that clearly defines the product and verifies the attractiveness of the product prior to heavy spending. Primary research to determine the customer´s needs, wants and preferences are done, in addition to a competitive analysis, a detailed technical appraisal and detailed business

and financial analysis. This result in a business case with the product definition, a key to success, a thorough project justification and detailed project plan.

- The development stage includes the implementation of the development plan and the physical development of the product. A lot of different tests are conducted to ensure that the product meets the requirements. The deliverable at the end of this stage is a prototype product. Market analysis and customer feedback are activities running in parallel with the technical work.
- Stage 4 tests and validates the entire viability of the project, namely the product itself, the production process, customer acceptance and the economics of the project. Some of the activities in this stage are in-house product tests, user trials, market pretest and revised business and financial analysis.
- Launch is the final stage where the commercialization happens. It involves implementing the market launch and production plan, distribution and quality assurance. Now the product should be ready for sale.
- Project evaluation should be carried out approximately 6-18 month after launch. Here the focus should be on what have been learned, how to get better and if the goals are achieved.

The gates:

Each stage is separated by a gate. The gates serves as quality control checkpoints, go/kill and prioritization decision points and are where the action plan for the next stage is decided. The format of the gates can be seen in figure 2, and consists of deliverables, criteria and outputs.

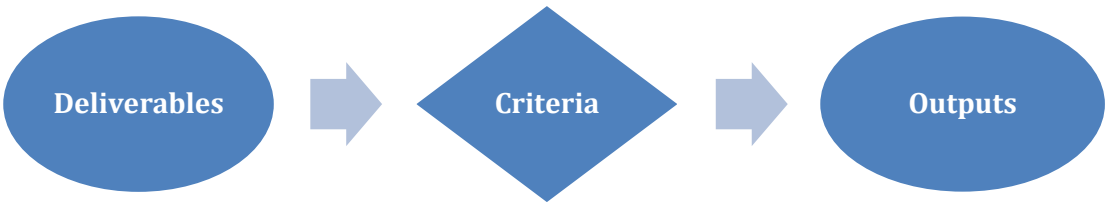

Figure 2: Format of the gates in Coopers Stage-Gate model

The deliverables are what the project leader and team must bring to the gate decision point. This is typically the results of the completed activities that are carried out in the stage. These deliverables are based on a standard list for each gate, and are decided at the output of the previous gate. The criteria is what the project is judged after, in order to make the go/kill and prioritization decisions. Defined outputs can be a decision (go/kill/hold/recycle), an approved action plan for the next stage, and a list of deliverables and date for the next gate. (Cooper 2001)

Each gate has its own list of criteria for use by the gatekeepers. There are mainly three types of criteria; readiness-check, must-meet, and should-meet. Readiness-check is yes/no questions to check whether the requirements are fulfilled. Must meet is yes/no questions that include the minimum criteria that the project must meet in order to move forward, while the should-meet are highly desirable project characteristics used to distinguish between superb and minimally acceptable projects usually in scorecard format. The score is used to make go/kill decisions and to prioritize different projects against each other. (Cooper 2001)

2.2.2 KEY SUCCESS DRIVERS

Cooper (2001) recommends that a number of best practices are built into the Stage-Gate model in order to yield superlative results. These are summarized in figure 3, and described shortly below.

Figure 3: Summary of best practices: the key success drivers (Cooper 2001)

Most of the businesses new product effort´s suffer from lack of focus. The trend is too many projects with not enough resources to execute them well. The lack of resources may be regarding people or money, or the fact that limited set of resources are used in too many projects because of focus failure from the management. Wrong focus causes failure to set priorities and tough go/kill decisions and the gates becomes weak. There is a need for tough go/kill decision points, where the poor projects are weeded out, the resources are directed toward the truly deserving projects and the focus is on the result.

The companies have to drive the quest for product advantages. They have to seek truly superior products, not redesigning or repeating current practices. To solve this, at least some of the criteria at every gate should focus on product superiority and competitive advantages. Some customer actions designed to deliver product superiority should be included in each stage of the process, and it should be demanded that the project team deliver evidence of product superiority to gate reviews.

A strong market orientation, trough the whole process, with voice-of-customer is important if a positive new product performance is the goal. It should be a customer-focused approach to gain insight into customer problems. Early preliminary market assessment to assess market opportunity, voice-of-customer research to identify needs, competitive product analysis, and analysis to determine the customer/user value, must be executed and tested in constant iteration with the customers, from stage 1 to launch.

Quality of execution is about doing it right the first time. There is a need for focus on improving business processes to eliminate errors and to meet the requirements all the time. The solution is a more systematic and quality based approach to the way companies conceive, develop, and launch new product through visualization of the innovation process. Get the details of the process right, practice discipline to the process and the result will be a high-quality output. Parallel processing helps to cover the need for a complete and quality process. In parallel processing many activities are undertaken concurrently, rather than in series, and more work is done in an elapsed time period. It also reduces the chance for an activity to be overlooked because of lack of time. The activities are designed to feed each other, and the entire process becomes more cross-functional. New product processes requires input and active participation of players from many different functions in the organization.

The model must be built for speed. All time wasters and work that do not add any value to the current process must be eliminated. Get rid of unnecessary work or people that are not really needed in this particular project. The model must also be flexible and dynamic, so it can handle changing conditions and varying circumstances of projects. The project team should map the best path forward by use of the standard process as a guide. They are permitted to combine gates and collapse stages, or go back to previous ones, and move long-lead-time items forward.

Not all projects have the same size or risks, and lower-risk projects do not need all the activities and stages that higher-risk ones do. For the management to be able to assess how well NPD and the process is working, the model must feature solid performance metrics. Success metrics is often included in the evaluation phase of the model, and include first-year sales, product profitability and on-time performance.

Whether a product is a success or failure is often decided in the crucial first step or tasks of a project that precede the actual development of the product. The up-front homework defines the product and builds the business case for development. An ideal new product process ensures that these early stages are carried out and that the product is fully defined before the project is allowed to become a full-fledged development project. Solid homework is a key for success.

2.2.3 THE "DIRECT" PROJECT GOALS

Despite all the different types of projects that exist, they all have the same general objectives that play an important role related to project performance. These are; scope, time and cost. They are referred to as "direct" project goals. In project management, scope means the specified deliverables. (Meredith and Mantel 2012)

According to Meredith et.al (2012) are customer expectations so important that it is considered to be included as one of the dimensions. The client specifies a desired outcome, before the design and implementation are decided. Then the client views the results again. This process should continue throughout the entire project. But the fact is that this is lacking in the reality. As a result the client´s desires is not well reflected by the initially and final specified scope of the project.

The three "direct" project goals are shown in figure 4, with the specified project goals on the axes.

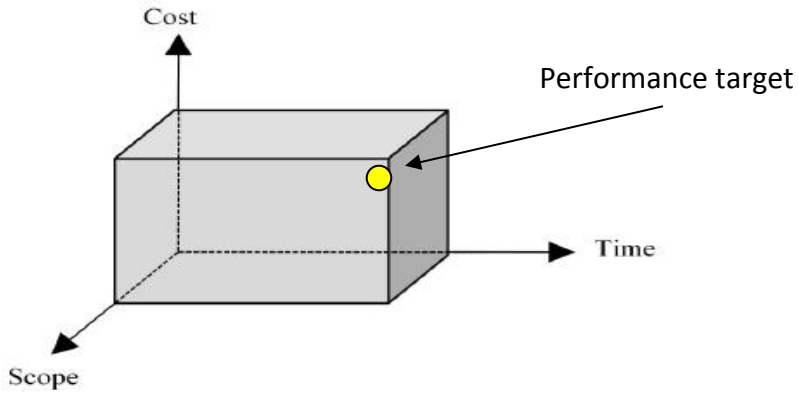

Figure 4: Direct project goals – scope, cost and time

The meaning by this figure is that all projects needs to be performed and delivered related to scope, cost and time. One of the goals cannot be changed without affecting the others. The time refers to the amount of time available to complete the project. The cost refers to the budgeted amount available. The scope refers to what must be done to produce the projects end result.

2.2.4 PROJECT PORTFOLIO MANAGEMENT

Because of the importance of developing research projects, most companies engage in several different sorts of projects. Especially big companies need to do research in different directions. This leads to the need for organizations to have portfolios consisting of projects. In this thesis, project portfolio is defined as:

> *"A group of projects that are carried out under the sponsorship and/or management of a particular organization"* (Archer and Ghasemzadeh 1999)

A key managerial task is to dedicate resources across all this projects. Project portfolio management (PPM) is critical to company performance, and is by Harvey (2005) defined as:

> *"A set of business practices, that brings the world of projects into tight integration with other business operations. It brings projects into harmony with the strategies, resources, and executive oversight of the enterprise and provides the structure and processes for the project portfolio governance "*

What PPM is all about, according to Harvey (2005), is shown in figure 5.

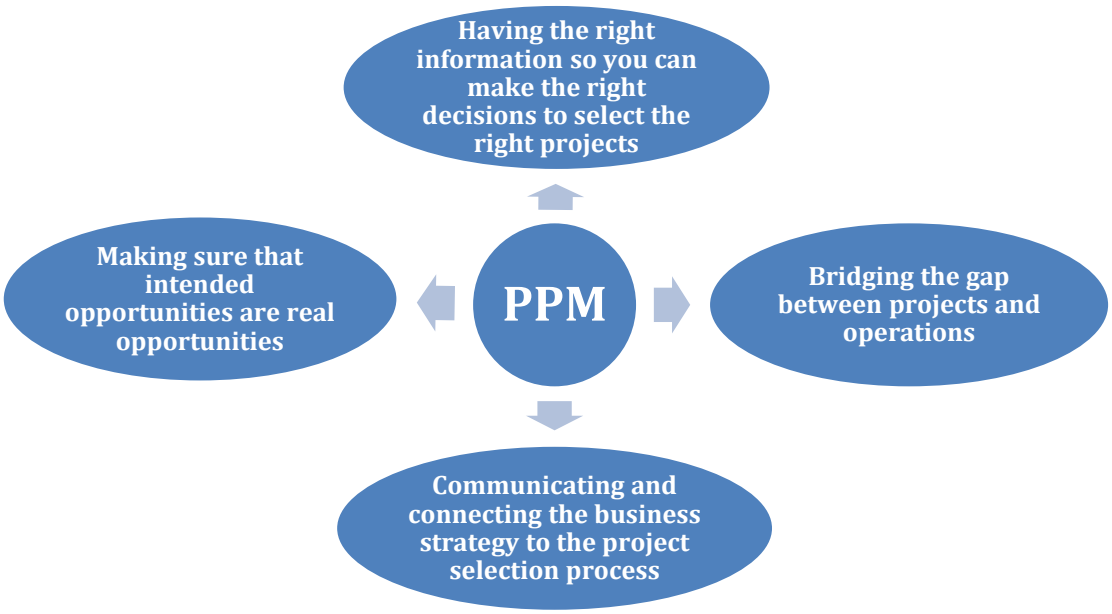

Figure 5: What PPM is all about (Harvey A. 2005)

There are several reasons why a company should include PPM. According to LaBrosse (2010); Harvey (2005); and Archer & Ghasemzadeh (1999) includes the benefits of PPM:

- A portfolio of projects that are closely aligned with the organization´s strategy and goals
- The best use of resources by focusing on high-priority efforts
- Elimination of redundant, underperforming, or outdated projects
- Key projects that are monitored for performance so that corrective actions can be taken

Implementing PPM into the company does not mean any new functional position defined in the organization. PPM is viewed as a process that has to be supported by the leaders and managers already employed in the company. The PPM process is added to the already existing responsibilities to these senior managers. (Harvey 2005)

Due to the importance, PPM is a difficult task for the managers. They meet challenges regarding which projects to include in the portfolio, and which to terminate, how to allocate resources to them through the whole project life cycle, and how to balance the portfolio. The main managerial activities related to PPM is, according to Blichfeldt and Eskerod (2007)shown in figure 6.

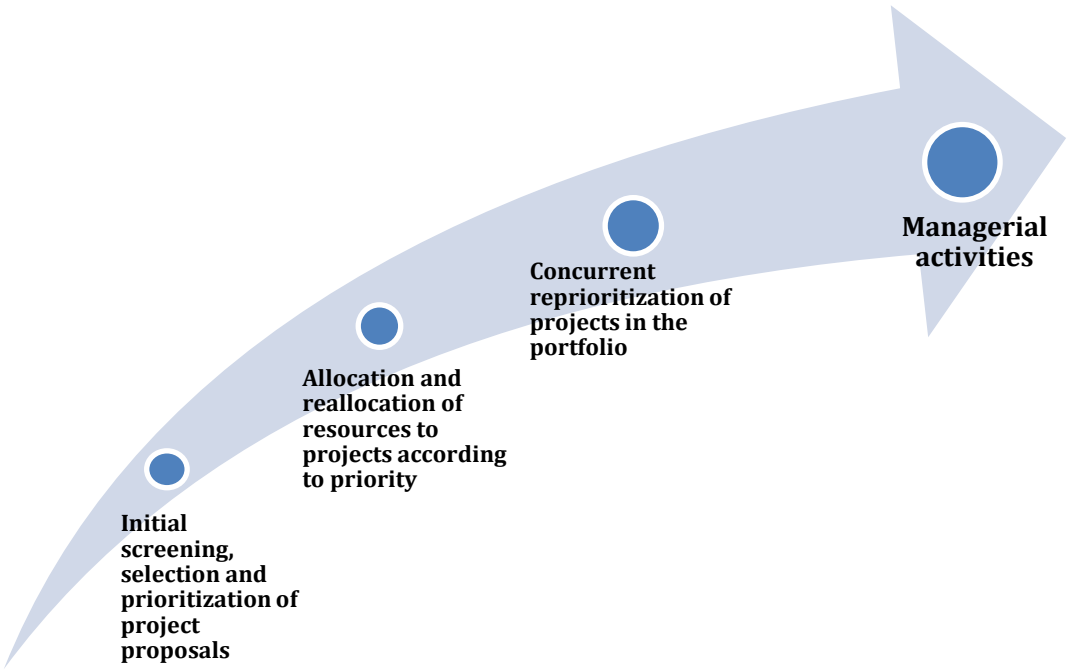

Figure 6: Managerial activities (Blichfeldt et.al 2007)

2.3 PORTFOLIO MANAGEMENT FOR R&D PROJECTS

Product innovation is one of the most important endeavors of the modern corporation. Customers as well as shareholders seek a steady stream of innovative new products; customers because they demand value for money, shareholders because they seek profitable growth. The global market change rapidly, and the need for companies to stay ahead of their industry, force them to rely on R&D as a source of strategy for long-term growth and sustainability (Mikkola 2001). R&D projects should have a long-term perspective and it is important that these projects are evaluated in relationship with customers, and that a set or a subset of R&D projects are evaluated together.

Senior executives who manage to optimize their R&D investments will win in the long run. Management in successful businesses, within product innovation, focuses their resources on the right arenas, define the right new product strategy for the company, select the winning new product projects, and strive to achieve the ideal balance and mix of projects. (Cooper, Edgett and Kleinschmidt 2001) This is what portfolio management for R&D projects is all about: resource allocation and investment decisions to achieve the business´s new product objectives. The definition of portfolio management of R&D project that is going to be used in this thesis is as follows;

> *"Portfolio management is a dynamic decision process, whereby a business's list of active new product (and development) projects is constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritized; existing projects may be accelerated, killed or de-prioritized; and resources are allocated and re-allocated to active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations."* (Cooper, Edgett and Kleinschmidt 2001)

The portfolio decision process encompasses or overlaps a number of decision-making processes within the business. This includes periodic reviews of the total portfolio of all projects, taking go/kill decisions on individual projects on an on-going basis, and developing a new product strategy for the business. All this is completed with strategic resource allocation decisions across business units and strategic arenas.

Portfolio management of R&D projects is challenging on many levels, but therefore all the more important. It deals with future events and opportunities, which means that much of the information needed to make right decisions is uncertain and unreliable. Portfolio management of R&D projects focus on what might be; new opportunities, new ventures, new products. The fact that the environment is dynamic, results in ever changing status for the projects in the

portfolio because the market changes and new information becomes available constantly. The R&D projects in the portfolio are at different stages of completion. Nevertheless, they compete for the same limited resources. This leads to managers making comparisons between projects with different amounts and quality of information. R&D projects are often interconnected. There are synergies between the projects, and undertaking one project may actually facilitate another. All these main challenges makes portfolio management and prioritization of R&D project a critical management task. Despite the doubtful information available, resource allocation decisions still must be made. The ability to choose the right R&D projects and make the right investments is vital for winning the new product competition. New products are the leading edge of business strategy; new product choices are virtually synonymous with strategic choices. (Cooper 2005, Cooper et.al 2001, Mikkola 2001)

2.3.1 GOALS IN PORTFOLIO MANAGEMENT OF R&D PROJECTS

The portfolio management of R&D projects is important because choosing the best projects after what maximizes the value of the portfolio does not necessary result in the best possible portfolio as a whole (Chien 2002). It is not just the involved projects summarized value that matters, but also the balance and strategic suitability of the portfolio. If, for example, the projects are of high risk, the result is an unbalanced portfolio, even though all the maximum value projects are included.

The choice of the "right" portfolio approach method depends on which goal the company has highlighted (Cooper et.al 2001). The goals for portfolio management of R&D projects are summarized in figure 7. It is clear that it is potential for conflict between the different goals, and focus on one approach may sacrifice another.

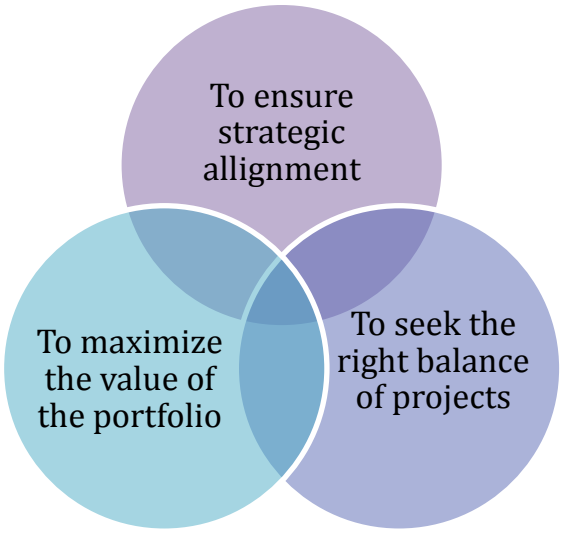

Figure 7: Goals in R&D portfolio management

In order to manage portfolios of R&D projects, organizations rely on different methods or techniques. In contrast to regular portfolio management models, new product portfolio models plot products that do not even exist yet, and allocate resources for these. This makes the R&D portfolio decisions hard to manage and complicated. Different methods, in different categories, have been developed by different authors during the years. The original models were highly mathematical. A survey carried out by Cooper et.al (2001) identified that even though financial methods were most commonly used, they gave the worst performance result. Financial methods are used to estimate the benefit of the R&D project. The methods that performed best was strategic ones, which is used to show the connection between research projects and organizational strategy.

The common denominators across companies are the goals management is trying to achieve. All goals are important, and there is no clear consensus that some are better than others. More about each goal and its methods are given in the following sections.

2.3.1.1 ALIGNMENT TO STRATEGY

The main focus regarding this goal about strategic alignment is to ensure that the final portfolio of R&D projects is strategically aligned and truly reflects the businesses strategy. All active projects must contribute to achieve the goals and objectives highlighted in the strategy. Strategy becomes real when you start spending money, so resource allocation across business areas, markets, and project types must truly reflect the desired strategic directions of the business. (Cooper et.al 2001)

Strategy is a needed to direct the company into certain directions, and to motivate the individuals in the organization to work towards achieving a shared goal (De Wit and Meyer 2010). In other words, strategy is the organizations ability to remain ahead in its industry and sustains competitive advantage.

The strategy is the root to everything. The goal about maximizing the portfolio value is meaningless unless the value is measured in terms of the company´s goal which is part of the strategy. Also the goal of obtaining balance is about strategy, since it is the strategy that describes what the ideal balance is. Which R&D projects the business selects and where they decide to spend money, must be related to the vision, mission and strategy of the company.

LINKING STRATEGY TO THE PORTFOLIO SELECTION AND OPTIMIZATION

According to Cooper et.al (2001) three broad objectives distinguish themselves in the desire for obtaining strategic allignment in the portfolio.

- **Strategic fit:** Address questions regarding if all the projects are consistent with the strategy. Do they fit into the key areas or focus area?
- **Strategic contribution:** Ask questions related to what the projects must do to ensure that the strategy being realized and goals achieved. What will it take to win new market segments?
- **Strategic priorities:** Focus on whether the breakdown of spending reflects the strategic priorities. Is the majority of the spending used in projects that contribute to growth?

The specifications of a strategic arena often leads to a logically list of projects that is necessary to conduct and be successful in that arena. The company has to enter the top priority projects. If gaps in the product line are identified, these must be filled with required product developments. A production review of existing products must periodically be executed, to keep the product line fresh, and to identify the gaps. A competitive analysis is necessary to point out needs for new products, either immediately or in the foreseeable future. Such an analysis gives answers to where the businesses products are relative to those of its competitors, where they have advantages and where the probable future offerings are revealed. Market trend- and technology trend assessment must be conducted to make forecasts and to discover new possibilities.

2.3.1.2 MAXIMIZING THE VALUE OF THE PORTFOLIO

Value maximization focuses on allocation of the businesses resources to maximize the value of the R&D portfolio for a given spending level. The aim is to select projects that maximize the total sum of values or commercial worth´s to all active projects, in terms of some business objective like NPV or internal rate of return (IRR) (Cooper et.al 2001). In theory, this is a praiseworthy goal, but in reality, it is difficult to put a reliable economic value on projects you don't even know is going to be completed.

METHOD TO BE USED FOR SELECTION AND OPTIMIZATION OF THE PORTFOLIO

The methods used to achieve this goal range from financial to strategic models, each with its strengths and weaknesses. All models ending with a rank-ordered list with the projects linked to the highest value at the top, since the objective is to maximize. The simplest approach, according to Cooper (2005) is to calculate the NPV on each project and then rank all of them according to this result. The best projects are at the top of the list, and the management chooses projects down the list until there are no resources left. Many businesses already have a requirement regarding calculating NPV to each project, which causes little extra work by the use of this approach. The NPV calculates the economic value of a project. For the project to proceed to the next stage, the NPV must be positive. Thus the NPV can be used as a key input for the go/kill decisions at the gates.

There are several problems connected to the use of NPV to prioritize the portfolio. Because of the high uncertainty regarding R&D projects, the financial inputs used in the method is not reliable. The method assumes that only financial goals are important, without taking the strategically considerations into account. Risk, limited resources and interrelationship between projects, are some important issues not taken into considerations. But the model also has some attractive features. The team must do some research to be able to make the assessment and think trough the projects carefully before the development. According to Cooper et.al (2001) is it possible to include the financial method in the decision tool, and see the value in relationship with the other evaluation areas.

2.3.1.3 OBTAIN PORTFOLIO BALANCE

The goal of seeking balance is about accomplishment of the desired balance of projects, in terms of a number of parameters (Cooper et.al 2001). It is about finding the right mix of projects. Examples of parameters can be:

- Long-term versus short-term projects
- High-risk versus lower-risk
- The various markets the business operates in
- Different technologies or technology types
- Incremental versus radical new technologies

Cooper et.al (2001) identified in their study that the majority of companies have too many small projects in their portfolio. They were missing the major breakthroughs that ensure growth in the future. Portfolio balance is important in order to manage risk. The essence of risk management is diversity, so it is important to obtain the right balance between risk and rewards.

HOW TO SELECT AND OPTIMIZE THE PORTFOLIO

It is difficult for a business to know the optimal split of project types. Cooper et.al (2001) discovered in their study that there were a shift towards much more innovative and bolder projects as one moves from worst to best performers. Top performers take on a higher proporsion of larger, more innovative projects.

Cooper et.al (2001) study revealed that most manager´s opinion was that scoring models fail to visually view the balance of the projects in the portfolio. Portfolio maps or bubble diagrams are by experience much better.

Bubble diagrams views the R&D projects as bubbles on a two-dimensional X-Y plot. The X and Y axes represent an optional dimension of interest. Each individual project in the portfolio

represent one bubble, and their size usually associated with one third important key characteristic. According to Cooper et.al (2001) the bubble diagram is more a supporting tool rather than a relying dominant portfolio tool. This is because numerous diagrams and plots are necessary to make a reliable point.

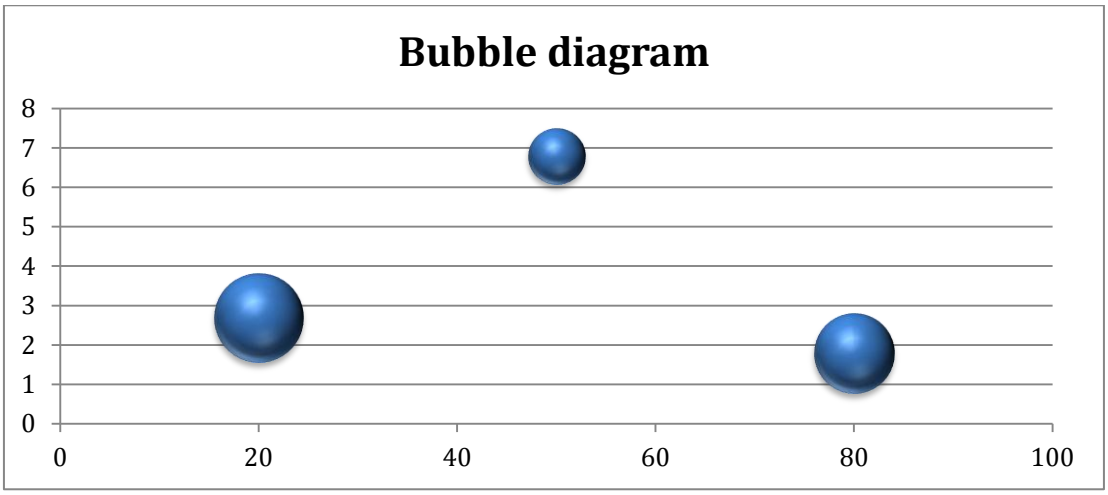

Figure 8: Bubble diagram

2.4 EVALUATION, PRIORITIZATION AND SELECTION

To be able to pick the right development project, each project must be evaluated, prioritized and selected. The outcome objective is to rank the projects and dismiss those with small business value.

As mention earlier, portfolio-evaluating for selecting R&D projects is a very important task for the management due to physical and financial constrains or scarce resources. There are suggested many different evaluation tools and techniques that can be used to estimate, evaluate and choose during the years, but most of them are not widely used due to high complexity and strong requirements (Archer et.al 1999).

According to Chien (2002) most of the earlier studies deal with the portfolio selection problem by evaluating individual projects first, and then look for ways to combine the projects for an optimal R&D portfolio. Individual evaluation cannot be done without consideration of the other projects in the portfolio. The key is the optimal mix of projects. It does not necessarily include all very good projects, if the case is that they do not fit into the overall portfolio objectives. Chien (2002) state that the objectives that are considered in evaluating the portfolio is different from those considered when selecting individual projects. Therfore, when selecting R&D portfolios, individual projects should be evaluated from a portfolio perspective, and then linked project

measurements and portfolio measurements with the consideration of the project interrelations. Risk is also an issue, according to Chien (2002). The decision maker should consider the objective of minimizing the portfolio risk in addition to the objective of maximizing the portfolio attractiveness.

Another study of interest is one made by Archer et.al (1999), who suggested a decision-process framework where decision makers are free to choose the techniques they find most suitable for the process. From this follows that the process can be outlined in an environment which is only partially supported by computerized modeling and databases, since the users are flexible by the choice of techniques in each stage. This instead of rejecting models based on mathematical, financial or strategic nature. The selection process is seen as part of a bigger system, which can lead to requirements about that managers need to have a broader insight and understanding of the process.

The framework consist of three phases; strategic consideration, project evaluation and portfolio selection. The purpose of the first phase is to use different techniques to assist in the determination of a strategic focus and overall budget allocation for the portfolio. The second phase is used to evaluate a project independently of other projects. The final phase deals with project balancing and project selection based on their interactions with other projects or other interdependencies. This phase also includes continuous updates of the portfolio through feedback loops.

Chien (2002) points out that financial measure is often one of the evaluation areas or criteria considered in project selection decisions. Mathematical programming methods are generally not used. Cooper et.al (2001) identified that the portfolio of funded projects does not reflect the business strategy. There were disconnection between spending breakdowns on projects and the strategic priorities of the business. In addition they found that there were consistently poor portfolio quality, weak go/kill decision points and many companies had to many trivial projects.

Mürer Stemland (2012) recommends a portfolio approach rather than single project-evaluation when a company is going to evaluate and choose the right projects to increase the profitability and sustain the competitive advantages. The measurement process with only single projects is easier to perform and gives less amount of work needed by the analyst. But the company needs to see the whole portfolio of projects as part of the organization, because all the projects are fighting over the same resources. The projects are often influenced by other projects concurrently developed. This result in that interaction between projects would play an important role on the value of each individual project. Due to limited resources, the company also has to find the right balance between long and short term projects and safe and risky ones. To manage this, the whole portfolio has to be viewed as one.

Mürer Stemland (2012) state that the NPV model and the scoring model is the most popular methods used. According to Cooper et.al (2001) are scoring models today effective tools for prioritizing projects and obtain an optimal portfolio. Their study revealed that those companies relying heavily on scoring models achieved a superior portfolio of projects on several important performance dimensions.

Several factors have impact on the final system. Identification to the objectives and alignment to the company´s strategy plays an important role on how the system should work. The systems objectives are the purpose of the measurement. Examples of this can be diagnosing activities for supporting decision making, motivating personnel, reducing risk and uncertainty, and improving R&D performance. The organizational structure and the company´s size are also important to the final system. This can be seen in context of the available resources in terms of time, money, human resources, know-how´s and the type of industry. This result in impossibilities in finding a system that fits for various companies. The system has to be adapted to the specific company. (Mürer Stemland 2012)

2.4.1 THE SCORECARD TOOL

In a scoring system, a list of criteria or statements are developed to rate projects. The statements can be known, thought of or estimated, and is used to distinguish between good and bad projects within different evaluation areas (Cooper et.al 2001). Each statement is rated, typically on 1-5 scales, before it gets multiplied by weightings. Then, the different evaluation areas get summarized. The attractiveness of each project is the final score. Scoring models can be used at Stage-Gate decision points and as help to managers for prioritizing projects in the portfolio. Prioritizing becomes more complex as the number of evaluation areas and statements increases. The consensus appears to be that a range of seven to ten statements are workable. (LaBrosse 2010)

According to Harvey (2005) is the key to a successful scoring model the construction of the scoring statements being used. Another key is whom and how to decide the different scores or ratings. It is important to include all relevant groups for a 360-degree view, and a management team consisting of department heads from key line and staff functions should be included in the decision (LaBrosse 2010).

The weighting is handled differently across businesses. Some factors may be more important than others, and should have more weights. Some companies use variable weights, dependent of type of project, while other companies use equal weights. If using variable weights, it is important to remember that projects cannot be compared against each other. By changing the weights, you have changed the scoring model as well.

Scoring models provide a great amount of data that can be displayed and used in various ways. Data have been used for go/kill gate decisions for years on individual projects. The most common here is to compare the score to a cut-off criterion. The scoring output can also be used at portfolio reviews to rank projects against each other. There exist two approaches for this. One is to rank the attractiveness scores. Another is to rank the projects against each other on each of the criteria score. If this is done, it is useful to choose only a handful criterion. At last the output can be used as a diagnostic tool. One of the strengths of a scoring model is the process that people go through as they discuss the projects, its scores and scales, and then come to an agreement. Scoring models provide a list of questions for discussion, and much learning take place during the process. It helps to identify critical areas, the projects strengths and weaknesses are carried out through low scores on some parts, and actions needed. (Cooper et.al 2001)

Cooper (2005) suggest a scorecard divided into strategic alignment and importance, product and competitive advantage, market attractiveness, ability to leverage competencies, technical feasibility, and reward versus risk. Strategic alignment and importance includes statements like alignment of project with business strategy, importance of project to the strategy, or impact on the business. Product and competitive advantage includes product delivers unique customer or user benefit, product offers customer/user excellent value for money, competitive rationale for project, or positive customer/user feedback on product concept. The market attractiveness statements can be different ratings of market size, market growth and future potential, margins earned by players in this market, or competitiveness. Core competencies leverage includes project leverages core competencies and strengths in for example technology and production. Technical feasibility includes size of technical gap, familiarity of technology to the business, newness of technology, technical complexity, or technical results to date. The last area, financial reward versus risk, includes size of financial opportunity, financial return (NPV), productivity index or certainty of estimates.

Cooper (2005) further recommends that the projects are scored by the senior managers, and the scores are tallied, averaged across the evaluators, and displayed for discussion. The projects attractiveness score is the weighted or un-weighted addition of the score, taken out of 100. A score better than 60% is usually required for a go decision.

2.4.2 CONTENTS IN A EVALUATION SYSTEM

The system that is going to be used to evaluate and prioritize projects in the portfolio can, according to Mürer Stemland (2012), consist of many different evaluation areas and measures. When a company is going to select which evaluation areas to include, there are several points that can be used as a starting point:

- A balanced system, that is connected to the corporate strategy and has multiple evaluation areas, will have a positive effect on a successful system.
- Evaluation areas selected in terms of growth will have a positive effect on a company´s competitive advantage.
- A system that is adapted to strategy and innovation will have a positive effect on the alignment to R&D.
- Implemented risk management in the system will cover the uncertainty related to R&D when trying to measure the value.
- Qualitative and quantitative information should to be combined to be able to evaluate the projects, and to find the most reliable value on each project.
- Need to have sufficient evaluations areas to cover all the areas of importance.
- Keep it simple. 4-8 evaluation areas are recommended.

EVALUATION AREAS AND MEASURES

Mürer Stemland (2012) proved that consideration of both financial and non-financial measures together, for evaluating R&D projects, will have a positive effect due to the reliability of the system. One consideration mentioned with just financial measures is the problem related to a decrease in the scientist´s and engineer´s motivation and creativity due to the highly uncertain value they need to put on their lifework. The financial values do not always set the right label on the projects, for example a health, security and environment (HSE) project. In many circumstances it would be easier to justify the project with non-financial measures.

Mürer Stemland (2012) presented a framework for measuring the value of R&D projects consisting of six different evaluation areas. These are described in the following:

The first evaluation area is a financial area. This handles the profitability, cost and other quantitative measures. The theory uses several different measures within this evaluation area. Some examples can be discounted cash flow, keeping within R&D budget, cost reduction from new products, expected NPV and IRR.

The next evaluation area recommended is named responsiveness. Here public issues, with governmental impact and HSE are included. HSE is important to include in a measurement to ensure that their role not become an unofficial part of the organizational target settings. HSE issues have a positive impact on the company´s image, profitability, competitiveness, markets, and products. This will affect the future economic survival of the organization. Measures to be included here can be human resources, minimum impact on the environment and climate, impact on society and impact on improved health and safety.

Risk and uncertainty are important issues when it comes to R&D projects. Focus on risk management can help the team that conducts the projects to identify and monitor critical risks effectively throughout the process. The next evaluation area is named reasonableness, with risk and uncertainty as main focus. The theory claims that the higher risk the projects have the higher payback if they are successful. For each kind of risk, specific analysis methods and appropriate control measures must be executed. The result also gives a view on the company´s ability to perform projects, and the reason why it does not perform according to needed. This includes the technology-, human-, facts-, and method/organizational-skills necessary. It is about creating intellectual capital. Measures that can be included in this area is willingness to take risk for the current project, lack of required skills and lack of efficient development operations.

Alignment to the corporate strategy is important to be able to build an effective organization. The projects that are going to be selected must be related to the strategy, and this evaluation area is named strategic fit. Measures regarding this can be alignment to technology strategy or business strategy and its content. Also included in this area are the employees, and requirement for constantly development and learning environment. This contributes to obtain a strong organization.

Innovation and R&D are closely connected, which result in innovation as an own evaluation area. This area is important to be able to clearly separate the commercial and financial results of the company from the value it adds to its customers and shareholders in terms of innovation. To be able to have the opportunity to track R&D results, measures related to alliances and cooperation also are included in this area.

The last evaluation area is related to technology and competitive advantages. Here market, customer, quality, and value to the users/customers are the main factors. The competitive advantages are dependent on the company´s ability to deliver value to the customers, and the competitive position to a company is determined by its market power. Most used measures within this area is market share or size, time to market, feedback from the customers/users, customer satisfaction and the products potential for giving customer increased value.

3 METHODOLOGY

This chapter describes the methods used for information gathering and analysis of which this thesis is based upon. Limitations of the methodology and an evaluation of the validity on the qualitative findings are also carried out. At the end of the chapter, theory and information about the support interviews and group discussions used as feedback is presented.

3.1 RESEARCH METHOD

The idea behind this thesis began after an internship in Statoil RDI FC, summer 2012. During the summer, Statoil started an offensive of value assessment in the company, and participation in several meetings within value assessment and methodology were carried out. Also, assessment sessions together with researchers, subordinated responsible for different types of R&D technologies or projects, trying to get the right value on their project, were performed this summer. Own experiences, after the summer, were that putting a financial value on each type of projects was not the right way of doing project evaluation, prioritization and selection. The interest in the topic developed a desire to be able to find a system giving all types of projects the ability to point out their importance and getting the opportunity to find a fair value for the business. Also Statoil were interested in finding out more about value assessment within R&D, and wanted a research on the topic.

To get more experience and develop greater knowledge within the theme, a pre-diploma was conducted autumn 2012. The study was a literature review with title; “The value of R&D”. The purpose of this was to find out what the literature and theory said about how to measure the value of R&D projects, and how to evaluate and choose the right projects within a company. The study resulted in a framework proposal which suggest evaluation areas, and several measures that could be chosen within each area. This had to be adapted to the specific company, for the managers to be able to find the value of an R&D project. Also the need for a company to see the whole portfolio, when finding the value of a single R&D project, was revealed.

In addition to the pre-diploma, continued participation in value assessment meetings at Statoil were conducted. This was important to be able to follow along in the value assessment process in Statoil, and to learn and get more experiences. These meetings have found place every 2nd week since the summer internship.

The desire to implement the findings into a real company intrigued to study the topic more in-depth. After several meetings with Statoil, it was revealed that they wanted to find out how

they could optimize their R&D portfolio. For this thesis, tighter research questions were decided to be able to contribute in finding a portfolio approach adapted to Statoil, and their needs.

Several methods were assessed to find out the best possible approach for solving the research questions. Benchmark methods, historical data and quantitative analysis across similar companies were all considered carefully. Due to time constraints and lack of possible competing companies available, these methods were not chosen as research method. This will be discussed more in the following sub-chapter about limitations in the methodology.

The best available method was to do a case-research study on a company within a given industry. To do this, a broader understanding from available literature was studied, combined with insight from practitioners, in order to propose theory and methods which are both relevant and founded in theory and practice. This includes a case study based on data and documentation inside the company, to study how it is today, how it can be in the future, and what recommendations can be done. Interviews and feedback discussions were used as support and corrections to already suggested proposals. More information about the interviews and feedback sessions will be presented later in this chapter. In addition, qualitative reading of relevant theory was studied. A summary of the whole process can be seen in figure 9.

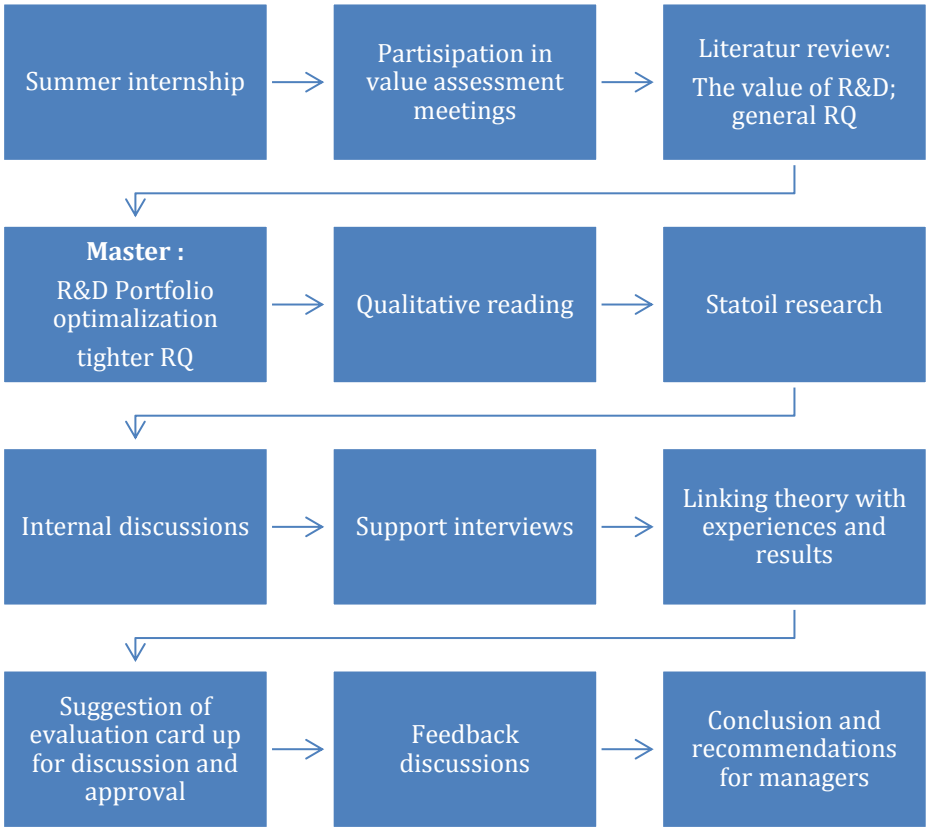

Figure 9: The research process

3.2 LIMITATIONS OF THE METHODOLOGY

The method chosen for solving the research questions in this thesis was a case study approach research. This method was chosen due to the availability of data and documentation and to be able to use own knowledge and experiences.

Probably the best method for this case would have been to start with a benchmarking approach. Benchmarking models are useful to determine how well a company is performing compared with other similar organizations. A benchmark is a point of measurement. (Yin 2009) Benchmarking is a time-consuming and expensive process that needs a lot of commitment to succeed. Due to the time constraints in this thesis work, and missing connections with possible "best practice" companies, this method was not carried out. Another issue regarding the benchmarking that has been up for discussion is the problems with accepting the results. . It is easy to find an excuse and an accepted explanation due to differences between the companies. There will be questions regarding if the "best in class" companies are comparable within strategy, size, structure and model, to mention some factors that play an important role. To be able to get a fully overview within the given industry, and to have comparative results across businesses, historical data collections and quantitative analysis should also have been carried out. Due to the same time and comparable constraints mentioned above, these methods were not included either.

In this thesis there have been included 3 support interviews and 3 main feedback group discussions. While this approach has illustrated and implicated a range of issues that are important, and the value of the understanding of the theory in real life have been invaluable, there have to be pointed out the limited degree of validity in such a small sample set. Since the number applied is limited, it is possible to say that these alone are not enough to completely draw conclusions from.

Another limitation regarding the interviews and discussions are how they view the reality. The understandings are subjective, and based on the participants own experiences, understanding and background. The information has questionable validity because it may not be representative of the population in general.

By use of group discussions there may also be limitations related to participation of each person in the group. There can be some participants that do not say what they really mean. This can lead to not getting the right representative results from each participant.

3.3 EVALUATION OF THE QUALITATIVE VALIDITY

This thesis is a case study of a company in a given industry, based basically on qualitative research. A case study is an empirical inquiry, which focus is on contemporary phenomenon within its real-life context, and where the boundaries between phenomenon and its context are not clearly evident. Research is an oriented and methodical search process for new knowledge, in the shape of answers to previously stated questions, leading to insight and theories. (Yin 2009)

The quality of a good research is characterized by reliability and validity. Reliability is related to the degree of which a study can be replicable. This means that the results will be the same if the operations in the study are repeated. It is difficult to replicate or repeat a qualitative research because the natural settings are constantly changing. Unless there is data showing the changes, it is risky to make claims that a study can be replicated. This thesis is conducted by only one observer, which eliminates the problem regarding the inter-observer consistency that can lead to different results. A throughout described research process increases the replicability further. During the work with this thesis all processes, actions and sources of data have been carefully documented. The fact that this thesis is based on both publicly and internally available information makes is possible to question the reliability.

Validity can be divided into three; construct validity, internal validity, and external validity. Construct validity is to establish correct operational measures for the concepts being studied. To increase the construct validity, multiple sources of evidence have been applied.

Internal validity means that there is a good match between the researcher's observations and the theoretical ideas developed. To enhance the internal validity of a study, Newman and Benz (1998) recommends several strategies. This involves cross-checking of information from different dimensions and a researcher could return to the subjects who were interviewed and check if what you have recorded was what they had said in the interview. Also discussions regarding the interpretations and conclusions of the findings with a person interested in the study to get in-depth opinions, and keeping of detailed and accurate records of everything the researcher did and of the data collected is recommended. To increase internal validity, pattern matching, and addressing of rival explanation have been used. Due to time constraints the interviewed persons have not checked the results. The outcome from all the feedback discussions and interviews have been recorded, strait after the interview the notes were done, and any observations made during the interview was also written down strait after.

External validity is defined as the extent to which the findings of a study may be generalized to another setting or another group of people (Yin 2009). It can be discussed whether this is important and consistent with the qualitative perspective. If generalization is the objective,

quantitative data should have been used. But an in-depth description of a particular phenomenon is sufficient for the researcher to make generalizations to other individuals. To enable the findings of qualitative research to be generalized, the study should, according to Newman et.al (1998) should be applicable, context dependent and transferable. There are no significant differences and it is difficult to generalize to the population based on the findings of a sample. The greater the similarity between subjects, the higher is the possibility of making generalizations. If the findings can be transferred to another context or situation, it is generalized. It is the researchers own responsibility to transfer the findings of one study into another setting.

The validity is also important regarding the collected data. The internet contains a lot of useful facts, including different sorts of documents, but at the same time a great deal of misleading and incorrect information can be found (Myers 2013). It is impossible to prevent totally from the error, but Myers (2013) has proposed four criteria's that can be used to certain of the documents validity. For assessing the quality documents, there have to be authenticity, credibility, representativeness and meaning.

Authenticity means that the object is what it claims to be. To obtain authenticity, the documents have to be genuine and of unquestionable origin. All the data used have been checked for errors and forgeries. Credibility refers to how far the author is to be believed. The credibility is achieved when the documents can be corroborated. Since the purpose of qualitative research is to describe or understand a topic from the researcher's eyes, the researcher is the only one who can legitimately judge the credibility of the results. Representativeness refers to the extent to which a subset can be taken as representative of a wider set of documents. The representativeness is in place when the documents are current and dated. All the documents used in this thesis are current and dated, and this information has been carefully collected. Finally, meaning refers to how the document should be interpreted and understood. Meaning is when evidence is clean and comprehensible. These criteria have been used when information have subjectively been accepted or rejected.

3.4 INFORMATION ABOUT THE INTERVIEWS AND FEEDBACK DISCUSSIONS

Qualitative research interviews and feedback sessions were conducted in later parts of this thesis work. These approaches were used as support and corrections in the qualitative research case of Statoil, and how to find a model for an optimized R&D portfolio. There have been carried out different types of personal interviews and group discussions. When finding a model adapted for Statoil, the experiences and beliefs from employees internally in the company was important to cover both a factual and meaningful level within the specific theme.

In this sub-chapter there will be an introduction to interview as a method for qualitative research work, and information about the interviews and discussions carried out.

3.4.1 INTERVIEWS AS AN METHOD FOR QUALITATIVE RESEARCH

Interviews are particularly interesting for getting the story behind a participant´s experiences and meanings. The interviewer can pursue more in-depth information around specific topics that can be useful in further investigation. Interviews are often chosen, before for example a questionnaire, when there is a need for deeper understanding and little is known about the theme, or where detailed insights information are required from individual participants. An interview also gives the interviewer the opportunity to probe or ask follow-up questions. The fundamental purpose of the research interview is to listen attentively to what the respondents have to say, in order to acquire more knowledge about the topic. (Gill 2008)

According to Gill (2008) there exist three fundamental types of qualitative research interviews: structured, semi-structured and unstructured. Structured interviews are verbally administered questionnaires, where a list of predetermined questions is asked. There are small variations in the questions, and with no scope for follow-up questions to responses that warrant further elaboration. This results in that this type of interview is relatively quick and easy to administer. It is often used if clarification of certain questions is required.

Semi-structured interviews consist of several key questions that help to define the areas that are going to be explored. This structure also allows the interviewer to diverge in order to pursue an idea or response in more details. It provides the participants with some guidance on what to talk about.

Unstructured interviews are performed with little or no organization. Often just an opening question, like “can you tell me about your experiences regarding …“, is used. Then the rest of the sequence often will progress based upon the initial response. This type of interviews does not reflect any ideas or preconceived theories. This is often time-consuming interviews that can be difficult to manage and participate in, due to the lack of predetermined questions and guidance of what to talk about. Often used when significant depth is required, or nothing is known about the subject area initially.

3.4.2 THE INTERVIEWS

In this thesis interviews were chosen, instead of a questionnaire, to get more personal feedback and experiences specific for the company. The interviews were conducted in personal meetings and in-person. The interviewed was given information before the interview took place, and meetings were booked.

A semi-structured interview, regarding scorecard and value creation in Statoil, was conducted first, to get deeper insight in the thoughts regarding the specific topic from experiences inside the company. The flexibility in this type of interview allows for discovery of information that is important to the participant, but not has previously been thought of as pertinent by the researcher. The interview was with an employee in Statoil, who has created a scorecard for Statoil earlier, and that have experiences within the theme it could be useful to listen to, and learn from.

After the first interview, the work with an interview guide started. It is important to ask questions that are likely to yield as much information as possible, and also be able to address the aims and objectives of the research. In a qualitative research interview, good questions should be open-ended (i.e. require more than a yes/no answer), neutral and understandable. The interview guide was piloted on several respondents prior to data-collection, to establish that the guide was clear, understandable and capable to answering the questions asked, and to make some changes if necessary. Clear means simple, easy to understand and short questions. The interview guide can be found in appendix A.1.

After collecting the necessary in-depth qualitative theory and empirical findings, two structured interviews were performed. Because of the nature of structured interviews, they were perfect when little use of in-depth information was required. Both interviewed A and B work in the RDI FC department in Statoil. They answered the questions given in the interview guide in appendix 7.1. The interviewed A is relatively new employee in Statoil, but have a lot of experiences from other innovative business areas. A is working as a financial analyst in Statoil. The interviewed B has long experience in Statoil, and knows the systems and culture very well. B is head of the RDI FC department.

All the interviews were recorded. The approach of recording the interviews makes it possible to focus on getting through the questions, and to be sure that all important information was noted. Each interview was then transcribed, translated, synthesized and presented in this thesis as a summary in chapter 4.3.1.

3.4.3 GROUP DISCUSSION AS AN METHOD FOR QUALITATIVE RESEARCH

The idea behind this approach was to collect data from multiple participants simultaneously and to capitalize on communication between the participants that share common experiences. Information that is not publicly or possible to find in documents can be found.

It is possible to draw similarities with the theory regarding focus groups when this method was thought of. Focus group is a quantitative research method where a narrowly focused topic is discussed by group members of unequal status who do not know each other (Gill 2008). Focus

groups is a good approach to examine the thoughts, experiences, stories, points of views, beliefs and needs of individuals. A focus group is normally used as a preliminary technique.

In the method used in this thesis, all the participants in each discussion known each other, and had approximately the same prerequisites. Group interactions were part of the method, and gave the opportunity to let the participants discuss among themselves. It is also carried out at later stages of the research, used primarily as support, feedback and correction technique.

Insight into the similarities and differences of understanding could also be drawn. This was helpful related to finding a system without biases, and reduce the possibility for misunderstandings and wrong use.

3.4.4 THE GROUP DISCUSSIONS

During the work related to the adaption of the system used to optimize the R&D portfolio to Statoil, three main group discussions were carried out. The participants were all employees in Statoil. The first discussion was with the department RDI FC. Then a discussion with the chief researchers at Statoil was carried out. At last, a feedback session with the users, the top leaders for each portfolio, was performed.

These discussions were important to get insight experiences and were used as a feedback and recommendation process. At each discussion a proposal of what this thesis thought of as the most important evaluation areas and a set of associated statements for Statoil was presented in a table. This proposal was based on theory and empirical findings arrived during the work with this thesis, and own experiences. After the presentation, there was an open discussion about the content, and the participators could give feedback and recommendations.

Each feedback and recommendation was thoroughly considered and processed, one by one, in the further research work. It is important that the final system is kept simple, so not all the proposed recommendations were brought further. The system should only consist of the most important areas and statements associated with Statoil, in order to function as desired and give Statoil a system that optimizes their R&D portfolio. Between each discussion, an improved table was developed.

Each discussion was recorded, transcribed and translated. A summary is presented in chapter 4.3.2.

4 EMPIRICAL FINDINGS

In the beginning of this chapter, a short overview of the industry in the Norwegian Continental Shelf (NCS) will be introduced. Due to time constraints and necessary refinements the thesis will focus on the Norwegian oil- and gas- industry, and the environment and opportunities in this market. Then an introduction about Statoil and necessary information about what they consists of is presented. The strategy and additional information that already exists in the organization are also described. This information is important to be able to make a system that is adapted to Statoil. A well adapted system is more easy to use, and will increase the willingness by the managers to actually use it. At the end of the chapter a summary of the support-interviews and feedback-discussions are presented.

4.1 THE OIL- AND GAS INDUSTRY IN NORWAY

The petroleum industry is one of the main industries in the energy industry. The value chain of the petroleum industry, range from downstream to upstream industries. This includes global processes like oil exploration, oil extraction from wellhead, storage, measurement, transportation, refinery, petrochemical and chemicals. The largest volume products from the industry are fuel oil and gasoline. (Norsk Olje & Gass 2013)

Oil and gas activities on the NCS have been the driving force in the Norwegian economy for decades. The sector is the country´s most important industry, and has formed the basis for developing the nation´s welfare state. More than 60 % of Norwegian petroleum resources remain beneath the seabed included 25% waiting to be discovered. This offers huge opportunities for the Norwegian community. (Norsk Olje & Gass 2013)

NORWAY´S PETROLEUM HISTORY

The oil and gas history of Norway is characterized by wise political decisions, world class industrial development, and huge value creation. Norway has a copious history in the petroleum industry, and can now celebrate more than 40 years as an oil and gas producer. (Statoil.com 2013)

The first assumption that it was chances of finding oil or coal on the continental shelf off the Norwegian coast was claimed in 1958. After some years with failures, Philips Petroleum made the first commercial discovery in 1969, and in 1971 the first oil was produced at the Ekofisk field. The field also contained substantial quantities of gas, which initiated the start of great volume of Norwegian gas sold to continental Europe. The largest gas field that began production on the NCS, Frigg, was discovered in 1971, and had platforms on both British and

Norwegian sides of the boundary. The decommissioning of the Frigg field began in 2005. One of the world´s largest offshore oil discoveries, Statfjord, was discovered in 1974. The first discovery in the Norwegian Sea off mid-Norway, Midgard (now part of Åsgard), was done in 1981. Two of the most well known Norwegian fields are Snøhvit and Ormen Lange. Both came on stream in 2007. Snøhvit, which was discovered in 1984, was then ranked as the northernmost producing field. Ormen Lange, which was discovered in 1997, was Europe´s third largest gas field, with the world´s largest gas wells. (Norsk Olje & Gass 2013)

THE ENVIRONMENT

Overcoming the climate challenges are one of the most important tasks facing the world community today. Simultaneously there is short on electricity in the world. Due to growing population and the fact that people becomes more prosperous, the call for additional energy supplies increase rapidly. Oil and gas will play an important role in meeting the world energy needs far into the future. Since Norway is an important exporter of energy, they have a major role in this. (Norsk Olje & Gass 2013)

The petroleum industry has a goal of zero discharges, and work continuously to reduce discharges to the sea from operations on the NCS. Produced water accompanying hydrocarbons up from the reservoir, and containing small oil droplets, represent the largest source of discharges during the production phase (Statoil.com 2013). The petroleum industry involves a great use of chemicals, which is debilitating for the environment. The Norwegian oil and gas industry has for long devoted substantial resources to eliminate discharges of chemicals, and this should still have top priority. (Norwegian Oil and Gas Association 2012)

Possible high risk destruction is largely acute in the case of spill of oil. Statistical calculations indicate very low risk in the NCS, but it cannot be guaranteed that an accident never will happen. The oil companies must therefore pay great attention to measures for cleaning up spill. All work related to HSE preventing incidents and accidents are the most important consideration for all actors in the business. In the NCS there are systems and regulations developed to set stringent standards for technical quality, separate barriers and operational procedures to avoid anything going wrong during drill and production. This has reduced the risk significantly. (Norwegian Oil and Gas Association 2012)

MARKET OPPORTUNITIES

Since the beginning, the petroleum industry has experienced economic fluctuations and varying prices for oil and natural gas. But, over the period as a whole, the industry has been characterized by growth and rising production. (Norwegian Petroleum Directorate 2011)

There is an optimistic picture of the future for the Norwegian Petroleum industry, and there are great opportunities for value creation for a long time to come. In the Report from the Storting (White paper) (2010-2011), an industry for the future – concerning petroleum activities, presented to the Norwegian parliament, there were noted that four areas had to get great attention. These were improved recovery from producing fields, improved development from commercial discoveries, exploration in open areas for petroleum industry, and finding new areas for such operations.

2011 was one of the most eventful years in the NCS, since a number of substantial discoveries were made. Statoil found oil in the Barents Sea, which was the biggest found there since the 1980´s. On this basis, there are reasons to be optimistic and to believe that Norway can continue to be a leading European oil and gas nation far into the future. These large discoveries emphasizes that the resource potential in the NCS is still high. The Norwegian Petroleum Directorate estimates Norway´s total resources to be an expected value of 13 billion standard cubic meters of oil equivalent (scm oe). This provides total recoverable resources, included those still to be discovered. The remaining resources can lay the basis for new discoveries. (Norwegian Petroleum Directorate 2011)

Technology and expertise related to exploration, development, optimum recovery from producing fields, and developing resources far north have been important. A continued focus on development, research and adaption of new technologies will be crucial for future value creation. Despite the large discoveries, the trend is that exploration in the NCS is too low, there are too few discoveries, and those made are too small. Oil output has fallen 40% from 2001 to 2010. New and attractive exploration acreage needs to become available. This is urgent because of the long time between exploration and production. But it is important also to continue to produce all the commercial resources which already exist on stream. (Norwegian Petroleum Directorate 2011)

4.2 THE STATOIL WAY

This section gives a short description of Statoil, the business areas, the TPD RDI portfolios, the corporate technology strategy and additional information about Statoil. This information is important when the final system is going to be adapted to Statoil.

4.2.1 STATOIL IN BRIEF

Statoil is an international energy company with operations in 35 countries. They are headquartered in Stavanger, Norway, and have approximately 21 000 employees worldwide. Helge Lund is the company´s CEO. (Statoil 2011)

In 1972, the Norwegian State Oil Company, Statoil, was formed, and two years later the Statsfjord field was discovered in the North Sea. Statoil merged with Norsk Hydro´s oil and gas division on 1. October 2007. The new company was given the temporary name StatoilHydro, and together they reached a size and strength for considerable international expansion. The company was renamed Statoil in 2009 to accord with government wishes. (Statoil internal website 2013)

Statoil was listed on the New York and Oslo stock exchanges in June, 2001. Statoil has grown up along with the emergence of the Norwegian oil and gas industry, and they have over 40 years of experience from the oil and gas production on the Norwegian continental shelf. The Norwegian State holds 67 % of the shares of the company through the Ministry of Petroleum and Energy. US investors hold 10.2 %, private Norwegian owners hold 8.9 %, UK investors hold 5.0 % and others 8.9 %. (Statoil internal website 2013)

4.2.2 BUSINESS AREAS

As figure 10 shows, Statoil is divided into seven business areas. This thesis focuses on TPD and its Research, Development & Innovation (RDI) section.

Figure 10: Statoil´s business areas

TECHNOLOGY PROJECTS & DRILLING (TPD)

TPD is headed by executive vice president Margareth Øvrum. The TPD business area has a global responsibility for developing and implementing new technological solutions for exploration, improved recovery, field development, concept development, and safe and efficient operations. (Statoil internal website 2013)

TPD comprises of the following business clusters:

- Projects
- Procurement
- Drilling and Well
- Technology excellence
- Research and Development and Innovation

TPD have several goals. They should ensure competitive procurement and manage supplier relations. They should plan and execute safe and efficient drilling and well operations, in addition to other development projects. Finally, they are going to maintain and optimize the global standards within Statoil. (Statoil internal website 2013)

TPD - RESEARCH, DEVELOPMENT & INNOVATION (TPD RDI)

RDI is one of the business clusters in TPD. Head of TPD RDI is Karl Johnny Hersvik. Earlier, this was named just Research and Development (RD). 15. August 2013 Innovation was included to ensure broader and deeper focus on innovation in Statoil. The new name became RDI. The purpose of the re-organization was to be better shaped for tomorrows challenges, and to be able to meet Statoil´s growth ambitions. (Statoil internal website 2013)

4.2.3 STATOIL´S RDI PORTFOLIOS

TDP RDI has several portfolios, as shown in figure 11. The TPD RDI structure is divided in five permanent business units – innovation, exploration, mature area development and IOR, frontier developments, and unconventional, with projects included as an addition to the formal organizational structure. Each of them are described briefly in the following, based on different Statoil internal presentations (2012), Statoil internal website (2013) and Statoil (2011).

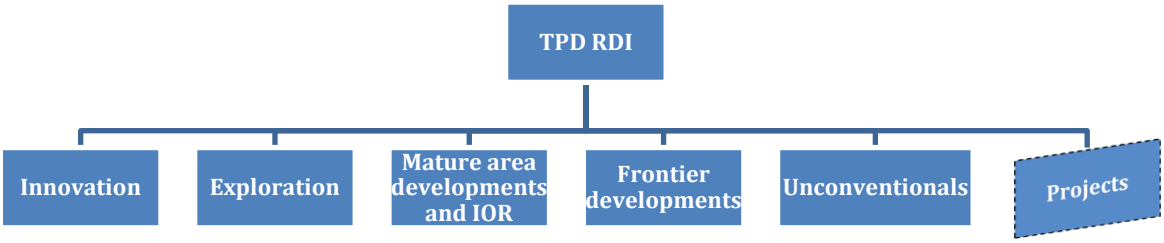

Figure 11: Organizational design TPD RDI

INNOVATION:

Innovation is a new unit dedicated to increase Statoil´s innovation capabilities, by identifying and implementing ideas that strengthen business performance and help Statoil grow faster than the competitors. The unit should work broadly. They are mainly focus on four areas – technology, commercial, process and organization. The aim of the unit is to increase the ability

to exploit the potential of synergies between these areas through systematic use of processes, tools and facilitation.

Through tight collaboration with other business areas and staff units they will focus on generating and implementing ideas, ensure corporate alignment, and develop innovation as a core organizational competence and integrated way of how Statoil work.

Blue Sky portfolio:

Blue sky is projects with high reward and high uncertainty. Both dimensions have to be satisfied for a project to become a Blue Sky. High reward means that it is a technology for access and optionality that add value to Statoil worldwide. The technology has radical new concepts. High uncertainty, means that success is uncertain due to whether the idea or concept actually works, aiming to challenge accepted truths, and requirements of significant changes also in surroundings and organization.

The Blue Sky projects have great attention by the management. It is given flexibility in early phases, and allow for both successes and failures.

EXPLORATION:

The R&D program to exploration embraces projects with the aim of developing new methods, tools and technologies to support and maximize the value of Statoil´s exploration activities. Both short-term needs for the exploration community and long-term needs to look for future breakthrough concepts are executed.

The unit has four main areas - Seismic Imaging and Interpretation, Siliciclastic plays and Reservoirs, Carbonate Plays and Reservoirs, and Basin and Petroleum System Analysis.

MATURE AREA DEVELOPMENTS AND IOR (MADI):

This unit develops technologies for increased recovery across mature areas with strong focus on the Norwegian Continental Shelf. The aim is to maximize recovery through development of technologies for cost efficient work processes and operations. MADI deliver IOR solutions for the future, and the unit covers business areas like seismic imaging and interpretation, reservoir characterization and recovery, and drilling and well constructions, in addition to license to operate solutions.

The main areas within this unit are; Flooding for enhanced Recovery, Challenging Reserves and Resources, Drilling and Well solutions, Safe and Optimized Productions, and Lab and Test Facilities.

FRONTIER DEVELOPMENTS:

This unit is responsible for research and technology development within four different areas. Extended reach enables alternative developments in combination to solutions in challenging conditions for challenging hydrocarbons. GoM Paleogene & Ultra Deep Water address specific issues related to the Gulf of Mexico Paleogene reservoirs, and other ultra deepwater areas. Arctic Technology develops technology for arctic specific challenges with time critical enablers. The last area is Offshore Heavy Oil who develop technologies to increase profitability of offshore heavy oil fields.

UNCONVENTIONALS:

Unconventionals are energy for future generations, and the unit will play a key role in meeting the future energy needs related to growing global populations. Also this unit has four main areas. Heavy oil technology centre (HOTC) focus on delivering technology solutions that will enable the sustainable production from heavy oil deposits worldwide. Shale oil and gas develop technical advantages that allow extraction of commercial quantities of oil and gas from reservoirs previously regarded as impossible. Refining and renewable have focus on maximization of the value of produced hydrocarbons, and new value chain develops technology options for future growth.

PROJECTS:

The purpose of the Projects entity is to accommodate strategically important projects that need to be lifted up on a higher managerial level for a defined period of time in order to get a prioritized and quick start up with sufficient strategic management focus.

4.2.4 STATOIL´S STRATEGY

Over the last decades, Statoil have been transformed into a company with increasing global reach. Today, Statoil is one of the world´s largest suppliers of oil and gas. Due to their position, the company is committed to accommodate to the world´s energy needs with applying technology and creating innovative business solutions in a responsible manner. Statoil´s corporate governance is based on the company´s corporate values and ethical guidelines. Statoil´s values are; Courageous, Open, Hands-on and Caring. (Statoil internal website 2013)

THE CORPORATE TECHNOLOGY STRATEGY

Statoil´s main goal is to have a production above 2.5 million barrels of oil per day in 2020. To manage this, they have to become a world technology driven company with focus on innovation. Technology is highlighted as a key competitive edge for the company, and is critical to succeed in an increased scope and dynamic environment. It is important that the technology development and implementation meet the corporate ambitions. The corporate technology strategy is the translation of the corporate strategy, and how TPD RDI must deploy and focus in order to contribute to Statoil's overall goals. The strategy focuses on prioritization of technologies for value creation, growth and access. (Statoil, Corporate Technology Strategy 2012)

Described in the Corporate Technology strategy (2012), Statoil have three principal directions for increased focus on driving growth through technology. These are license to operate, expansion of capabilities and business critical technology ambitions. These will be described in the latter.

License to operate:

All technology development and implementation must be founded in operational excellence, corporate HSE and climate policies to strengthen the License to Operate. Statoil´s ambitions are to become an industry leader in HSE and to secure operational excellence throughout the company. To manage this, continuous improvement of safe and reliable operations and integrity management (facilities, well and reservoir) are essential. This must be reflected in all the development and implementation activities.

Expansion of capability:

An increasing scope and complexity of Statoil´s business and technology portfolio have implied a need to expand the set of existing and future capabilities. Expansion of capability set is about building new leading capabilities for access and growth. Statoil must leverage their culture for creative technological solutions to solve complex technical problems with innovative solution

combined with prudent risk management. They must utilize their extensive projects and operational experience to introduce new solutions. To ensure future growth in new areas Statoil requires a portfolio of technology bets which are evaluated and monitored all the time.

Business critical technology ambitions:

Statoil have four critical business technologies, each with their own ambitions and actions for improvement. These are; seismic imaging and interpretation, reservoir characterization and recovery, drilling and well, and subsea wells.

Seismic imaging and interpretation is important to increase the discovery and recovery rate, which are critical for both successful exploration and production. Statoil needs multiple key essential actions. They have to ensure access to high quality seismic data and computing power. They must continue to build internal capacity, leverage on third party solutions, and create new capabilities for selected essential issues. At last they have to strengthen their integrated geology and geophysics work.

Reservoir characterization and recovery should be pushed to the next level to maximize the value. Statoil´s average recovery factor on the NCS is 49 %, and it is significantly lower internationally. There is great value potential in increasing this factor. (1 % can equal more than NOK 300 billion with oil price of $80 per boe) The factor is dependent on depositional settings and reservoir complexity. Key elements Statoil need to conduct to improve are to develop fast and precise models integrating all relevant data, utilize permanent reservoir monitoring, and increase the use of reservoir stimulation techniques.

Drilling and well is a focus technology because step change in well construction efficiency lead to drill more cost efficient wells. The ability to deliver wells is limited due to drilling capacity and internal and external cost efficiency. Increased efficiency will allow more customized wells to be drilled. To ensure this, Statoil have focus on implementing new automation and regulation technology, improve their drilling window management and mature light exploration drilling.

Approximately 50 % of today's production comes from subsea wells. Further development is important to be able to go deeper, colder and longer. This will accelerate and increase the production, increase the recovery, facilitate economic marginal field developments, extend field life and areas, and increase the responds to new business challenges for the complex portfolio theme. Essential actions for Statoil are to implement standard work over systems, drive implementation of subsea pumping and compression , and to develop subsea processing for cold flow, heavy oil and deepwater.

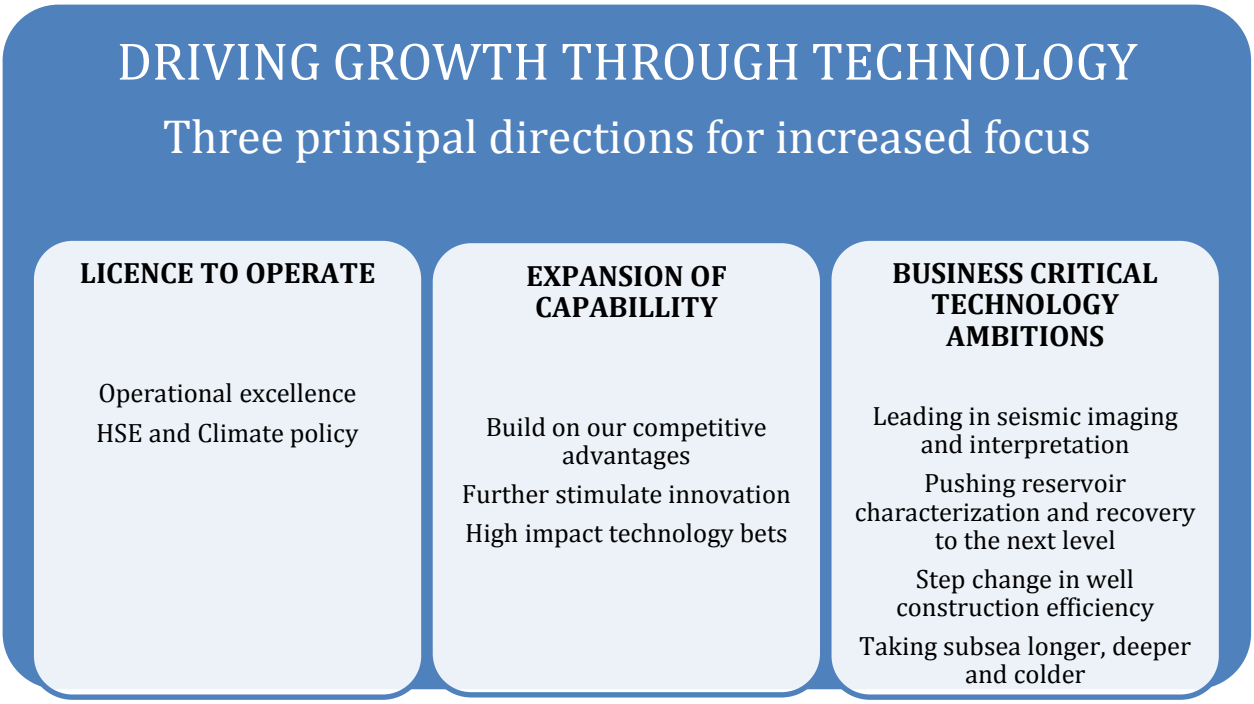

Figure 12: Summary of Statoil´s three principal directions

TECHNOLOGY CLSSIFICATIONS:

In the corporate technology strategy, there are also pointed out a classification of technology projects. These are: (Statoil internal website 2013)

- **Fundamental :** business push for sustained technology improvements
- **Focus:** balanced technology and business push to close technology gaps
- **Frontier:** technology push to create new business opportunities

4.2.5 STATOIL INFORMATION

Statoil already have a lot of information that is required for the researchers, managers and staff to know and use. Some of the most important ones related to R&D projects are described in this section. An introduction to the economic decision-analysis method, the technology development implementation work process, the technology development plan (TDI), the one pager, the high impact deliveries, an easy earlier scorecard, and some basic definitions are described.

4.2.5.1 STATOIL´S ECONOMIC DECISION-ANALYSIS METHOD

In theory, the return of investment (ROI), also named rate of profit, is the ratio of money gained or lost on an investment relative to the amount of money invested (Luenberger 2009). In Statoil is the required rate of investment 8 %. Statoil is committed to maximize value for their shareholders through optimal decisions that contribute in reduced cost or/and increased revenues (Statoil, Investment manual 2012). This optimal value is achieved through fulfilling the Corporate Technology Strategy, and through developing and implementing technology in an innovative and smart way. To be able to manage this, and try to put financial values on each project, Statoil has started value assessment by use of an economic decision-analysis method. Cash flow- or NPV analysis is the foundation of the method, which also includes risk analysis. This to be able to capture the minimal and maximal outcomes, with associated probabilities.

The method is implemented in a software tool named STEA. Decision trees are used to structure decision points, risk and outcomes, and includes all necessary information needed to take decisions. Drawing these trees help the researchers and managers to see the opportunities that lie in the technologies and projects. This makes it easier to choose the optimal path of decisions. The software tool calculates all needed financial values, like NPV and IRR, both before and after taxes, and gives flexibility to run different scenarios easily in the search for the right path.

The method has several purposes. It can be used to justify single technology development plans or projects, by demonstration of added value, and as estimation method to find potential business value and impact for Statoil. It can be used to take right decisions during a project, as choice of path optimization by maximizing value within each project. The method can also be used as portfolio analysis in order to, among others, prioritize and optimize the portfolio. Distribution of risk and technology dependencies are identified, which make it easier to see the total picture of the portfolio.

How to use the method:

The method is about structuring the problem, capture the uncertainties, through risk identification, and quantify the key measures. This is done by the use of decision trees. The problem needs to be structured properly to be able to make the right decisions given what we know about the future. You have to be prepared for managing future uncertainties. The quantification is done by calculating the cash flow. Cash flow is the movement of money into or out of a business, project, or financial product. The risk identification covers both the negative impact and the positive impact. The method is used to identify risk scenarios, assess the probability and assess the impact.. There are different types of risk. Systematic risk that cannot be influenced and non-systematic that can. Examples on the systematic risk can be oil price, currency and inflation, that all will have impact on the whole world. This is taken into account in

the cost of capital, so it is important not to reduce the value of the project by using money on reducing risks. Due to this, there is no need to pay the risk any further attention after optimizing. Examples on non-systematic risk can be exploration discovery, reservoir recovery, production profits and development costs. These are things that can influence a single project, and that have to be included in the risk analysis.

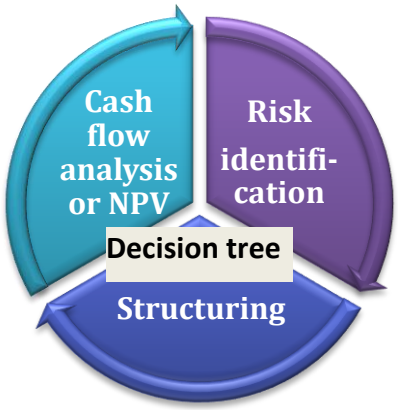

Figure 13: Statoil´s economic decision-analysis method

4.2.5.2 TECHNOLOGY DEVELOPMENT AND IMPLEMENTATION

In Statoil, value is created when technologies are implemented to meet the business challenges. To increase the value, the same technology should be implemented several times. To manage this, the work processes and tools have to be effective. Technology development implementation (TDI) is a new work process that describes the steps to follow from identifying a business need or getting a good idea, until the technological solution is implemented. (Statoil internal website 2013)

The work process:

The work process consists of six sub-processes, as the figure 14 shows. These are; identify and manage one business need, plan one new technology, research and develop one new technology, perform first-use, perform multi-use, and assess external technology. A description is given in the following (Statoil, FR 12 - Technology Development and Implementation 2013):

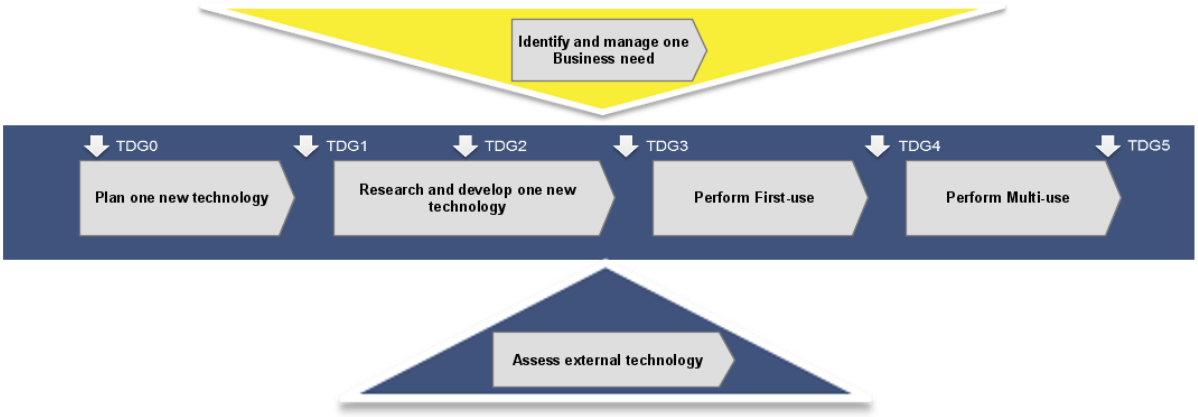

Figure 14: An overview of the work process in TDI

The process starts with identifying and managing a business need throughout the life cycle of the need. The deliveries at the end of this phase are a prioritized and quality assured business need, and an initial version of a business case.

Phase two is the "plan one technology". This phase includes planning to identify time, cost and resources required to realize the business case for each identified new technology. Some of the purposes with this part are to ensure that alternative solutions are evaluated, ensure early involvement of relevant participants, assess risks involved and establish a risk management plan. The deliveries at the end of the phase are a verified business case and a technology development plan (TDP) (explained later). In this phase Technology Decision Gate (TDG) 0 and TDG 1 are involved.

The third sub-process is the research and development phase. The purposes of this phase are to develop and qualify new technologies ready for first-use according to plan, to do quality assurance and ensure business alignment and to mature the business case. Deliverables here are a technology approved for first-use (Technology Readiness Level (TRL) 4), a technology development report, accepted handover of responsibility and an updated business case.

Perform for first-use and multi-use are phase four and five. The deliveries in the "perform first-use" phase are a technology proven and ready for broad implementation (TRL 7), an updated business case, a first-use plan and report, identified multi-use candidates and implementation success criteria. All of this is executed at TDG 2 and TDG 3 gates. The deliveries in the "perform multi-use" phase are broad implementation of new technologies, and a multi-use plan and report. The multi-use technologies could be technologies with large potential benefit for the business and need a push from the technology organization. The multi-use phase is executed at the TDG 4 and TDG 5 gates.

The last phase is the "assess external technologies" that is going to verify the maturity of technology qualified or proven outside Statoil, in addition to assess the associated risks. This phase also includes assurance of correct development, and the first-use activities are identified. The deliveries are an external approved and verified technology, and an updated business case and first-use plan. This is executed in the TDG 0 and TDG 3 gates.

A short description of the different TDG milestones:

TDG milestone	Description
TDG 0	Approve start technology
TDG 1	Approve start technology development
TDG 2	Approve first-use planning
TDG 3	Approve start first-use
TDG 4	Approve start implementation in individual assets
TDG 5	Approve completion of multi-use

Table 1: TDG milestones

A short description of the different TRL levels:

The scale spans from TRL 0 (the idea stage without a certain concept) to TRL 7 (proven technology). The two most important milestones are the TRL 4 and TRL 7.

TRL levels	Description
TRL 0	Unproven idea/proposal
TRL 1	Concept demonstrated
TRL 2	Concept validated
TRL 3	New technology tested
TRL 4	Technology qualified for first-use, and is a pre-requisite for approving TDG 3
TRL 5	Technology integration tested
TRL 6	Technology installed
TRL 7	Proven technology in Statoil, and a pre-requisite for TDG 4

Table 2: TRL milestones

4.2.5.3 THE TECHNOLOGY DEVELOPMENT PLAN

Each new technology in Statoil must have an approved Technology development plan (TDP) in order to get permission to start developing. This is a document that includes necessary information about one new technology. The plan starts with the purpose of the technology, included a description of the business challenges that will be addressed. Then there is a description of the technology, technology benefits, how to meet the business needs and challenges, and the preliminary requirement specifications. Next, a detailed scope of work for the research and/or development, with qualification phase up to first use, is described. Here also a short description of the background and context of the technology is included. (Statoil, Technology Development Plan)

A plan on how to manage Intellectual Property shall be established next. This includes, among others, decision on where the IP shall rest and identification of a plan for delivery. In this section also the communication policy is specified. This is how knowledge transfer of the finished technology solution will be secured. (Statoil, Technology Development Plan)

The manager is responsible for describing a procurement plan. This includes a brief summary of all actual and foreseeable procurements, evaluation of the market situation and available suppliers, and estimated contract values. This is followed by an implementation chapter, with implementation criteria and maintenance and support after implementation. The next chapter, risk assessment, is divided in risks associated to R&D activities (TRL0 – TRL4) and risks associated to use of the technology (first and multi use). The first is an assessment of risk for the team participating in the R&D performance. The second is a simplified risk assessment of the downsides, assessed for the users. (Statoil, Technology Development Plan)

A TDP shall specify the start and end dates for each main phase leading to milestones in the R&D work. This includes time estimates for all main activities necessary to make robust decisions at each TDG. Cost estimates for the R&D and Statoil funding sources are also filled in a table at the end of the TDP. Finally, a description of the R&D team and the stakeholder group, with roles and names, are filled in together with a log for updates of the document. A business case is included as an appendix in the TDP. (Statoil, Technology Development Plan)

4.2.5.4 ONE PAGER

One pager is a one sided document that summarize the most important issues regarding a new technology. Included in this page is a short description and background of the new technology, with objectives, main deliverables, type of business area, and project achievements. Business potential and strategic fit are also shortly described. This part includes HSE value, potential added values, alignment to the corporate technology strategy, impact on the business

development and if the technology have blue sky potential. Also cost forecast, NPV calculations and certainty of the estimates can be included. Next in the one pager is an implementation part. Here first user and multi user are described. Also willingness and capability to take risk can be included. A description about the risk is also a part of the page. At the bottom of the page are a timeline that views what TDG level the technology is in, and a picture spot where it is possible to include a graph or decision tree, or just a figure. (Statoil internal website 2013)

To summarize, on this page you can find information about:

- Description and objective to the new technology
- Description about the business potential and strategic fit, included NPV
- Implementation, included fist-user and multi-user
- Risk
- Timeline
- Graph/picture/tree

4.2.5.5 HIGH IMPACT DELIVERY

In an attempt to weed out the best technologies, 10-15 deliveries are selected by the management and given the name High Impact Delivery (HID). The deliveries should be within 80% probability of delivery within a 4 quarter period. A HID is given a priority in the department, and is ensured a completed quality assured value assessment, by STEA, prior to delivery.

To be nominated as HID, minimum one out of five criteria must be supported. It could support Business Critical Technologies according to the Corporate Technology Strategy, it could support long term strategic business needs from one of the Business Areas, the technology has high value (HSE or NPV), it has breakthrough or step change potential, or it may have actions/deliveries on the RDI Management agenda. (Statoil internal website 2013)

4.2.5.6 A SIMPLE SCORECARD USED ON SINGLE PROJECTS

Statoil already have a scorecard that they use to put a final score on a project. The scorecard shall be used at TDG 2 level.

The scorecard conducts of four elements that are weighted against each other to produce a score on each project. It combines individual scores for business impact, strategic impact, HSE improvements and risk to calculate a total score. The weights are 0.5, 0.2, 0.2, and 0.1, respectively, and each element is ranked with high, medium or low. In addition to these weighted elements, technology classification, level of innovation, and probability for success is

included. This have a connected comment field, where the user can fill in appropriate information. (Statoil internal website 2013)

4.2.5.7 STATOIL DEFINITIONS

- **Technology Decision Gate (TDG):** This is a milestone where line management approves to proceed to the next phase of the TDI.
- **Technology Readiness Level (TRL):** This level indicates how far the technology development, qualification and implementation for a new technology have progressed.
- **New technology:** New technology in Statoil is a technology that is not proven. New technology applies also for the first application of Proven technology in a new environment or an unproven technology in a known environment
- **One new technology:** One new technology is a technology that by itself builds a business case, adding value when applied in operation
- **Proven technology:** The technology is proven when it has reached TRL7. This implies that the technology has been through First use in Statoil, and is proven for Multi use
- **Technology:** Any specific information and competence whether in tangible form such as models, equipment, methods, manuals and software, or in intangible form, such as training, work processes or technical services.
- **First use:** First use of new technology is defined as the first application of a new technology in Statoil operations. The main purpose of the first-use id to mature new technology to proven technology, ready for broad implementation in Statoil. The technology is ready for first-use when it has reached TRL4.
- **Multi use:** Multi-use of new technology is broad implementation of proven technology at individual users through special attention and effort from technology owner implementation, to ensure maximized value creation.
- **HID:** High Impact Delivery.
- **Blue sky:** This is projects with high reward and high uncertainty. The projects have high attention by the management, and derby given more flexibility in early phases. Both success and failure are allowed.

4.3 INTERVIEWS AND GROUP DISCUSSIONS

To be able to shape a good discussion, and to gain more people´s point of view about the theme in this thesis several feedback group discussions and support interviews have been performed. As mentioned in the methodology chapter 3, there have been conducted four interviews. In terms of the discussions, these have been conducted during the process of finding answer on research question three. The group discussions have been first with the RDI Finance and Control (FC) department, and then with four chief researchers at Statoil. Also feedback from the L3 leaders has been conducted on the final proposal. A summary of the interviews and discussions is given in the following.

4.3.1 SUMMARY OF THE INTERVIEWS

The interviews were conducted to get support and more experiences within the theme of this thesis. An introduction to the interviewed is given in the methodology chapter 3.4.2. There have been carried out three interviews, and a summary of them is given in the following. The first semi-structured interview is summarized alone, while the two others, who are based on the interview guide, are presented together.

The semi-structured interview regarding scorecard:

In the case of evaluation and scorecard, he means that business impact for Statoil is important to highlight. The value of each technology is the key. He also informs about that in Statoil, HSE improvements are imposed. You cannot do any changes without HSE improvements, this is a requirement. He is also very concerned with that the system must be aligned with the customers. His meaning regarding success within R&D is when as much as possible are put into use. His experiences within Statoil is that there are too many technologies that are developed, but not become applied later. The customers have to participate in the decision-process, and to increase the probability for success there is a need for a customer early in the process.

He also talks a lot about research and the ideas. It is important to take care of the research, not just have focus on the production. The ideas are the essential, it must be room for failure to become successful and hit the jackpot. Statoil need to drive innovation, and not just measure R&D. The system should not be a measure on ideas. It is important to keep the final system simple and user friendly.

Interview results from the interview guide (appendix A.1):

In interview A an optimal portfolio was thought of as the right selection of projects, with the right balance between them. Everything has to be linked together with strategy and organizational goals. “Statoil have to do the selection of projects that contributes to value

maximization". The projects in the portfolio must have grounding in the strategy. The interviewed mean that it is important to see connections and the total picture. It is not possible to "throw all single projects in a sack". In interview B it was said that an optimal portfolio for Statoil answers their business needs. It must be a good balance between short and long term technologies, and the innovation level. There must be some Blue sky projects, with high risk. It is important to think beyond 2020. All projects must give value to the company.

Both the interviewed agree that portfolio optimization should be conducted through a common model in the whole RDI, with several evaluation areas. Also both financial and non-financial areas must be included. This is important to be able to make good discussions and prioritizations across the portfolios. In interview A there was a proposal of a split of the process. Do the project selection and marking, in areas already chosen as a priority by the top management, on a lower level, and then the actual management of the portfolio, with balance, on higher level (L3). Some leaders have big portfolios, and then it can be easier if the details are managed at L4/L5 level. The interviewed B suggested another model for some speculative projects, with higher risk than the others. Maybe they should have some other criteria. The evaluation process should be conducted at both single and portfolio level. First single-evaluation should be done, and then portfolio-evaluation to be able to see the connections and find the balance. "One project can be valuable, but another with the same goal can give even better income".

Both the interviewed have heard about cancellation of projects in Statoil, but all agree that this is something Statoil can become much better at.

Both agree that evaluation and prioritization of an R&D portfolio must be conducted. B means it is necessary to know what Statoil is doing, to have an idea of where to go, and what to solve. But within research you are not suppose to succeed 100%. A means it is important not to have too much financial-portfolio management. Within research we have to allow failure. There must be allowed to do research and have ideas. It must be a thought on what to do research on, what to solve, but it is important to not become too focused on a tool for optimization.

Regarding project success, A answered that this is to create something that is attractive and have the ability to become implemented, and used. Something has to be changed, there must be an effect. This means; if you are using 1 mill in a project, it is not a success before you get more than 1 mill in return. According to B, project success is when something is delivered with a quality and within the necessary schedule. To be a success for Statoil, the project must expand Statoil´s business-opportunities. The project must support the company´s requirements.

In the questions regarding use of weighting in the evaluation system, A is not sure if this is the right thing to do. Maybe something in the middle can be a solution. A means a score is

dangerous; it is too easy to see too much at the score and forget everything else. Not a score, but some sort of marking can work. B´s opinion is that it would have been elegant, but to get a system that works it would require a lot of time. B means also that the process can be too automated, and it can result in losing the leadership-focus, and involvement. Engagement from the management is important. Both A and B agree that to use the system as an information display is a better solution. If this can be done, Statoil have achieved a lot. It must be some common basis points to be able to start a good discussion.

4.3.2 RECOMMENDATIONS AND FEEDBACK FROM THE GROUP DISCUSSIONS

The discussions have been about what to include in Statoil´s evaluation card. This was important to make sure the card is adapted to Statoil, and that it includes the most important factors important for Statoil and their way of doing business.

As a starting point in each discussion a suggestion of the final evaluation card have been introduced. Then the discussion partners have been given an opportunity to submit their comments, feedback and advices. Based on this, several points have been revealed and updated.

The first discussion was with the RDI FC department

The system must be simple, and consist of easy and “strait to the point” questions or statements. This is important to avoid misunderstandings. There were some disagreements in terms of weighting, and how to be able to make an analysis and use the findings. If the different choices within each evaluation area are going to be weighted, there must be a very good consistency in the ratings. And to obtain the best result, there was a proposal regarding use of which choice that gave the best score. Peoples want to get the best score, and if they are unsecure about two or more options, they often choose the one that gives best result. The proposal was to switch what is the best output used in the weighting, to make it impossible to predict by the user.

The top manager wants an evaluation area that says something about project execution or performance. What are the characteristics of a good project?

Regarding the strategies in Statoil, it was revealed that both the department and the researchers think it exist too many strategies in the company. All technologies will find one strategy that fits to justify their technology and give those reasons to continue. The corporate technology strategy is not all up to date. This results in existence of activities that are outside the corporate technology strategy.

In earlier scorecard made for Statoil, and also mentioned in the strategy, are the technology classifications. All technologies and projects should in the principle be labeled with one of them. But this label have never been used to something, and there are an opinion about that this is just checked without any further thoughts behind. This has resulted in very bad quality on the data. Very few people in Statoil know the meaning behind these labels.

Market attractiveness was one proposed evaluation area that was discussed. Proposed choices to be included was if it is likely that the technology could give Statoil increased market share, and if Statoil could earn margins by the competitors by conducting this technology. Also the relevance for Statoil, and the point in using money in a technology that in few years are developed by others, and thereby use the money on other technologies instead, was suggested. The conclusion from RDI FC was that this was an evaluation area that is not important for Statoil. Many other factors have more importance. Statoil is not interested in market shares and the market in general. They are not a production company that produces final products. They deliver technologies to users. The recommendations were not to include this, if the evaluation card should be adapted to Statoil.

The financial evaluation area is difficult. All agree that this evaluation area must be included, but which statements or choices to use, is a difficult task. The proposal for discussion included both the NPV and IRR as mathematical parameters, and different scale of these. The department recommends the scale to be chosen such that there will be a good spread between all the projects in RDI. Then we avoid having all the technologies within one statement. Further, the RDI FC said that IRR is important to be able to see how much money that comes in return of the investment, but their experiences is that this is information nobody have. They recommend only NPV to be included, to make it as simple as possible.

The data available today is of very bad quality. They are calculated on different basis, and this is difficult to compare. Not all technologies have an NPV value either. This has to be taken into consideration.

Discussion with the chief researchers

The chief researchers are five experts in Statoil, with responsibility for each their portfolio. There was conducted a discussion with four of them.

All think it was a good idea to include several evaluation areas into the system, to be able to see the context. They wanted also to be able to use a bubble-diagram to see the balance and compare the different projects against each other. In their bubble-diagram they usually use probability for success as one axis, and value in money ($) in the other. To the size of each bubble, they use the amount spend. For the managers to be able to make bubble-diagrams,

they recommend that an evaluation area named probability for success to be included in the final evaluation card.

For the evaluation card in general, they recommend to use letters instead of numbers to distinguish between the different statements. They have experienced that many are afraid of numbers, because they automatically think of one better than the others. They are familiar with the problem regarding technologies or projects that have difficulties estimating a financial value. Therefore it is so important that the strategic fit area is included, since it can be used to justify those with bad estimates, or no financial values.

When it comes to the problem regarding weak quality on the financial values, this is not a good enough reason to not include the financial evaluation area. The problem as they see it is that it is the researchers themselves that set the estimates, and then the values do not become quality assured. They mean that it has to be clear roles for the financial area. If the data is not quality assured and calculated the right way, there have to be a demand to choose the no data available statement. But then they must have an approved business case.

The financial evaluation area must see into the future. “Money used, is money gone”. The NPV includes all the cost we know from the business case, but it is too narrowly to just include the NPV calculations. They recommend also the IRR to be included. The problem is that this is missing from today´s TDP´s in Statoil, so this is not a value people request for.

The chief researchers think it is a good idea to include a project execution area. This will make it possible for the managers to be able to go back and see what they have to fix first. What is most critical for the technology or project to become a success?

The HSE/License to operate area gets good feedback. This is an area that has to be included. This area brings out the nuances, and highlights the importance of doing research on many different things. If it is included, it helps on the awareness about the theme. Everybody should have conscious awareness about HSE. One proposed statements within this area was that the technology was a requirement. They think this was a too strong statement, and proposed to either make it a show stopper or a green card for a business case if missing success.

The chief researchers suggest use of the terms pull and push when talking of customer alignment. This is well known terminology in Statoil. To use FUIT says too little. It is the way further that is important. There must be an alignment with the customer’s needs and wants. First use is a form of implementation, but if the project stops right after this implementation, this is negative. The research does not stop before multiuse (TRL4). This is where the value is created to the customer.

The innovation proposal has before this discussion been divided into two evaluation areas; time to impact and innovation level (incremental versus radical). There came a proposal of including the probability for success into the innovation level area. Here they also recommend low as one option, and medium/high together, to be able to separate the worst cases. Probability for success means the probability for the business case to be fulfilled. The whole point is to succeed.

Feedback from the L3 leaders

Finally, some feedback from the L3 leaders, who is going to use the evaluation card, was given.

They had big concerns about the validity of the NPV data. The way the calculations has been conducted, makes it impossible to make comparisons. Only a few technologies have good enough data. It must be a requirement to pick the "no data available" statement if the values are not approved and of good quality.

They were afraid of the ranking, and concerned about the final result. For example, that it is not possible to distinguish the strategic statements against each other. Both technologies to reach the goal of 2020 and future business technologies are important, and have to be done. Also time to impact have to be included to see the balance.

5 DISCUSSION

In this chapter will the research questions be answered based on earlier presented theories and empirical findings. The first research question would give an answer of how a company should proceed to be able to optimize their R&D portfolio. This means how to prioritize and select the right mix of project to obtain maximum value and right balance in the R&D portfolio. Included in the answer are what an optimal portfolio consist of and how the company must think and be organized to reach the goal.

Research question two looks at which type of system the company must implement, and how the system is going to be used to find the results needed to obtain an optimized R&D portfolio,

The third research question is the actual adaption to Statoil´s R&D portfolio and what Statoil´s evaluation card should consist of to optimize their specific R&D portfolio. At the end of the discussion, the final evaluation card is filled out and presented.

After answered the different research questions, implication for theory will be discussed. This will give answers to how the Statoil related findings can be implied in a general company. The general evaluation card, that is the result from the implications for theory discussion, is then presented. This discussion ends with a general model named Mürer Stemland´s R&D optimization portfolio model, which is described stepwise. Finally, the chapter presents the recommendations for the managers and further research, followed by limitations for this thesis.

5.1 Q1: HOW CAN A COMPANY, LIKE STATOIL, PROCEED TO OPTIMIZE THEIR R&D PORTFOLIO?

As the empirical findings shows, a big company like Statoil has several different portfolios consisting of different technologies or projects. A key managerial task is to dedicate resources across all this projects. PPM can be implemented in the organization to manage this. PPM is the systematic process of selecting, supporting, and managing a company´s collection of projects. The projects are managed under the same umbrella, and may be either related or independent of one another. Use of PPM ensures communication and connection of the business strategy to the projects and bridging the gap between projects and operations across the organization.

If a company does not practice PPM, they will risk having projects that should have been selected and included in the portfolio, but are not, and projects that remain in the portfolio even after they no longer serve the company´s best interest. The result is that many projects does not support the goals of the organization, or they are not delivering what they promise.

The key managerial activities related to PPM are initial screening, selection and prioritization of project proposals. Related to development project, it is important to remember to take care of the research and its ideas. In the interviews it was revealed that the ideas must get permission to be tested out, and that failure must be allowed. This is some of the difficulties with R&D projects. No one can look into the future. Portfolio planning is based extensively on forecasting. But a company must be careful in betting the future on data such as these. Everyone involved in the process, should become a devil´s advocate. This means that there is a need to question things that look too good. Someone has to ask the difficult and probing questions. This indicates that there is a need for a system to evaluate and prioritize in a company, also within R&D business. In interview B it emerged a need for a system to be able to know what Statoil is doing, what to search for and what to solve.

An optimal portfolio consist of optimal projects that is performed best, and that fits with the other projects in the portfolio. It must be the right mix of project to obtain maximum value and right balance. It also has to be aligned with the company´s strategy. This was confirmed through the interviews. In interview A an optimal portfolio was said to be "the right selection of projects, linked with strategy and organizational goals". In interview B it was said that an optimal portfolio for Statoil answers to their business needs. "It must be a good balance between short and long term technologies, and the innovation level". According to Cooper et.al (2001), will the managers who successfully optimize their R&D investments, win in the long run.

To get optimal projects, theory from chapter 2.2 must be taken into consideration. As the theory indicates, Cooper (2001) recommends a Stage-Gate framework to reduce the failure-rate within new development projects. It shall guide new technology projects from the beginning to the end. Statoil have much of the same framework trough the TDI work process, described in the empirical findings (4.2.5.2). The TDI work process describes the steps to follow from identifying a business need or having an idea, until the technology solution is implemented and multi-use is completed (TDG 5).

Something missing in the TDI process, which is included in the Stage-Gate model, is the pre-stage evaluation. This is important to be able to learn from finished technologies and projects, to find success projects, and to constantly look for improvements in the work that is carried out. It is important to localize both critical and good technologies and projects, and the work should not be finished before evaluation has taken place.

Both the State-Gate framework and the TDI work process is made for single new development projects. Much of the same thoughts can be transferred to portfolio handling. There is a need for selection and prioritization to get an optimal portfolio, and there is a need to have criteria to decide whether to continue or kill a project. The projects in a portfolio are at different stages, and there must be possible to take decisions despite this. Since the projects are future

happenings, the estimates made on each projects can be evaluated if the criteria and basis for the discussion are the same.

In theory chapter 2.2.2, Cooper (2001) recommends a number of best practices in order to increase the probability for superlative products, and thereby portfolio success, increased profit, and company growth. Many of these best practices can be implemented in Statoil´s way of handle projects and how to get an optimized portfolio, and many of them are already implemented in the TDI work process, and through the TDP (4.2.5.3) which ensures a good up-front homework and an early technology definition, since the TDP must be approved before starting the process. There is a need for sharper focus for the managers to be able to set priorities and tough criteria to weed out bad projects and place the resources right. There is no point in prioritizing, if it does not lead to actions. It must be possible to stop projects that have been started when more information has been available, or the projects do not fulfill its expectations. It was revealed in the interviews that this is something Statoil can become much better to handle. Too few projects are cancelled. They have no system for this, and no backlog of projects that have been stopped.

So far, the discussion has been on how to get optimal projects. Another challenge that has to be taken into account when optimizing the portfolio is the synergies between projects. One bad technology or project may actually facilitate another. There are often interrelationships between the technologies. It is not good enough to have only good projects, if they do not fit together. It is no point in having ten technologies that solves the same problem, no matter how optimal and perfect each technology is. There is a need for a system that handles this problem in the company. This must be a system that makes it possible to not only see each single-technology and evaluate independently, but that manages to see the total picture.

In the empirical findings in chapter 4.2.5.1 Statoil´s economic decision-analysis method is presented. It is intended to use this method for financial calculations, but the structure part of the method, that includes decision trees, can be used to find optimal technologies and projects, to see the opportunities that lie in each of them, and to see the connections between them. Decision trees are used to structure decision points, risk and outcomes, and includes all necessary information needed to take optimal decisions. This makes it easier to choose the optimal path. This can be done without the financial values as input. Just the drawing of the tree, will view the opportunities and give those responsible deeper insight.

In the theory, chapter 2.4, several methods are proposed for this purpose. Mikkola (2001) state that it is important that a set or subset of R&D projects are evaluated together. Archer et.al (1999) recommends a decision-process framework where the decision makers are free to choose the techniques they find most suitable for the process. Chiens (2002) experience shows that the portfolio selection problem should be handled by evaluating individual projects first

and then looks for ways to combine the projects for an optimal R&D portfolio. From the interview B it was suggested that the evaluation process should be conducted at both single and portfolio level. “One project can be valuable, but another with the same goal can give even better income”, it was said. Also in interview A it was suggested a split of the process, with details selection at lower level (L4/L5) and portfolio management in L3. “It is not possible to throw all single projects in a sack; you have to see the connections”.

The method of Archer et.al (1999) will not work in practice. To be able to create a good discussion, and to be able to compare the projects across the portfolios, there must be a common model in the whole organization. This is also supported by the interviews. It must be a system that take into account that the technologies and projects are different, with different areas that brings out the true value. Mikkola´s (2001) method is partly true. Evaluation on the whole set together is the best way of obtaining portfolio optimization. If just evaluation on a subset is performed, it is not possible to see the whole picture. Chien´s (2002) model is the best model. It must be a parallel process. Each project must be evaluated to be conducted in an optimal way, and that the potential and capacity is utilized to its maximum.

Despite other proposals, the evaluation, selection and prioritization of technologies and projects must be handled by the managers. The total amount of projects has to be taken into account, because all the projects are fighting over the same resources. Some leaders have big portfolios, and then it could have been easier if some of the selection within prioritized areas had been handled at a lower level. But individual evaluation cannot be done without consideration of the other projects in the portfolio. The key is the optimal mix of projects. It does not necessarily include all very good projects; if the case is that they do not fit into the overall portfolio objectives. Also Mürer Stemland (2012) recommended, in chapter 2.4, a portfolio approach rather than single project-evaluation.

Short answer to the research question Q1:

PPM can be implemented to dedicate resources across all projects, and to ensure that the projects support the goals of the organization and deliver what they promise. Evaluation and prioritization of the portfolio are important to be able to find the optimal R&D portfolio, and this must be done despite the difficulties related to R&D measurement, and with the same basis for discussion. An optimal portfolio consists of optimal projects that fit with the other projects in the portfolio. There is a need for a portfolio evaluation approach, not a single-project evaluation process. Individual evaluation cannot be done without consideration of the other projects in the portfolio. Decision trees can be used to see the opportunities that lie in each project, and to see the interrelationships between several projects. The key is the optimal mix of projects.

5.2 Q2: WHAT METHOD TO USE, AND HOW SHOULD IT BE USED?

In this section there will be a discussion of what method the thesis recommends to use, and how it should be used to find the optimal R&D portfolio.

What method to use:

To find the optimal portfolio, there is a need for finding a method or system that fits. There have been proposed a lot of different systems during the years, but no right answer has been found. There are several reasons for that. One is that the system have to be adaptet to the spesific company. Mürer Stemland (2012) revealed, as described in 2.4, that there are many factors that have impact on the final system. The organizational goals and strategy play an important role. Since the strategies are different in each company, there will be differences on which evaluation areas that is going to be choosen. Other factors that are important on the final result are organizational structure, the size of the company and type of industry. Statoil is an big company, which gets much attention and many policies from different directions. All these things have an impact. To be able to keep the system as simple as possible, the evaluation areas must be choosen because of their relevance and importance. This cannot be the same across companies.

Another reason for not finding a valid system, is conflicting goals in portfolio management for R&D projects . As it appears in theory chapter 2.3.1, portfolio management for R&D projects has three main goals; value maximization, strategic alignment and finding the right balance of projects. To choose the best project after which gives the maximum value, does not necessary result in the best possible portfolio as a whole. It is not just the involved projects summarized value that matters, but also the balance and strategic suitability of the portfolio. For example, if the project is of high strategic importance, like a license to operate project, it may be at the expense of some other goals, like maximum value and profit to the company. The theory within portfolio management for R&D projects suggests a lot of models regarding each goal, and the recommendation is to choose what is best related to the organizational goals. No model that takes all the goals into consideration is found yet in the theory. But what if it is possible to take the best practices from the most popular models, and make a new complete method?

The fact that R&D portfolio models plot input that do not exists, and with estimates that is highly uncertain, make the search for a perfect model, and the evaluation process it selves, difficult and complicated. As described in chapter 2.4, Cooper et.al (2001) revealed that the most popular methods is the financial ones, like the NPV. But it was also revealed that these gave the worst performance results. Mürer Stemland (2012) revealed that the two most used models were the NPV and a sort of scoring model. The NPV model is a simple and easy model, but it does only measure the financial values. Then all those projects that have difficulties

regarding estimation of a value will get wrong behavior and look like a bad project. If all these projects then get stopped in the evaluation, this will lead to disaster. Cooper et.al (2001) points out several disadvantages with a financial model. This includes the highly uncertain estimates which gives unreliable results, and the lack of strategically considerations and interrelationships between projects. Mürer Stemland (2012) points out that a system with only financial measures may result in a decrease in the scientist´s and engineer´s motivation and creativity due to the uncertain value they are required to set on their lifework. But also some attractive features were revealed regarding the research that must be done to find the numbers which result in increased knowledge. To ensure these advantages, and the fact that it is recommended trough Mürer Stemland (2012) and the interviews that a model should comprising both financial and non-financial evaluation areas, this thesis is going to try to find a evaluation model that includes at least one financial evaluation area.

A scoring system is, as described in chapter 2.4.1, a model that uses evaluation areas, with rated statements, to obtain a final score on each projects trough weighting of the different evaluation areas. As mentioned in the theory, Cooper et.al (2001) states that a scoring model is an effective tool for prioritizing and obtaining an optimal portfolio.

In the attempt on finding a system that achieves all the needs, a modification and adaption of the scoring models is going to be used. The model is going to include one financial area, to cover the value maximization goal, and also the strategically considerations are included. The idea is to utilize all the advantages regarding the scoring model, but to eliminate the disadvantages. This in addition to other main findings revealed in the thesis.

The scoring model has many advantages. One of the most important ones is the possibility to use several evaluation areas in the process. To be able to evaluate the projects from a portfolio approach, in an equitable manner, each projects must be given the opportunity to be showed off at the same starting point. It is much easier to have a fertile and serious discussion, if the basis is the same. Since it exist multiple projects in Statoil, and the amount of information about each one of them are of unequal quality, it can be positive to make a system that consist of multiple evaluation areas that can be used as basis for the common discussion. Each project can then get the opportunity to get their value up front, without being deleted immediately. Several guided areas, with statements, also make it possible to evaluate and compare across the different portfolios. The portfolios in Statoil points in different directions, but if the evaluation areas are the same, as a basis for the comparison, there is more likely to be able to evaluate and prioritize across the department. It is not certain that each portfolio should cut in for example the same amount of cost. It may be possible that one of the portfolios should cut more than the others and that one maybe should get more resources than they already have. The poorest project in one portfolio can be at the same level as the best one in another.

If this is going to work, the evaluation areas must be selected in a way that all the most important factors are highlighted. This mean, if a project or technology have difficulties with calcultating an NPV, they can get the opportunity to show their importance in another area. This is in line with the findings from Mürer Stemland (2012)(chapter 2.4) and the interviews, who recommends multiple areas for evaluation. A model that uses several evaluation areas is an effective way of combining terms, can be used to capture multiple goals within an organization. This also ensures that serious areas are not overlooked, since multiple areas can be covered. Several evaluation areas also ensure not too much emphasis on financial factors, whose reliability is doubtful at the early stage of a project.

One problem related to the scoring model, is that the system can be too complex. The interviews and discussions for this thesis have revealed that it is important to keep the system simple. Mürer Stemland (2012) recommends 4-8 evaluation areas, while LaBrosse (2010) recommends 7-10. It is therefore possible to assume that a place between 6-10 is within the limit. To make the system less complex, it is important that the model, an especially the statements, are as easy and understandable as possible. For the model to be used, there can not be any possible misunderstandings and irritations from the users. Then the whole point with getting the same basis for the discussion is wasted. It can be clever to look for information that already exists in the company, and that the researchers and managers already need to know or is required to use elsewhere in the organization. This will also reduce the workload for the involved parties. This can result in an interest for the system, and they will see the benefits that come with. There must be a reason why this information is already utilized. It is a reason to believe that this is useful and important information. Already known information will also help avoid confusions. By use of the company´s terms and language the users will easier understand what it is asked for, and believe that this is important and unique. Experiences shows that employees in big companies have a lot of tasks that must be executed, and they are not too happy with new requirements and demands. This will not be a big problem if known information is being used, and the high benefits with the use are clear.

Another possible disadvantage is the weighting process. Weighting is positive in order to reveal that some evaluation areas are more important than others. But in the case of Statoil, that is a big company with many different projects it becomes difficult to decide what evaluation area that is the most important ones. If different weighting is used on different projects, this will give a final score that is not possible to compare. Because when you change the weights, you have changed the scoring model as well. It is also difficult to decide what weight the different areas should have. And the interrelationships between different projects become difficult to find. In the empirical findings, chapter 4.2.5.6, a description of a scorecard for Statoil, included weighting is described. This model produces a total score on each project, used to evaluation and prioritization. This satisfies not the findings so far in this discussion. Since it should be a

portfolio approach and the weighting has so many disadvantages, this model is not something this thesis is going to build on. The model weights four out of seven elements included, in the model and it can be easy to forget the ones not included in the final score in an evaluation and prioritization process.

How to use the method:

As mentioned in the theory, chapter 2.4, Cooper et.al (2001) claims that the scoring model fails to visually view the balance of the projects in the portfolio. It is the weighting that gives problems with visualizing the balance. The factors that are important regarding balance, is impossible to rate. It is the right mix that shapes the balance, and there is no right or wrong answer related to one project. For examples, all the projects cannot be of either short or long term, but the company needs to have projects of each, along the entire scale. The balance is very important, and must be included in the final evaluation method. Finding a solution on how to find the balance, leads directly to the next sub-discussion; how is the method going to be used?

The type of choices or statements to include in each evaluation area is dependent on the use of the system, and its purpose. Should the statements be rated and end up in a total score of each project, or should it be statements as basis for a discussion? In other words; should the system be used as a scoring-model with weightings, or as an information display without weighting?

If the system is going to be used without weighting, it will be used to display information to the managers in a useful way. This approach means that the management must review the system, integrate and assess the information, and then make the evaluation and prioritized list themselves. The scoring approach provides the management with a list of projects ranked and prioritized according to certain weighted evaluation areas. In other words, it will produce a prioritized list based on a final score.

To find out what approach to choose, pros and cons regarding both the scoring model and the information display will be carried out in the following.

A scoring model makes it easier to prioritize. All the projects can just be ranked after the final score. It will be some work in the pre-phase, to find out what evaluation areas that are most important, and to choose the weights, but after this it will be less amount of work on each manager. It will be a mechanical system that makes the prioritization list. Despite this, the managers must still do the final prioritization work. There are simply too many factors that are far beyond any capacity of any mechanical model to capture. As mentioned before, are the innovation factors impossible to rank. It is not possible to rate short term against long term, or incremental against radical new technologies. A company cannot do just one of the things. Just short time will lead to problems in the future, and just long time will not earn any money in the

present time. In incremental versus radical is it always positive to do research in new and better ways, but it cost money and is risky. Reuse of some of the existing knowledge and competencies has lower risk and a more secure income.

Another example is if the project is far behind the original plan, but this is done because there is a close collaboration with the customer and the customer does not have the capacity to receive the technology before. Then it is a good reason why the project is behind, and this is not possible for a mechanical model to see. If it is a wish from the customer to delay the technology, this is positive. Then the project cannot get low score because of this. There are many cases that are similar, where it is necessary to see several of the evaluation areas up against each other. If low in one area, it can be a good explanation behind. Projects that are enabler for another technology can also fit into this category. It can be a good reason to conduct a bad project, if it helps a great project to obtain success. There are too many if´s in each evaluation area. There is often a reason why something is done the way it is.

Also the requirement to strategic alignment can be difficult to rank. It is difficult to rate activities that ensure the goal in 2020 against long-term activities for future business opportunities. A strategy can highlight multiple goals, and it is difficult to rank them. All the possibilities have to be seen, and the purpose is to find the right mix and obtain the right balance. A portfolio with the right balance is a better starting point for doing the right prioritizations and selections, which lead to an optimal portfolio. This again will lead to competition advantages. If the managers still have to do the final prioritization process, they can do it all the way.

With a scoring model, the prioritization job will be done as a much similar process and based on more solid facts. The managers do not have to have the same deep understanding of each project. If the system is going to be used as an information display, deep understanding will be a requirement. It is a great amount of work that has to be done, and for managers with big portfolios, this will take some time. But this can also be positive. To get deep insight in each project, they can be aware of all the opportunities that follow from a project, and the portfolio can become even more optimal. A great understanding is also positive for the personal learning process. In interview B it was mentioned that a mechanical model can result in losing the leadership-focus, and involvement. Engagement from the management is important.

But there are also problems regarding just managers who take the decisions. When it is individuals that are suppose to take decisions, their feelings and personality can affect the choice. Managers do not necessarily make good and consistent decisions. It is better if a system can be developed to replace at least some of the work provided by the managers. And, who is going to take the decisions?

As mentioned in the theory (2.4.1), Harvey (2005) recommends that all relevant managers, leaders and staffs are included in the decisions. The fact that it is people who take the decisions, make it interesting to consider the personality effect in the selection process. Despite well established techniques and methods, they are estimated by humans with different experience, personality and personal characteristics. It is impossible to assess the selection process without consider personality effects to the decision makers. Having a group of people that are responsible for the final result can reduce these problems. Also the same discussion basis across the organization can help. Then the system becomes widely used, and there are many people with experiences with how to use it. To know that other managers, with the same decision-power, will see and discuss the results make it more probably that the decision-maker becomes more thoroughly and that the failure rate becomes reduced. The decision-makers must stand responsible for the marks, and be able to defend them.

If there is a weighted model, a final score on each project is produced. If this is going to be basic for the final prioritization and evaluation process, it can be too much attention on the number and the rest of the prioritization and selection process can be taken too easily. The decision-makers just see the score. It is easy to get blind on the footnotes that are written with small letters. This is also the opinion to the interviewed person A.

As it has been highlighted in the discussion, there are benefits and drawbacks related to both approaches. To summarize, managers, not a decision model are the decision makers. This implies that the portfolio tools used must be a decision-support system and display the right kind of information. The final prioritization list must regardless be a non-mechanical process, due to the fact that there are too many factors that are impossible to rank, that play a different. There is also easy to get blinded by the score, and be affected of this in the final prioritization and evaluation process. But the fact that the decision-makers are just human beings may cause that the results becomes too much influenced by feelings and personality. Managers do not necessarily make good and consistent decisions. Also the great workload that ends up on each manager to get the needed deep understandings is a disadvantage with the information display approach.

It seems like the information display approach is the best choice, this is also supported by the interviews. But the downsides are very negative. To preserve the benefits related to the information display, and reduce the disadvantages, a intermediate approach is going to be chosen in this thesis. This will be explained in the following.

The method can be used as a decision basis, and include some sort of ranking to weed out the best projects. The decision makers have limited time available, and if the project that there are no doubts shall be developed are weeded out, they save a lot of work. This is not projects that should be evaluated against other projects within the same portfolio, or across the other

portfolios in the company anyway. The proposal is to mark the projects with the colors; green, yellow or red. Like a traffic light. Then the success-projects are given the green light, the middle ones get yellow, and the critical ones gets red. This is also good for finding the success projects, to find the success stories and to learn from them. By setting one of three possible colors rather than an advanced score also reduce the focus problem. No there is not possible to get blind on a number any more.

Then, when the leaders are evaluating they can first look at the red, and then the yellow ones across the portfolios in the company. No red projects are going to be deleted at once, but now they can be discussed against each other on the same basis, by the use of the results from the evaluation areas.

Another issue is how the statements should be numerated. The group discussions revealed different opinions on this. The meaning is that the statement that fit the most is going to be chosen. The idea behind the system, is to not have any ranking or rating between the different statements. Since the statements are not going to be a starting point for any weighting, but just give a basis for discussion, it can be scary to include starting numbers related to each statement, to distinguish them from one another. Numbers often leads to competition of being the best, and the lower the number is, the better. This can result in biases in the evaluation. To avoid this, the proposal is to separate the different statements with letters, from A to E. If, in any circumstances, the project fit more than one likewise, the statement must be put in a way that the best/most important statements belongs to the highest letter.

Short answer to the research question Q2:

The company needs a common system, to be able to discuss the results and evaluate across the portfolios in a fair and serious discussion. To deal with the weaknesses and retain the strengths, a modification of the scorecard is the proposed model in this thesis. The method is almost completely going to be used as an information display, as a basis for a good discussion. Many evaluation areas and statements are impossible to rank, and a display approach will give all projects the same fair possibility to highlight its value and impact on the business. An information display also ensures managerial engagement and insight in each project. Also, too much attention on a final score is avoided. To reduce some of the disadvantages, the method includes a total evaluation area, included a traffic light system, to indicate within which success rate the project lies (red, yellow or green), and to know what projects to begin the evaluation and prioritization process on.

Without weighting, the method cannot be called scorecard, due to its similarities. Therefore, it is given the name **Statoil´s evaluation card.** This also indicates that it is adapted to Statoil, and no other companies. The card should consist of several evaluation areas, both financial and non-financial, to ensure that all important areas are covered. Then different types of projects can be valuable. Each area has related statements that must be chosen by the decision-makers. When the card is filled in, the statement that fits the most must, within each evaluation area, be chosen.

5.3 Q3: WHAT SHOULD BE INCLUDED IN STATOIL´S EVALUATION CARD?

As discussed in the previous research questions, there is a need for an adapted system to manage to find an optimal R&D portfolio for Statoil. It is important that the evaluation card includes the most important factors related to the specific company, to meet the organizational goals and to be able to evaluate, prioritize, select and find the right mix of projects. The result is given in the final evaluation card, which can be seen in the next sub-chapter; 5.4.

It is important to develop a system that is going to be used and that does not meet resistance from the users. By including information and terminologies that already exist in the company, the complexity will be reduced and the system is kept simple. Examples of information and Statoil terminologies, described in the empirical findings chapter, are main goals from the corporate strategy, FUIT, MUIT, HID, business case, blue sky projects, TDP, cost, forecast and NPV.

THE EVALUATION AREAS WITH STATEMENTS:

Many different evaluation areas and statements are proposed in the theory. The result has been a proliferation of suggestions, ranging from financial areas, with measures like NPV or R&D spending as a percent of sales, to more complex areas like strategic alignment and HSE. Financial results alone have limited value as a measure. The interviews confirmed this. There are so many other factors that also are important and should be highlighted. The focus has to be on the whole range of values, and a combination of several areas. By use of Cooper´s (2005) recommendations described in 2.4.1 and Mürer Stemland´s (2012) framework described in 2.4.2, together with the goals for portfolio management for R&D projects (2.3.1) and empirical findings (chapter 4) the evaluation areas and statements that gives the optimal Statoil´s evaluation card, is going to be discussed in the following.

Strategic fit and importance:

There is no doubt that strategy should be one of the evaluation areas. Theory recommends a system that is closely connected with the corporate strategy. This is important to be able to link the organizational goals to everything that happens in the company, and ensure strategic alignment. To cover the impact on the business, this evaluation area is called strategic fit and importance. Strategic importance is a way of justifying a project with low or negative financial results, if it deemed to be valuable to the organization.

It is important that the technology R&D meet the corporate ambitions. From the corporate technology strategy, described in 4.2.4, the principal direction of; business critical technology ambitions, can be seen in connection with this evaluation area. These ambitions point out four business critical technology areas. One of the statements must therefore be that the technology

belongs to one of those four (seismic imaging and interpretation, reservoir characterization and recovery, drilling and well and subsea wells). In Statoil there exist other technologies that also contributes and support the goal of 2020, but that is not a business critical technology. These also have to be given a statement.

Statoil´s 2020 goal is not a very long-term goal. Businesses that can be important in the future, but that Statoil do not have today, are important to search for, and must be included in the statements. There must be some technologies and projects that seek longer than 2020. This is pure speculation projects, which gives the potential future fit. Statoil's projects in arctic can be an example within this statement.

Statoil have some special projects with high importance, selected by the management. These are the HID´s (described in 4.2.5.5) and Blue Sky projects (4.2.3). It can be valuable to include these in the evaluation card, for the managers to be able to find them, to have better control over them and to see where they are in comparison with other projects. This can be included in the strategic fit and importance area since it is a strategic management decision to find the candidates.

No strategic alignment or projects that support the laid of business should get one statement, to cover the activities that lies outside the strategy. This is technologies that not ensure long-term profit, but that just run with inside the organization. Statoil have many different strategies, and the corporate technology strategy is not all up to date. The amount of strategies makes it easy for all the technologies to find a strategy that fits good enough to get allowance to continue developing. Since the other statements are sat the way they are, and the one that fits the most must to be chosen, will the projects this applies to have no other choice but to check for this statement.

Financial/ Value creation:

It is clear that it has to be included a financial evaluation area. All the different theories and results have this area included. The purpose with this area is to be able to see if the project contributes to increased profitability and reduced cost.

From the theory 2.4.1, Cooper (2005) has called this related area "financial reward versus risk". This means that risk is included in the financial area. One of the recommendations from Mürer Stemland (2012) (2.4.2) was to include risk management to cover the uncertainty related to R&D when trying to measure the value. If this can be included together with financial measures, this is covered.

In Statoil´s decision-analysis method, presented in 4.2.5.1, risk and uncertainty are included in the calculations. It therefore becomes natural not to have an own evaluation area for risk, but

to include them in the financial area. The system should be simple, and it is not necessary to include more areas than needed. The economic decision-analysis method in Statoil should be included in the statements. Decision-analysis is a tool to lean on when common sense is difficult and there is a need to make the right decisions given what we know about the future.

Decision-analysis as value assessment is a wanted priority in the time to come in Statoil. The long term desire is that this is performed by all technologies and projects in the future. But this will take time, and nearly none of today's technologies have this in their business plan. The fact that value assessment with STEA is a requirement for a HID, which is the most prioritized deliverables, says something about how important this is to start doing with all R&D projects.

Next there is a discussion on how many mathematical parameters to include in the statements, and which ones. In portfolio management for R&D projects (chapter 2.3.1.1), the value maximization goal includes NPV and IRR as possible parameters that can be used. Since R&D projects are future happenings, the number used are just estimates with high uncertainty. The cash flow does not appear until the technology is deployed in products, systems or services. The NPV is very often used to present the economic value, due to its simplicity and user features. This is also a well known parameter in Statoil, so this has to be included. The feedback from the chief researchers was to include more than one parameter, and they believed that IRR should be included as well. The problem is that the number is not included in the TDP, so the value is not already known information. This thesis recommends that both values become included in the future, but for now just the NPV is included in the evaluation card. The numbers to each statement must be chosen so they give a good spread of projects, to avoid having all within the same statement.

The recurrent feedback on this evaluation area was that the data, if available, is of very different quality. There is no point in comparing data that is not set on the same premises. It will be like comparing apples and pears, it is not possible. This will result in dissatisfaction within the users, and there is a possibility that everybody will excuse their number and result. There must be an option to check for no data available. This is a demand if the data is not quality assured or calculated the right way. Guessing is not allowed. Not all technologies and projects have the opportunity to estimate financial numbers. If these have an approved business case, they get the opportunity to choose this as an own statement.

Customer alignment:

The ability to deliver value to the users or customers is important. The goal of a new product development must be to enhance customer value by increasing technology performance. The best practices described in chapter 2.2.2, state that the projects that use the voice of customer as input have the highest probability for success. In the theory of project performance (2.2.3),

customer expectation was mentioned as one important dimension. The expectations to the client should be realigned and integrated throughout the entire project. It is important that R&D projects are developed in relationship with the customers. To ensure focus on customer alignment, this is proposed as an own evaluation area.

The interviews also revealed that "there must be a customer to obtain success". In Statoil, this means that the technology must have a FUIT. But the actual value is first created when the technology goes to MUIT. The FUIT says nothing about potential future users.

The feedback from the customer and having a close collaboration during the process must be more important that just having a FUIT or a MUIT. Collaboration implies that there is a user. It is not important to only have a user, if the user is not satisfied with the final development. But to use the term collaboration can be scary and lead to dissatisfactions. There can be a good reason why there is no close collaboration. Alignment with the customer's needs and wants may be better approach. In Statoil the terms customer push and pull is used as terms related to this topic. A push technology is RDI driven, while a pull technology is customer driven. If these are used as outer statements in the evaluation card, the degree of alignment with the customer's needs and wants can be in the middle.

Innovation:

Mürer Stemland (2012)(chapter 2.4.2) recommends an innovation area to be included in the evaluation card. As described in chapter 2.1, is innovation one of the most important key activities needed for companies to survive in today´s increasingly competitive and globalized marketplace. Innovation is no longer seen as an optional investment, but as a major instrument of company growth and a critical factor for future business success. In Cooper´s (2005) framework presented in theory 2.4.1, there is no innovation area recommended directly. But, both the core competence leverage and the technical feasibility areas can be seen in connection with innovation. Innovation must be included in the final evaluation card.

From Statoil´s corporate technology strategy, presented in chapter 4.2.4, the principal direction; expansion of capabilities can be placed in this evaluation area. Statoil want to be an innovative company, and this is one of the main focus areas. To ensure this, the new department RDI becomes a reality in 2012 (4.2.2). It is stated in the corporate technology strategy that Statoil want to utilize their extensive projects and operational experience by introducing new solutions.

Innovation is difficult to rank, no option is better than the other. A company must conduct short-term technologies for increased income to survive in the present, but also long-term technologies are important for the development of future income. This evaluation area is going to be used by the managers to see the right mix of the projects, to obtain an optimal portfolio, and thereby competitive advantages. This ensures the maintenance to the portfolio

management of R&D project´s goal of finding the right balance, presented in chapter 2.3.1.3. The resources have to be balanced to sustain competitive advantages, since Statoil compete in a tough industry, and cannot expect to out-compete all competitors.

Which statements to choose is a problem within this evaluation area. There are so many different factors within innovation that are important. The theory talks about degree of newness, low versus high risk and time to impact as the most important ones related to balance. Risk is implicit included in many of the other evaluation areas, so this will not be covered here. To solve the statement problem, the proposal is to divide the innovation area into two new areas. These are called time to impact and level of innovation.

Time to impact:

Time to impact is an evaluation area used to obtain the right balance in the portfolio. There is a need for both short-term and long-term technology. The managers can use this area to see if there is a good spread of technologies in the years to come, and if they are covered to get profit now and in the long run. Development of a new technology takes time, so the future has to be thought of early. The statements related to this area are just a timescale, from short to long time to impact.

Level of innovation:

This area is going to state if it is an incremental technology or a radical one. It says something about the degree of newness in the technology, and whether the project is a game changer or a stone-by-stone project. New development is important, but there is also important to use known knowledge in the development. There is a need to find the right balance also in this evaluation area. The statement “no change from existing technologies” cannot be included because there must always be a development. If not, there is no R&D project.

Probability of success:

The chief researchers recommended inclusion of an evaluation area for probability of success. They proposed to include it in the level of innovation area, but this would have resulted in a very complex area, difficult to understand. To make sure to keep the system simple, an own area that states the probability for success is included in the evaluation card. It is better to use both areas together in an evaluation discussion instead. For example can a technology that has radical change from existing technologies and low probability for success (thereby high risk) be a candidate for the Blue Sky portfolio.

The desire to achieve success is the main reason why Statoil, and all others, do business. But what is success? In the interviews, A thought that success is to create something that is

attractive and have the ability to become implemented, and used. “There must be an effect”. According to B is project success when something is delivered with a quality and within the necessary schedule. To be a success for Statoil, the project must expand Statoil´s business-opportunities, and support the company´s requirements. In this case probability for success means the probability for the business case to be fulfilled.

The level of innovation and probability of success is just given three statements each in the final card. The reason for this is because they are used as balance input, and instead of finding up additional statements or divide the ones already included into smaller pieces, it is best to just to have three, to get a good spread of the results. It becomes easier to see the trends this way.

Enabling for another technology was one area this thesis considered to be associated with the evaluation card. This is one of the reasons why portfolio approach is so important when evaluating. If only the single projects are evaluated, the interrelationships between technologies cannot be seen. But what if the other technology is a failure? There is no guarantee for success despite help from another technology. If the enabling became an own evaluation area, there is a chance for letting too many bad projects continue due to enabling for another technology. There must be a degree on how bad the enabler can be, before it is more profitable to develop another enabler instead. A technology cannot be an enabler at any cost. This area is not included in the final evaluation card.

HSE/ License to operate:

Not mentioned in Coopers (2005) recommendations, but in Mürer Stemland´s (2012) framework (described in 2.4.2), is HSE. HSE can be seen in connection to license to operate projects. The projects are often performed because it is a requirement, or the alternative is disaster and not possible. As the empirical findings in chapter 4.1 shows, are the environment important, and this is a critical area in the oil and gas industry. HSE has to be a focus area, due to the serious consequences an accident may cause, and is thereby included in the final evaluation card. HSE issues can also have a positive impact on the company´s image, and can affect the future economic survival of the organization.

License to operate is one of the three principal directions stated in the corporate technology strategy (4.2.4). In the corporate technology strategy, it is stated that Statoil´s ambitions are to be an industry leader in HSE, and HSE improvements are imposed. There is a requirement that all changes done have to lead to HSE improvements.

The statements in this area are quite simple. It is just the degree the technology has on the impact on HSE performance, from no impact to high. The last statement is when the technology is an absolute requirement. It is a show stopper or green card for a business case.

Project execution:

In addition to what is proposed through the theory, the system must take into account a request from the senior management in Statoil. One desire was to find a way to include a project performance area that can help finding out what prevents the project from obtaining success.

There is a tendency to think of project solely in terms of its outcome- that is, its scope. The time at which the outcome is available is also part of the outcome, as is the cost entailed in achieving it. From the theory in chapter 2.2.3, the three direct goals of a project are scope, time and cost. Cost can be financial costs, but also human resources are important. If a project needs to be finished earlier, increased human resources will get the job done faster, which again most probably will raise the project´s cost.

The statements in this evaluation area are going to be used in the evaluation discussions to find out what the most critical factor regarding project performance is. To distinguish between financial cost and human resources, the four factors are: scope, time, financial costs and human resources. When for example a project is given the yellow traffic-light, it can be possible to look at this area to find out what is missing, and what can be added, for the project to become a success. The last statement is reserved for the projects that runs according to plan, and that do not have any critical factors.

To be able to use bubble-diagrams:

After a discussion with the chief researchers in Statoil, it was revealed that they used, and wanted to continue using, the bobble-diagram model. This is a model related to the last portfolio management goal; seeking the right balance of projects. The best way of solving this is to include some factors regarding cost and/or forecast in the model, to give the possibility to use the bubble diagram for a selection of evaluation areas. The chief researchers often use value (in $) and probability for success as the axes and amount spend/size of the projects as the bubbles. The forecast is planned cost in the current year, and is what it is important to know. Used cost is sunk cost, so this is not important. This can be used as a picture on the size of the project, and is included in the final evaluation card. The plan is to fill in the estimated value as a number at the bottom of the card, and to use this in the making of a bubble diagram.

5.4 STATOIL´S EVALUATION CARD

In this section the final evaluation card adapted to Statoil is viewed. This includes the evaluation areas with set of associated statements important for Statoil, a forecast row used for bubble diagrams, and the overall evaluation system with the different traffic light opportunities.

Evaluation area	Statements (choose what fit the most)	Result/ comments
Strategic fit and importance	**A:** No alignment to the corporate technology strategy **B:** The technology supports the current business (against the goal of 2020) **C:** The technology supports potential future business growth (beyond 2020) **D:** The technology support one of the four business critical technologies **E:** The technology is a Blue Sky project or a high impact delivery	
Value creation/ financial value Decision-analysis method in STEA	**A:** No data available **B:** No data available, but have an approved BC **C:** NPV < 2MNOK, IRR < 10 %, quality assurance by STEA **D:** NPV <7 MNOK, IRR < 20 %, quality assurance by STEA **E:** NPV >7MNOK, IRR > 20 %, quality assurance by STEA	
Customer alignment	**A:** The project is a push project (RDI driven) **B:** There is low alignment to the customer's needs and wants **C:** There is medium alignment to the customer's needs and wants **D:** There is high alignment to the customer's needs and wants **E:** The project is a pull project (customer driven)	
Time to impact	**A:** Unknown time to impact **B:** The technology has <2 years to impact (short time) **C**: The technology has 2 -5 year to impact **D**: The technology has 6-10 years to impact **E**: The technology has >10 years to impact (long time)	

Level for innovation	**A:** The new technology is a incremental change from existing **B:** The new technology is a radical change from existing **C:** The new technology is a game changer	
Probability of success	**A:** Low **B:** Medium **C:** High	
HES / License to operate (LTO)	**A:** The technology has no impact on HSE performance/ LTO **B:** The technology has low impact on HSE performance /LTO **C:** The technology has medium impact on HSE performance /LTO **D:** The technology has high impact on HSE performance /LTO **E:** The technology is a HSE/ LTO requirement	
Project execution	**A:** The most critical factor is financial costs **B:** The most critical factor is time **C:** The most critical factor is the scope **D:** The most critical factor is human resources **E:** The project runs according to plan	
Forecast	Fill in estimated value in MNOK	
Overall evaluation	**Green:** Technology project is OK. Success project **Yellow:** Watch the project. Must be evaluated **Red:** Stop/revisit/bad performance. Must be evaluated	
Comment		

Table 3: Statoil´s evaluation card

5.5 IMPLICATIONS FOR THEORY

The discussion carried out to answer the two first research questions, about how to proceed to optimize an R&D portfolio, what method to use, and how to use it, are basically done on a general basis. The results will be the same for a general company, within certain limitations regarding size, amount of projects and number of R&D portfolios, compared to Statoil. In this section the thesis is going to find a general evaluation card that can be used by another company than Statoil. The general evaluation card can be found in the next section, 5.6. The result is going to be used as input in the general model for optimization of an R&D portfolio that is presented in section 5.7.

The evaluation card includes several evaluation areas, with multiple statements related to each one. This is important to highlight the value of different types of projects. The theory implies that the system must be adapted to each individual company to be able to find the most important areas for that specific company. This is because the strategy, priority areas and goals in each company, to mention some factors, are different from all others. But it should, despite this, be possible to find some similarities that can be used in a general evaluation card. The recommendations from the theory in chapter 2, and the findings from the preparation of Statoil´s evaluation card is going to be used as a basis for this discussion.

Several of the evaluation areas recommended in theory, are the same as those included in the final evaluation card adapted to Statoil. By this it is possible to propose to include the similar ones with some adaption requirements. In addition, some areas not in Statoil´s evaluation card are recommended.

Strategic fit and importance:

The strategic fit and importance area is necessary to include, but it have to be adapted to the goals and strategic priorities related to the specific company. The “no alignment to the corporate strategy” statement must always be included. In the general evaluation card there is also recommended to include a statement regarding the future. A company, who wants to survive, has to think further into the future, and begin the long-term development. The rest of the statements are left blank, and shall be filled in by the company according to its goals and focus areas.

Financial/ value creation:

The financial area also has to be further adapted to be aligned with the specific company. Here, the value creation numbers in the statements must be adjusted to give a good spread of projects. This to ensure that not all projects ends up in the same place. The recommendations from the Statoil adaption process were to include both NPV and IRR calculations in the final

card, to get more solid and useful information. In Statoil this was not possible due to lack of this information in the procedures. If this is a value the specific company has access to, it should be included. The statements in the general model are left blank to be filled out. This applies to all, despite the "no data available" statement.

Customer alignment:

The customer alignment area is also included in the general evaluation card, in accordance with the theories and Statoil proposal. Customer feedback is important during the whole R&D process, and to succeed, the developed new product must be something the customer will apply and wants to buy.

Market attractiveness:

One area, the market attractiveness, is excluded from Statoil´s card, but recommended in both Cooper´s (2005) model and Mürer Stemland´s (2012) framework, presented in chapter 2.4. Market attractiveness was one proposed evaluation area in the process to develop Statoil´s card, but this was not a preferred area for them. They said early that they were not interested in gained market shares and sizes. Despite this, it is not sure that this is the fact with other companies. Market attractiveness is a very common area to include, and is an area that gives a picture on if the marked needs the development, if there are sales opportunities, what the time to marked would be and if the company earns margins if the development comes out for sale.

This should be interesting for all companies in a competitive position. To survive in a highly competitive market, this type of information can be crucial due to project selection and prioritization. Market attractiveness is therefore recommended to be included in the general evaluation card. The statements related to market attractiveness, should include market share. It is important to distinguish between if the project is going to have an impact on this or not. Some projects are developed without any intention of the market. If the market share is important, it can be differentiated between if the project; is entering a whole new market, should contribute in increased market share, or maintain the existing markets position by keeping up with its competitors. The last statement to be included should cover the intention of that the project is going to result in being a market leader.

Risk/uncertainty:

From the theory chapter 2.4.2, Mürer Stemland (2012) recommend risk/unsertainty as an own evaluation area. Risk is more hidden in Statoil´s result. This is partly because Statoil have risks included in the financial calculations, and because risks can be seen indirectly through combination of the innovation and probability for success areas. If the project is, for example, a radical new development project with low probability for success, this is a high risk project if it is

prioritized. In research there must be room for new ideas and failures, so it is important to include some high risk projects in the portfolio. It is also claimed in Mürer Stemland (2012) that projects with highest risk, is the one with the highest income if they enter the marked. In the general evaluation area risk is not included as an own field, due to the possibility to find this by mixing other areas, and the fact that this can be included in the financial calculations.

HSE/License to operate:

One area just included in the Mürer Stemland (2012) framework from the theory, but in the evaluation card for Statoil, is the HSE/License to operate area. This thesis means that it is wrong by the theory not to include this sort of area. As revealed in the empirical findings 4.1, the goal in the oil- and gas-industry is zero discharges, so HSE have high priority for all businesses within this industry. There is generally too little focus on this area in all types of business worldwide. This area makes it possible to highlight all sorts of projects. Projects that get highest impact here, often has low in for example the financial evaluation areas. This is projects that often have biggest difficulties related to estimating a financial value. It is important to increase the awareness within this theme. By including this area in the final evaluation card, it will result in increased focus on HSE and license to operate projects. The risks by not doing these sorts of projects are so critical that all companies have to do developments within the field.

Innovation:

The areas within innovation become the same in both the Statoil card and the general model. This is the time to impact and the innovation level. This is important to obtain the right balance in the portfolio.

Probability of success and Project execution:

Not found anywhere in the theory, but suggested for Statoil are the two areas probability for success and project execution. Both should be included in the general model. The probability for success is important because it is success all projects are looking for.

Project execution is important to be able to look deeper into a project. This area can make it possible to see what the main problem is. It gives a statement on what prevent the projects from being a great success. The meaning behind this area is for the manager to be able to know what can be done shortly, to save this problem from being a failure and make it a success instead.

5.6 THE GENERAL EVALUATION CARD

In the general evaluation card, the company must fill in the statements that are missing, after the description that is given in the card.

Evaluation area	Statements (choose what fits the most) The statements highlighted with bold, must be filled by the company	Result/ comments
Strategic fit and importance	**A:** No alignment to the corporate technology strategy **B:** The project supports the future business growth **C to E:** ***Fill in three important business goals from the strategy***	
Value creation/ financial value	**A:** No data available **B:** No data available, but have an approved BC **C to E:** ***Fill in three appropriate values for NPV and IRR that gives a good spread of projects in the portfolio.***	
Customer alignment	**A:** There is no alignment to the customer's needs and wants **B:** There is low alignment to the customer's needs and wants **C:** There is medium alignment to the customer's needs and wants **D:** There is high alignment with the customer's needs and wants **E:** The project is customer driven	
Marked attractiveness	**A:** The project has no intention regarding market share **B:** The project enter a whole new market **C:** The project is going to maintain existing market share **D:** The project is going to contribute in increased market share **E:** The project is going to be market leader	
HES / License to operate (LTO)	**A:** The technology has no impact on HSE performance/ LTO **B:** The technology has low impact on HSE performance /LTO **C:** The technology has medium impact on HSE performance /LTO **D:** The technology has high impact on HSE performance /LTO **E:** The technology is a HSE/ LTO requirement	

Time to impact	**A:** Unknown time to impact **B:** The technology has <2 years to impact (short time) **C**: The technology has 2 -5 year to impact **D**: The technology has 6-10 years to impact **E**: The technology has >10 years to impact (long time)	
Level for innovation	**A:** The new project is a incremental change from existing **B:** The new project is a radical change from existing **C:** The new project is a game changer	
Probability of success	**A:** Low **B:** Medium **C:** High	
Project performance	**A:** The most critical factor is financial costs **B:** The most critical factor is time **C:** The most critical factor is the scope **D:** The most critical factor is human resources **E:** The project runs according to plan	
Forecast	Fill in estimated value in MNOK	
Overall evaluation	**Green:** Technology project is OK. Success project **Yellow:** Watch the project. Must be evaluated **Red:** Stop/revisit/bad performance. Must be evaluated	
General comment		

Table 4: The general evaluation card

5.7 MÜRER STEMLAND´S R&D PORTFOLIO OPTIMIZATION MODEL

The discussions that have been performed earlier in this chapter, and the results obtained, has ended up in a complete model that can be used by a general company to find their optimal R&D portfolio. This process is called Mürer Stemland´s portfolio optimization model, and is presented in the following.

This is a model for companies, preferably on a certain size, with more than one portfolio of different types of projects. It can be used by small companies as well, but then some of the steps have to be simplified. The process can be seen in figure 15, and each step is described after the figure.

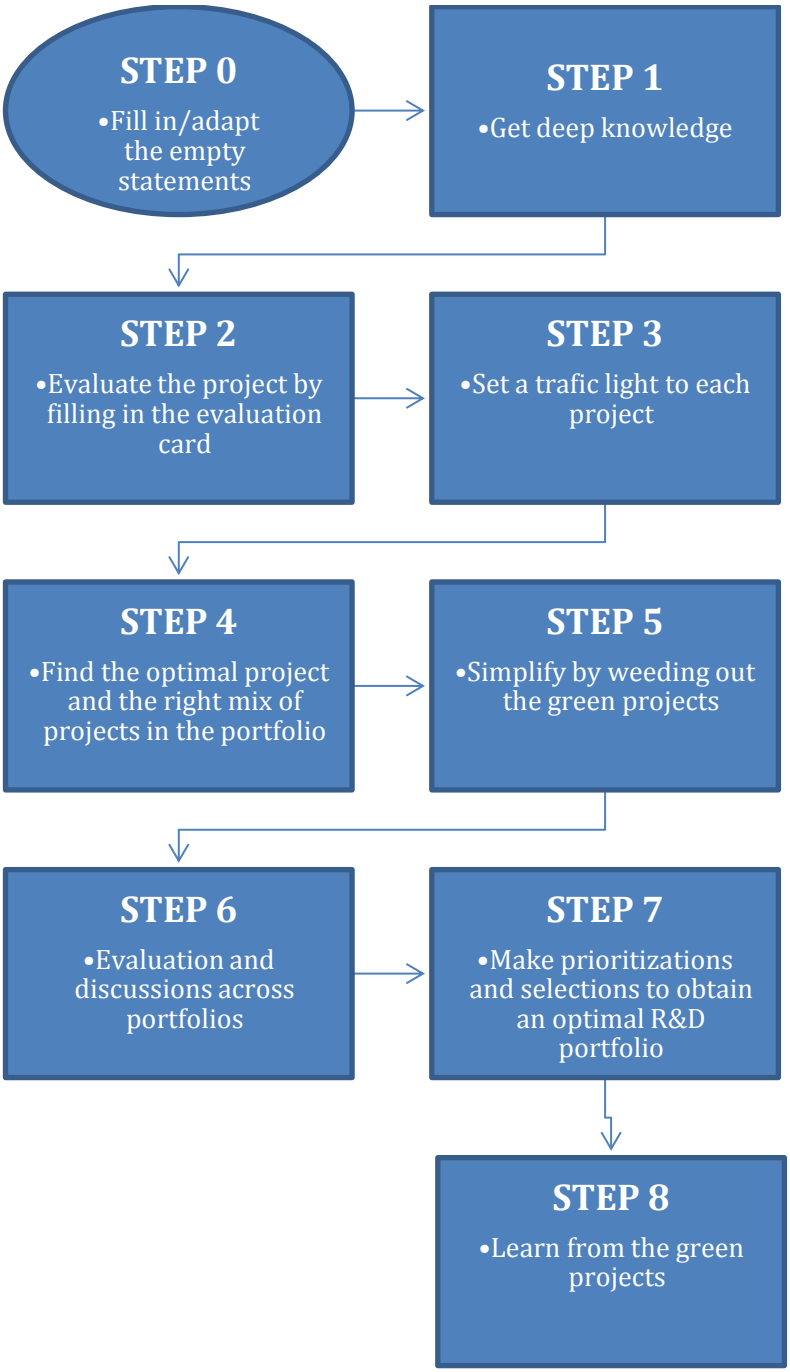

Figure 15: Mürer Stemland´s R&D portfolio optimization model

The process can be explained as follows:

- **STEP 0:** In this initial phase is the model going to be adapted to the specific company. The general evaluation card has some empty statements that have to be filled out. It is specially the strategic importance evaluation area that should be filled with statements about the organizational goals, priorities and focus areas pointed out in the corporate strategy. (It is taken for granted that the company has a good and updated strategy. If not, this has to be done immediately) Also the numbers in the financial evaluation area have to be sat. They should be sat such as it becomes a good spread of the R&D projects in the portfolio. The evaluation card should be updated periodically. To get the right result, it is necessary that all changes in the strategy or other relevant things get included. Also evaluation areas that is missing, or areas not needed, is necessary to update. Since the evaluation system should be adapted to the specific company to get the optimal results, the evaluation card that is proposed is just a basis, a starting point. The general evaluation card was viewed in section 5.6. (Statoil´s adapted evaluation card can be found in section 5.4)
- **STEP 1:** It is important that the decision-maker get the needed deep understanding of the project to be able to fill in the evaluation card right, and to get the opportunities and values related to each project up front.
- **STEP 2:** In this step the evaluation card is going to be filled out. Each project shall choose the statement that fits the most in each evaluation area. Also an estimate on the forecast should be filled into the card.
- **STEP 3:** After filling out the statement that fits the best, for all the areas, a total evaluation of the project must be stated. Each project is going to get a color; red, yellow or green, like a traffic light. A project is marked green if it is a good project or a project that is required to be conducted. A yellow project is a project the management needs to take a deeper look into. This project needs to be ensued and watched. Here, not everything goes according to plan, but it is not critical yet. A project that is critical and/or have severe faults should get the red color.
- **STEP 4:** When the whole evaluation card is filled out, it is time to use the gathered information. The card is an information display, and the whole purpose is to feed the decision-makers with information to be able to make the right decisions. An optimal R&D portfolio consists of optimal projects that fit together. This step is used to ensure that the projects are optimal, to find the interrelations between the projects and to find the right balance between the projects in the portfolio. The best balance method is to use the bubble-diagrams. The bubbles represent the color and the size of the bubble represents the forecast related to each project. The axes in the diagram can be chosen based on the different evaluation areas. Examples on this can be the probability for success against time

to impact, or innovation level. If a project has many opportunities, a decision tree can be used to view all the possibilities, to find the optimal path within the project.

- **STEP 5:** To be able to make the decision process easier to the decision-makers, the green projects is weeded out from the evaluation process across the different R&D portfolios. This is a project that is going to be included anyway. It is not necessary to look deeper into the project to see what is wrong or what can be done different, or should be discussed across the different R&D portfolios for prioritization and selection.
- **STEP 6:** The purpose in this step is to look deeper into the yellow and red projects, and discuss across the portfolios to find out where to place the resources right and which projects to cancel or set on hold. Must try to find the optimal projects with the right total balance. Have to see the total picture.
- **STEP 7:** In this phase the final selection is going to be done, and the total prioritization list is the result. This gives an overview over which projects to continue, which to set on hold, and which to cancel.
- **STEP 8:** In this last pre-phase the green projects are going to be investigated. These projects should be used as success-stories, and as projects the other can learn from. By comparing some of them, it can be possible to find similarities and factors that can be used by other projects to increase the probability for success. Due to the fact that we live in a dynamic environment, with rapid changes and a constantly search for new and better ting, much can still be learned.

The step 1 to 8 is an iterative process, used to find the optimal R&D portfolio over several periods. Each project is under development, new information is revealed and states are changed. It is important to perform an evaluation process periodically to have full control over the R&D portfolio all the time. Step 0 is performed when big changes are made in the company, or annually to find out what is best for that specified company.

5.8 RECOMMENDATIONS FOR THE MANAGERS

This thesis recommends the use of the Mürer Stemland R&D portfolio optimization model. There is a need for a common model and an evaluation card to be able to have a valid discussion on the same basis. There is a need to be able to evaluate, prioritize and select the right projects inside a portfolio and across the different sub portfolios, to obtain an optimal R&D portfolio. Included in the model, Statoil must use the evaluation card that is adapted to them.

Today, there exist too many different strategies in Statoil. The experiences are that the researchers always will find a strategy to be aligned with, and therefore a reason to continue

the development. It is recommended to update the corporate strategy more often. And to be more consistent in the use of what strategies that is the applicable.

Another issue regarding the strategy is that the main goal to produce above 2.5 million barrels of oil per day in 2020 is not a very long-term goal. This thesis recommends a goal further in the future. It is important to have a long-term goal to reach for, and rather have more short-term milestones along the way. To ensure the search for further improvements, and not become too confident with today´s results, a long-time perspective goal is needed.

Statoil uses a simple scorecard with part wise weighting at TDG 2 level. To use an evaluation method with weighting is not recommended in this thesis. This thesis recommends using a modified scorecard as an information display, as basis for a solid discussion, without weighting. The scorecard, used in Statoil, weights four out of seven elements, and produces a final score on each project. It becomes difficult for the decision-makers to take the elements that are not weighted seriously. It is easy to get blind in the score, and forget the others. There are different areas were a project can have its impact, and by use of only four elements that are weighted it is a possibility that important project, that can become a success, does not get an equitable chance to be evaluated on the right basis. The elements that are weighted against each other have been given different weights. It is important that these numbers become updated continuously to give the right output according to the present time. But if the weights are changed, the outputs cannot be used to compare different projects. The scorecard is executed as single-project approach, and gives no picture on the whole portfolio. This thesis recommends that the evaluation is executed as a portfolio approach.

Today the validity on the financial data in Statoil is too weak, and they are calculated or decided in too many different ways. This makes it impossible to compare, and use them in an evaluation process. One recommendation is to demand that these are calculated on the same basis. The estimates used in R&D projects will always be uncertain, but if the method is the same, there is at least the same basis to look at when finding data for discussion.

Since not all technologies or project have the opportunity to get a fulfilled value assessment, a fully STEA requirement for all the technologies and projects is not a recommendation in this thesis. This will only lead to resistance. But all technologies have the opportunity to draw a decision tree, and get the opportunities within each technology highlighted to be able to find the optimal path. This thesis recommends requiring a decision tree in each technology. But, all the technologies and projects that have the opportunity to estimate a value must do it. It is positive for each one of them if they manage to find a good NPV. The point is that it must be accepted that not all technologies have this opportunity.

Something missing in the TDP and in the knowledge of the responsible leaders is the IRR value. This value is important to get familiar with, to be able to see what the company gets in return for the money invested. It can also be used to distinguish small and large projects. In addition, since the NPV values are uncertain, it can be valuable to have more than one financial value to lean on when making the evaluation and prioritizations. The recommendation for the future is to include the IRR value in the TDP, and to use this in the evaluation card, together with the NPV value, when the time comes.

Something missing in the TDI process, but is included in the Stage-Gate model is the pre-stage; evaluation. This is important to be able to learn from finished technologies and projects, to find success projects, and to all the time become better in the work performed. The problem with not finding the success technologies and projects, are solved if the Mürer Stemland´s R&D portfolio optimization model is implemented. Then the green projects can be used as the successful ones to learn from. But the whole R&D process must nevertheless be evaluated. To be able to do this, it is recommended to include some kind of evaluation process in the TDI work process.

It has been revealed that Statoil can be tougher at the decision points during the development of a technology or a project. Today there is no system for cancellation of already started projects. Cancellations occur in Statoil, but not in a systematic way. This is often done outside the system, hidden from the rest. It is recommended that Statoil become more critical and consistent in the selection and prioritization process. To be able to do this, but still take care of the research and the ideas, there is recommended to establish and implement a backlog system. When a technology or project is cancelled or set on hold, it is placed in a safe for future R&D. This becomes like a bank of ideas and opportunities, and can be looked into in the future. The fact that a project is cancelled does not automatically mean that it is a bad project. It can be the timing or resources that are the problem. How this backlog system can be established and implemented can be a further research opportunity.

5.9 LIMITATIONS AND FURTHER RESEARCH

In addition to the limitations regarding the research methods mentioned in the methodology chapter 3.2, there are some limitation to the scope and configuration of this thesis that should be noted.

In the pre-study, literature review, there was a relatively comprehensive approach, where only the research within the topic of the latest years was included. The intention was to include the most salient work in the field so far. However, there is no guaranties that the selection is completely exhaustive, especially considering that there have been a lot of attempts to find a solution to this theme, and research have been done in generations. Further research can be to do a less comprehensive approach, and include older findings as basis for the theoretical approach.

Only the Norwegian Continental Shelf in industry history, environment and opportunities has been included. In terms of time constraints some prioritizations were made. Statoil is a Norwegian company. To reduce some of the necessary amount of background research to be able to focus more on the most important parts of the thesis, the international industry, environment and market opportunities, was excluded. Further research can be to examine the international industry, to find more market opportunities and possible priority areas to be able to succeed further in the global market. There may be new evaluation areas that should be included in the evaluation card that can give a good picture on what technologies or projects that can be valuable to take abroad.

There is proposed an evaluation card adapted to Statoil. A simplification of this has been borrowed and used at Statoil the last mount in a task from the top management, but the whole card has not been tested. There is also proposed a model that can help the general company, but the process has not been subject to empirical validation or verification. The hope is that researchers in the field start to focus on this result in the future.

In the conclusion, the main issues found are outlined. Some sub-set are further discussed in details, leaving other issues to the sections “recommendations for the management” and “further research”. Leaving some issues outside the scope on inquiry of the discussion might not give a complete picture to the reader, but in terms of feasibility and time constraints, some priorities were made.

Taking this limitation into consideration the hope is that the thesis still has novel value in the field and that the contribution is inspiring and might have an impact on how the R&D companies values their projects in the future.

6 CONCLUSION

Portfolio management for R&D projects focuses on what might be; new technologies and new projects. It is important to take care of the research. A lot of ideas must be tested, and they need to have permission to fail. Due to the uncertainty and difficulties related to R&D projects and the fact that it is future happenings, a company needs to have processes for evaluation, prioritization and selection to obtain an optimal R&D portfolio.

An optimal R&D portfolio consists of optimal R&D projects compatible with the other R&D projects in the portfolio. The synergies and interrelationships between the projects must be taken into consideration. The key is the right mix of projects to obtain maximum value, right balance and strategic alignment.

To find the optimal R&D portfolio, the company must implement a common portfolio evaluation method to be able to discuss and evaluate across the portfolios. The method, called an evaluation card, is a modified scorecard, without weighting, mostly used as an information display as basis for a a good and serious discussion. To be able to evaluate different types of projects in an equitable manner, each projects is given the opportunity to be showed off with the same starting point. The card consists of several evaluation areas selected in a way that all the most important factors in a company are highlighted. Each evaluation area have a set of associated statements, where the one that fits the most is going to be chosen. The evaluation card also consist of a total evaluation assessment, included a traffic light system where the projects are ranked from bad (red) to good (green) project, to indicate within which success rate the project lies. This makes it possible to know where to begin the evaluation and prioritization process, and to find and learn from the green success projects.

The evaluation card used to find the optimal R&D portfolio in a specific company has to be adapted because several important factors, like the company's goals and priorities, are unique. It is also necessary to look for information that already exists in the company, to make the system useful and less complex. Statoil´s evaluation card consist of the following evaluation areas; strategic fit and importance, value creation, customer alignment, time to impact, level of innovation, probability of success, HSE/License to operate and project execution. All the areas have adapted statements. Statoil´s final evaluation card can be found in chapter 5.4.

In light of the results derived from the research questions, this thesis has made the Mürer Stemland R&D portfolio optimization model. This is a model, consisting of eight steps, that gives a general company the opportunity to find their optimal R&D portfolio. A general evaluation card must be adjusted and adapted to the company before it gets filled out by the managers and will be used in the R&D portfolio evaluation, prioritization and selection processes. The model is presented in chapter 5.7, while the general evaluation card can be found in 5.6

REFERENCES

Archer, NP, and F Ghasemzadeh. "An integrated framework for project portfolio selection." *International Journal of Project Management Vol. 17, No.4*, 1999: 207-216.

Blichfeldt, Bodil Stilling, and Pernille Eskerod. "Project portfolio management - There´s more to it than what management enacts." *International Journal of Project Management 26*, June 2007: 357-365.

Chien, Chen-Fu. "A portfolio-evaluation framework for selecting R&D projects." *R&D Management*, 2002: 359-368.

Cooper, Robert G. *Product Leadership: Pathways to Profitable Innovation, 2nd edition.* Perseus Books, 2005.

—. *Winning at new products: Accelerating the Process from Idea to Launch, 3. edition.* Perseus Books, 2001.

Cooper, Robert G., Scott J. Edgett, and Elko J. Kleinschmidt. *Portfolio Management for New Products, 2nd edition.* Perseus Publishing, 2001.

De Wit, Bob, and Ron Meyer. *Strategy: Process, Content, Context, an international perspective.* Cengage Learning EMEA, 2010.

Gill, Paul. "Methods of data collection in qualitative research: interviews and focus groups." *British Dental Journal, Volume 204, NO 6*, March 2008: 291-294.

Harvey, A. Levine. *Project Portfolio Management.* San Francisco: Jossey-Bass, 2005.

Jeffery K., Pinto. *Project Management, Achieving competitive advantage, Second Edition.* New Yersey: Pearson, 2010.

LaBrosse, Michelle. "Project-Portfolio Management." *Project Management*, 2010: 75-79.

Luenberger, David G. *Investment Science, International edition.* Oxford University Press, 2009.

Meredith, Jack R, and Samuel J. Jr. Mantel. *Project Management, A Managerial Approach.* Wiley, 2012.

Mikkola, Juliana Hsuan. "Portfolio management of R&D projects: implications for innovation management." *technovation*, 2001: 423-435.

Myers, Michael D. *Qualitative Research in Business & Management, 2.edt.* SAGE, 2013.

Mürer Stemland, Kristin. "The value of R&D, A litteratur review, Pre-diploma work." *The value of R&D.* Trondheim: NTNU, Autumn 2012.

Newman, I, and C. Benz. *Qualitative-Quantitative research methodology: Exploring the interactive continuum.* Southern Illinois University Press, 1998.

Norsk Olje & Gass. *Norsk Olje & Gass.* 2013. http://www.norskoljeoggass.no/en/ (accessed April 2, 2013).

Norwegian Oil and Gas Association. *Environmental Report 2012.* Norwegian Oil and Gas Association, 2012.

Norwegian Petroleum Directorate. *Petroleum Resources on the Norwegian Continental Shelf.* Stavanger: Norwegian Petroleum Directorate, 2011.

Report to the Storting (White paper). *An industry for the future - Norway´s petroleum activities.* Meld.St.28, Norwegian Ministry og Petroleum and Energy, 2010-2011.

Statoil. "Corporate Technology Strategy." *Corporate Technology Strategy for Statoil.* Statoil, 2012.

—. "FR 12 - Technology Development and Implementation." Statoil internal document, February 2013.

Statoil internal website. *Statoil internal website.* 2013. http://www.entry.statoil.no (accessed February - May 2013).

Statoil. "Investment manual ." *Statoil´s Investment manual.* Statoil, 2012.

—. "Technology Development Plan." *Technology Development Plan for one new technology.* Statoil internal document.

—. *The Statoil book, version 3.0.* Statoil, 2011.

Statoil.com. *Statoil.* 2013. www.statoil.com (accessed April 5, 2013).

Trott, Paul. *Innovation Management & New Product Development, 5th Edition.* Prentice Hall, 2008.

Yin, R. K. *Case Study Research, Design and Methods, 3rd edition .* Sage Publication Inc., 2009.

APPENDIX

A. 1 INTERVIEW GUIDE

The interviewee:

- Name:
- Position:
- Years of experience:

Questions regarding optimization of a portfolio:

1) What do you think about when you hear the phrase; "optimal portfolio"?
2) How should the projects be to get allowed to be included in an optimal portfolio?
    - What criteria should be fulfilled?
3) Should portfolio optimization be conducted through a common model in the whole R&D department? Why?

Questions regarding evaluation, prioritization and selection:

4) Do you think single-project evaluation or portfolio-evaluation should be executed? Why?
5) Is it possible to evaluate an R&D project and portfolio, despite the R&D challenges?
6) Do you think the evaluation model should consist of several evaluation areas?
    - If not; which one?
7) Do you think both financial and non-financial evaluation areas should be included?
8) How do you define project success?
9) Have you ever heard about cancellation or stop of projects which were already approved or started in Statoil?

Questions regarding use of scorecard:

10) Who make decisions on selecting and prioritizing projects?
    i. Who do you mean should conduct the process?
    ii. Who is involved in the process today?
11) Do you think a scorecard should be weighted to give a final score on each project?
12) Do you think a scorecard should be an information display (as basis for a discussion)?
13) What is the best way of creating a good discussion?