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Content

Abbreviations

Abbr.	Meaning
A	Ampere
BNL	Byggenæringens landsforening
BREEM	Building Research Establishment's Assessment Method
CH4	Methane
CO_2	Carbone dioxide
CO_{2e}	Carbone dioxide equivalent
DNV GL	Det Norske Veritas Germanischer Lloyd
EGD	European Green Deal
EPCM	Engineering Procurement and Construction Management
EPD	Environmental Product Declaration
EU	European Union
FAME	Fatty Acid Methyl Ester
GHG	Greenhouse gas
GWP	Global warming potential
HFK	Hydrofluorocarbon
HPU	Hydraulic power unit
HR	Human Resources
HSE	Health Safety & Environment
HSEQ	Health Safety Environmental & Quality
HVO	Hydrotreated Vegetable Oil
IEA	International Energy Agency
IPCC AR5	International Panel on Climate Change Fifth Assessment Report
KW	Kilo watt
Kwh	Kilo watt hour
LCC	Life Cycle Cost
N2O	Nitrous oxide
NGO	Non-governmental organisation
NHO	Næringslivets hovedorganisasjon
NOK	Norwegian Kroner
NO_x	Nitrogen oxide
NSO	National Scheme Operator
PFK	Phosphofructokinase
PSS	Product-Service System
R&D	Research and development
RCP	Representative Concentration Pathway
SBTi	Science Based Target initiative
SF_6	Sulphur hexafluoride
SSB	Statistisk Sentralbyrå (Statistics Norway)
SWOT	Strengths Weaknesses Opportunities and Threats
UIS	University of Stavanger
UKGBC	United Kingdom Green Building Council
UNCC	United Nations Climate Change
US SIC	United States Standard Industrial Classification
V	Volt
WBCSD	World Business Council for Sustainable Development
WRI	World resource Institute

Abstract

Several of Norwegian building and infrastructure investors and developers has incorporated green construction requirements for their construction projects. Construction sites are required to use fossil-free or emission-free construction machines. The main contribution to emission for construction projects are the use of fossil fuel from transport, heating, and construction machines. For a heavy lifting cranes and specialized transport service provider, the emerging requirements for green construction methods create new challenges and opportunities for the business model.

This thesis project research what are the drivers for green construction requirements, the growth of these requirements and the trends for green construction technology. The project is based on a case study company in the heavy cranes and specialized transport service sector in Norway. The project reviews the current business model and discuss sustainable business model innovations for transitioning towards green construction. The project also discuss changes to the business model that may be necessary for a company to transition towards green construction solutions.

1 Introduction

1.1 Background

From the beginning of the 21st century, a paradigm shift has occurred in climate and energy policy and public opinion worldwide. This change in the political landscape has created a focused effort into dealing with global warming, climate change and the emerging energy crisis. The United Nations has initiated several initiatives to change the climate change policy on an international stage with contractual agreements such as the Kyoto protocol (UNCC, 2005) and the Paris Agreement (UNCC, 2016).

The result of international agreements from the United Nations and a focus on global warming, climate change and the energy crisis on a political stage worldwide has initiated ambitious goals to become carbon neutral in the foreseeable future. To achieve these goals, new regulations and procurement requirements have been incorporated to reduce GHG emissions.

The EU's European Green Deal is the new growth strategy and aim to set Europe on the path of transition to a climate-neutral, fair, and prosperous society, with a modern, resource-efficient, and competitive economy by 2050. The EU climate law with the "Fit for 55" package, EU aim for at least 55% reduction of GHG emissions by 2030 (EU Commision, 2021).

The Norwegian government has entered into an obligation under the Paris Agreement to reduce GHG emissions by at least 50% by the year 2030 compared to 1990 and implemented this into the updated Norwegian Climate Plan for 2021-2030 (Meld. St. 13, (2020-2021)). According to the National Transport Plan (Meld. St. 20, (2020-2021)) aim for 50% of all new lorries shall be zero-emission vehicles and goods distribution in the largest city centres shall take place with virtually zero emissions by the year 2030. The Norwegian national and regional governmental entities are large clients for infrastructure, building and civil construction. New regulations for public procurements for construction projects include the demand for green construction to reduce GHG emissions. In this context, the term green construction is used for both fossil-free and emission-free construction. Fossil-free construction use machines and equipment that do not emit CO_{2e} but allow for fossil-free alternatives such as bio-based fuel. Emission-free construction sites use machines that do not emit CO_{2e} or NO_X emissions at the construction sites, emission-free construction sites do not use bio-based fuel and rely only on power grid electricity, electric batteries, district heating, hydrogen power or other machines that do not emit CO_{2e} or NO_X.

Regional policies have increased their focus on requirement for green construction within the larger cities in Norway, and there has also been an development in research on green construction sites, (Fufa, et al., 2018; Fufa, et al., 2019; Davidsson, et al., 2018; Jul Røsjø & Kiil, 2018; Christoffer, et al., 2020; Andresen, et al., 2019). In 2016, Oslo Municipality set an ambitious goal of 95% reduction of GHG emissions by 2030 compared to 2009. To reach this goal, the Oslo Municipality aim for all construction sites within the municipality boarders to be fossil-free by 2025 and emission-free by 2050 (Oslo kommune, Klimaetaten, 2016). Stavanger and Bergen Municipality aim for all construction sites to be emission-free by 2025. Other municipalities have incorporated other similar obligations.

Several of Norwegian building and infrastructure developers has incorporated fossil-free and emission-free requirements in their procurement processes. Skanska, Veidekke, and Consto are some of the developers that are working towards greener construction sites. Norwegian construction sites are responsible for 3,3% of total emissions in Norway according to a report from Byggenæringens Landsforening (2019). The main contribution of this is the use of fossil fuel from transport, heating, and construction machines (Fufa, et al., 2018). Construction machines in this context is divided into

machines for ground preparations and machines for building processes such as mobile cranes, tower cranes and lifts.

Heavy lifting cranes maintain a central role in construction projects for material handling for most of the material and equipment used for construction. Heavy lifting cranes, such as mobile cranes, lorry cranes, tower cranes and other smaller lifting cranes is a vital part of the machines necessary for construction projects. These machines mostly use diesel fuel as the main energy source, but a focus on green construction processes have developed new machines on the market with alternative energy sources to reduce GHG emissions. For a crane and transport service supplier, this introduces new challenges and may lead to changes in the business model and supply network. This thesis project will take a closer look at business model innovation for crane and transport service supplier with a case study company.

1.2 Project challenge and description

The project is based on a case study of a Norwegian company that supply mobile crane and specialized transport rental services in Norway. The case study company is Crane Norway Group, a Norwegian cooperation company that supply heavy lifting cranes and specialized transport services within the Norwegian borders. The cooperation is comprised of several companies located at different locations in Norway, supplying the Norwegian market with mobile cranes and specialized transport. The company supply these services to all sectors that require heavy lifting and specialized transport services such as, construction, civil engineering, wind parks, petroleum onshore and offshore, and general heavy lifting and specialized transport projects. In 2021, the company had around 400 employees, 350 cranes and transport machinery, and had an annual turnover of 1 billion NOK. The author of this thesis project is currently working at the case study company as the engineering manager.

Mobile cranes and transport services is a vital part of construction site activities. The emerging market for fossil-free and emission-free solutions in this sector create new challenges and opportunities for a crane and transport service providers. Mobile cranes and transport units mostly use fossil-based diesel fuel. Many of these machines can run on biodiesel, such as HVO, this is however not standard. Typically, this must be specified by the client and with additional cost due to the higher price on biofuel. The price of the HVO diesel is approximately 60-75% higher than fossil-based diesel (Circle K, 2022). There is a development for electrically powered cranes and transport units, but the technology is relatively new. The cost for these machines is higher and there are new challenges and limitations to these machines. Electrically powered mobile cranes need access to the power grid or on-site electrical power supply and machines that run on batteries must be recharged with long charging time compared to refuelling time. Also, since the technology is relatively new, there are few options available for mobile crane type and sizes on the market with electrical power supply.

The challenge this thesis project address is what changes may be needed for the case study company as crane and transport service provider due to market changes because of the increased focus on green construction. What changes may the case study company need to its business model and supply chain when facing these changes in market demand. How may the case study company transition itself from traditional energy sources, mainly diesel-powered combustion engines, towards green construction solutions.

1.3 Purpose and scope

The purpose of this thesis project is to discuss sustainable business model innovations that may be required for a supplier in the heavy lifting crane and special transport sector in Norway. The scope of the project is to research the emerging trend with increasing requirement for green construction, with the focus on heavy lifting cranes and specialized transport. The requirements may come from regulations or from emerging market requirements downstream in the supply chain. This project will research the main drivers for this emerging trend and discuss possible continuous trend in the market demand for heavy crane and transport service suppliers.

The project will map out and describe the current business model of the case study company based on the business model canvas from Osterwalder and Pigneur (2010) and Richardson (2008). By describing the company value proposition, value creation and delivery, and value capture.

Further, the project will review current and emerging new technology for sustainable solutions, with the focus on current suppliers in the upstream supply chain for the case study company and a review of potential new suppliers that are developing solutions for green construction.

Finally, the project will discuss the possible business model innovations and changes that may be required to the case study company business model to meet the emerging requirements to reduce GHG emissions. The project will also discuss other possible sustainable business model innovations the case study company may introduce to become more attractive to clients, shareholders other stakeholders.

2 Methodology

This chapter present the research design and methodology used for this project. This will include describing rational for selection of research design, case selection and data collection procedures and data analysis procedures.

Choosing the research design and methodology is a vital part of the research project and set the basis for the collection of relevant data. The research design is the plan and the procedure for research that span the decisions from broad assumptions and detailed methods of data collection. This plan involves several decisions, the overall decision involves which design will be used to study the project topic. The selection of a research design is based on the nature of the research problem being addressed in the research project, the researcher's personal experiences and the audience for the study.

2.1 Structure/ research design

The methodology applied for this project started with a literature review of the major theoretical principles for this project. The literature review started with a search in the Oria database, the online library and research article database used by UIS students and faculty members. The literature search used the following keywords: Business model, Sustainable business model, Business model innovation, Green construction, and Emission-free construction.

For collecting data to evaluate the emerging demand for technology based on sustainable energy sources to the heavy lifting and specialized transport sector, this project has used a qualitative research and literature review. This approach has identified the main drivers for the demand for sustainable energy source technology and the emerging market requirements from public and private developers. The data is collected from public documents from the Norwegian government, research articles from search on Oria database and research reports on fossil-free and emission-free construction sites.

A market review of the downstream supply chain was conducted by reviewing the activity and requirements from a selection of clients of the case study company, and a market research to analyse the potential market for sustainable energy technology in the heavy lifting and specialized transport sector. This research is conducted by collecting data from public statements by clients and semi structured interviews with the relevant clients.

The review of the current business model has been conducted with a qualitative research method, using semi-structured interviews with key decision makers, author's own observations and document reviews from the case study company.

For the upstream supply chain, a review of the available and emerging technology is conducted by researching the activities from suppliers of heavy lifting cranes and specialized transport equipment. To collect relevant and up to date data, a review of the current technology is made by semi structured interviews with the main suppliers. The project has also researched other potential suppliers that develop technology for fossil and emission-free equipment and systems.

The project use SWOT analysis to review relevant parts of the business model. The purpose of the SWOT analysis is to discuss potentials for the sustainable innovation to the business model and to identify challenges that the company may face when transitioning into the rising demand for sustainable solutions in the lifting and transport industry.

2.2 Case study company

This thesis project is based on a case study of Crane Norway Group, a Norwegian cooperation that supply heavy lifting crane and specialized transport services. The cooperation is comprised of several companies located at different locations in Norway, covering the entire Norwegian market for mobile cranes and specialized transport. These services are supplied to all sectors that require heavy lifting and specialized transport services such as, construction, civil engineering, EPCM, wind power parks, petroleum onshore and offshore, and general heavy lifting and specialized transport projects. In 2021, the cooperation had around 400 employees, 350 cranes and transport machinery, and had an annual turnover of 1 billion Norwegian kroners. The author of this thesis project is currently working at the case study company as the engineering manager for Crane Norway Group.

The company has its origin from Stangeland Kran As established in 1979. During the expansion of the oil and gas industry in the 1980's the company grew to a cooperation company in the Norwegian heavy lifting and specialized transport industry. During this growth period, the company merged with almost 30 different crane companies in Norway. The cooperation consists currently of 8 different companies and has 22 offices and depots covering the Norwegian crane and transport market.

2.3 Limitations

This thesis project has viewed the cooperation, Crane Norway Group, as a single company. Although each company has their own speciality, this thesis project has considered all of them as one company. This is done because all of them use the same management system and work in cooperation without competition between them. The companies use the same systems for quality management, risk management, engineering, project management, and maintenance management.

There are a lot of different types of construction machines and specialized lifting equipment, but this project is limited to the discussion of technology trends within the current business model of the case study company. Only cranes and trucks related to the case study company is reviewed in this thesis project.

3 Literature review

3.1 Sustainable industry and green transition

In 1987, the United Nations Brundtland Commission defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”. This definition can be used for many different aspects of life, products, industries, and processes. Kibert (2007, p. 595) defined sustainable construction as how the construction industry together with its product, the “built environment”, among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants. Sustainability is not limited to just how we impact the environment. Although this is a large focus of this thesis, sustainability also includes how we impact society, economy, culture, and all aspects of life on this planet. The sustainable construction industry, with all its actors, must therefore consider the industry’s effect on its surroundings, and where each actor considers their own impact on its surroundings.

When considering sustainability in the construction sector, the boundaries of the supply network is quite extensive, especially when we consider the total lifecycle of a product. The extraction of raw material, manufacturing of products, transportation, assembly of products into buildings or structures, maintenance and replacement of systems, and disposal of waste, building systems, and finally the building structure. All these processes have their own challenges for sustainability such as, energy production and consumption, water consumption, waste, human health, local and global environmental impact, societal impact, financial impact and more.

A single actor in the industry may not have influence to change all aspects of an industry but will have influence in their surroundings in the supply network. It is therefore important for an actor in the industry to define the boundaries of influence in their supply network and the boundaries in their own production. This thesis project will only consider the boundaries of the case study company and single tier in the supply chain.

3.2 Sustainable business model

3.2.1 Business model

From a strategic framework perspective, the purpose of the business model is to explain new network- and activity system-based value creation mechanisms and sources of competitive advantage (Zott, et al., 2011, p. 1035). The logic from a strategy perspective is the execution of strategy to gain competitive advantage (Richardson, 2008). The business model should aim to be a framework for management to develop short- and long-term strategies for the firm and a source for further innovation and decision making.

A literature review by Zott, et al. (2011) revealed that scholars do not agree on a precise definition on what a business model is, the authors however found that common themes emerged among scholars of business models. Specifically, (1) the business model is emerging as a new unit of analysis; (2) business models emphasize a system-level, holistic approach to explain how firms “do business”; (3) firm activities play an important role in the various conceptualizations of business models that have been proposed; and (4) business models seek to explain how value is created, not just how it is captured.

Osterwalder and Pigneur (2010) describe a business model as a series of building blocks; the value proposition (product/service offering, client segments, client relationships), activities, resources, partners, distribution channels (i.e., value creation and delivery) and cost structure, and revenue

model (i.e., value capture). The business model is not the same as the business strategy, (Teece, 2010) rather it is a conceptual framework that link the firm's strategy to its activities or execution of the strategy (Richardson, 2008). The business model, as a framework for strategy execution, can be described as the correlation between value proposition, value creation and delivery, and value capture (Richardson, 2008). The business model framework, as described by Richardson, aim to provide a simple and logical structure for the strategist to think about how the many activities of the form work to execute the strategy.

The value proposition describes what the firm will deliver to its clients, why they will be willing to pay for it, and the firm's basic approach to competitive advantage. This is described through the firm offerings, target client, and the basic strategy to win clients and gain competitive advantage. The value proposition generally refers to the reason client will value a firm's (proposed) offerings, what the firm sells, and explicitly includes the intended client or target market (Richardson, 2008).

The value creation and delivery system describe how the firm will create and deliver the value proposition to its clients and the source of its competitive advantage. This is described through resources and capabilities, organization (value chain, activity system, and business processes), and position in the supply chain and supply network (links to suppliers, partners, and clients). It structures the organisation and architecture of the firm. It also specifies and describes the firm's sources of competitive advantages, its resources and capabilities (Richardson, 2008).

The value capture describes how the firm generates revenue and profit. This is described through revenue sources and the economics of the business (Richardson, 2008). The revenue model describes the sources of revenue or different ways that the firm receives income in exchange for products or services. The economic model covers the costs, margins, and various financial aspects of the firm.

This project will use the business model canvas from Osterwalder and Pigneur (2010) with the main elements from Richardson (2008) to describe the current business model of the case study company and to further discuss sustainable business model innovation that the company may need to develop in order to meet the emerging demand for sustainable solutions.

3.2.2 Sustainable business model and archetypes

While the business model explains how firms "do business", a sustainable business model incorporates a triple bottom line (TBL) approach that consider a wide range of stakeholder interests, including environment and society (Bocken, et al., 2014; Boons & Lüdeke-Freund, 2013). Bocken, et al. (2014) conducted a literature and business practice review to identify a wide range of examples of mechanisms and solutions that can contribute to business model innovation for sustainability. Through this work they introduced sustainable business model archetypes to describe groupings of mechanisms and solutions that may contribute to building up the business model for sustainability. These archetypes are: (1) Maximize material and energy efficiency (2); Create value from waste; (3) Substitute with renewable and natural processes; (4) Deliver functionality rather than ownership; (5) Adopt a stewardship role; (6) Encourage sufficiency; (7) Repurpose for society/ environment; (8) Develop scale up solutions.

The archetypes (Figure 3-1) are classified in three higher order groupings, which describe the main type of business model innovation: Technological, Social, and Organisational. The technological grouping includes archetypes with a dominant technical innovation component (for example manufacturing process and product design); the social grouping includes archetypes with a dominant social innovation component (for example innovations in consumer offering, changing consumer behaviour); the organisational grouping has a dominant organisational innovation change

component (for example changing the fiduciary responsibility of the firm) (Bocken, et al., 2014, p. 48).

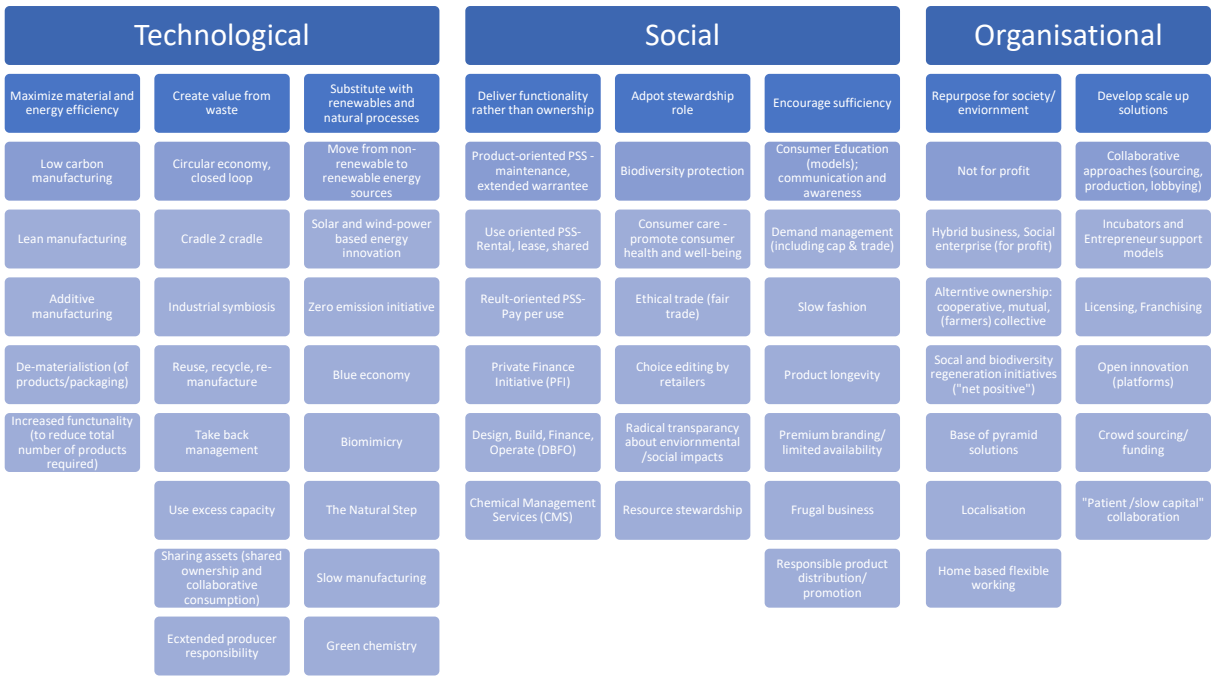

Figure 3-1 The sustainable business model archetypes (Bocken, et al., 2014, p. 48).

A sustainable business model can incorporate or focus on one or several of the archetypes in Figure 3-1 to create a sustainable business model. These archetypes are centred around value proposition, value creation and delivery as primary business model innovation. The concept of business model is an important tool for researchers as well as for practitioners to understand and to make progress towards competitive advantage and sustainable innovations (Boons, et al., 2013; Bocken, et al., 2014; Teece, 2010; Boons & Lüdeke-Freund, 2013).

3.2.3 Product-Service System (PSS) business model

The PSS business model is an emerging topic of study, driven by the desire to combine economic prosperity and sustainable resource management (Reim, et al., 2015). PSS are defined as a marketable set of products and services that are capable of jointly fulfilling clients' needs in an economical and sustainable manner (Goedkoop, et al., 1999; Tukker, 2004). In short, PSS business models provide both products and services to their clients. A PSS business model can fulfil clients' needs in an integrated and customized way, hence allowing clients to concentrate on core activities, build unique client relationships, enhancing client loyalty, and probably innovate faster since they follow their client needs better (Tukker, 2004).

An PSS business model should focus on selling functionality instead of selling products (Meier, et al., 2010). Meier, et al. (2010) made an analysis of 12.521 companies with over 100 employees from the OSIRIS database with US SIC codes 10-39 (from metal mining up to miscellaneous manufacturing) and compared the revenues of the firms. Those offering both products and services account for a major share of all revenues, while representing a much smaller share of firm numbers. Meier, et al. concluded in their analysis that companies that combine product and services offers lead to much higher revenue.

Reim, et al. (2015) suggest that PSS business models can be categorized by three distinct categories of business models: product-oriented, use-oriented, and result-oriented. In a product-oriented

category of PSS business model, the company, in addition to selling products, also commits to deliver a service related to the product. The value created for the buyer relates to the reduced work the client must do themselves and to reduce the number of suppliers. As a characteristic for this category, the focus remains mainly on selling a product, but it comes with extra services (Tukker, 2004). In a use-oriented category of PSS business model, the company does not sell a physical product but instead makes the product available under rental or leasing agreements (Tukker, 2004). The product, while still central, is not sold to the customer rather the use or availability is guaranteed for a certain period during which the company is paid periodically (Meier, et al., 2010). The ownership of the product in this case is not transferred to the customer, and the risks and responsibilities for the provider increase compared to product-oriented PSS business models (Reim, et al., 2015). In the result-oriented PSS business model, the company agrees to provide the client with a certain result or outcome rather than a specific product or service (Tukker, 2004). In this case, no specific product is necessarily involved, rather the company is totally responsible. The property rights stay with the company, and the client pays only for the agreed-upon results (Reim, et al., 2015).

The case study company is considered to have a use-oriented PSS business model by providing a specific service to clients where the focus is the machines used for the operations as well as the operational service provided by operators and project management.

3.2.4 SWOT analysis

SWOT analysis is a tool for strategic planning and for evaluating key features in a business or project. SWOT is an acronym that stands for Strength, Weakness, Opportunities and Threats. Strength and Weaknesses are internal factors, while Opportunities and Threats are external factors. A SWOT diagram analyses the business or project by focusing on each of these factors. It typically consists of four boxes, one for each area, but the exact layout may vary depending on the design of the scope. SWOT diagrams can be useful when trying to decide whether to embark on a certain venture or strategy by visualizing the pros and cons. By outliner positives and negative aspects. It can be a helpful tool when deciding how to move forward.

SWOT analysis should be used as a dynamic process for decision-making, it is a knowledge-based system developed mostly by brainstorming in the organization. It looks at present state and future possibilities for the organization. When used properly, SWOT analysis can help find the best match between environmental trends and internal capabilities (Chermack & Kasshanna, 2007, p. 388).

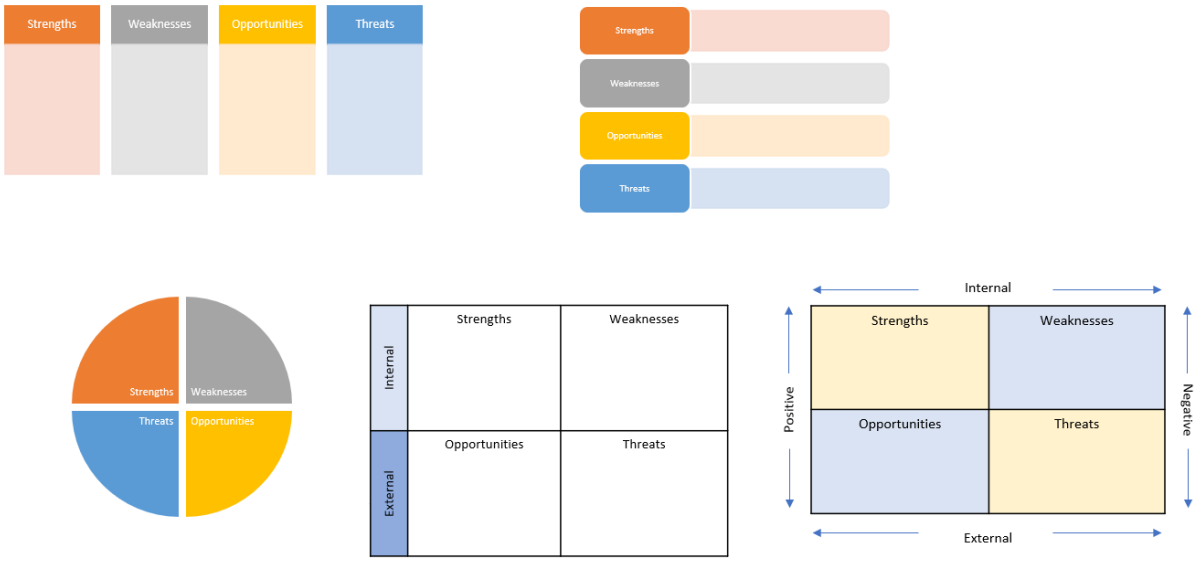

Figure 3-2 Examples of SWOT diagrams.

The first step is to identify the Strengths, these are the parts of the business that are doing well. These are the critical success factors, aspects of the business that are strong and give a competitive advantage. Recognizing these aspects may help the project to continue and find ways to leverage and build upon these strengths. The next step is to identify the Weaknesses, these are the factors that put the project at a disadvantage to the competitors. Figuring out what these weaknesses are and taking actions to lessen them before they hurt the business may be essential. This stage requires a detailed and candid analysis on what is going wrong in the business or within the organization. The next step is to identify the Opportunities that are available for the business or project. Pinpointing openings in the marketplace that can be taken advantage on to help the business grow or increase success factors of a project. These opportunities are caused by external factors such as market fluctuation, trends and so on. The Strengths and Weaknesses should be considered when assessing these opportunities. Not every opportunity is right for the business or project at the moment, but maybe not too far down the line. The last step is to identify Threats and how to respond to the threats to the business or project. Threats may be market fluctuations, governmental regulations, public perception and so on. These are all external factors that may affect the business or project in a negative way. Identifying these threats may lessen the effect or eliminating them when moving forward. The Strengths and Weaknesses should be considered when assessing the threats.

In the academic community there has been some concern about the value and use of SWOT analysis, these are mainly based on the lack of peer-review studies, research and the theoretical academic foundation of the SWOT analysis as well as its misuse (Hill & Westbrook, 1997; Chermack & Kasshanna, 2007; Helms & Nixon, 2010). Critics argue that the method creates a vague and over simplified result that is mostly based on opinion and subjective review and there are little to no strategic directions provided with the SWOT analysis (Helms & Nixon, 2010; Chermack & Kasshanna, 2007). Helms & Nixon also criticises the lack of clear methodology for quantification, weighing, ranking, or prioritizing. Chermack & Kasshanna (2007) and Helms & Nixon (2010) through literature review of case studies and research articles, discovered that there are some misuses of the SWOT analysis method, but it has some potential for practical use when used correctly. Some success factors for the SWOT analysis to be effective include:

- Define the objective of the SWOT analysis
- Include different parts of the organization for a wide perspective

- Provide an explanation of SWOT analysis procedures to participants
- Engage the group in dialogue and debate about the classification of each item
- Create an overview of the findings and give detailed description in a report
- Develop specific actions for moving forward
- Follow up on the actions and update the analysis with future developments

3.3 Green construction

Construction sites cause a lot of disturbances to local environment, such as noise pollution, and vibrations using heavy construction machines and construction equipment. Construction activities effect on-site work environment, the surrounding local environment, and local inhabitants. The Norwegian civil engineering and construction industry is responsible for approximately 1,2% of Norwegian total GHG emissions (Næringslivets hovedorganisasjon (NHO), 2016), and the on-site GHG emissions from construction sites represent around 5-10% of the total emissions from cities (DNV GL, 2019). The demand for green construction has been a growing demand ever since the Paris Agreement in 2016. For this thesis, the term green construction is used for all construction projects that aim for lower emission, fossil-free, and emission-free construction sites.

A clear definition of the terms fossil-free and emission-free is important for the continuous development of academic research as well for practitioner innovations. This thesis project will use the following definitions (Fasting, et al., 2017, p. 5; Davidsson, et al., 2018, p. 9; Fufa, et al., 2018, p. 9):

> *An emission-free construction site involves the use of energy sources that do not lead to CO_{2e} or NOx emissions the construction site. Emission-free options for heating include heating based on electricity, district heating and other energy carriers that do not lead to CO_{2e} or NOx emissions on the construction site. Emission-free options when using construction machinery include battery electric machines and electric machines connected directly to the power grid. When it comes to transportation, include emission-free alternatives battery electric or hydrogen powered trucks. In the longer term, it is also conceivable that it will develop other emission-free alternatives that will replace or may be in addition to the emission-free alternatives mentioned above.*
>
> *A fossil-free construction site involves the use of energy sources that do not emit CO_{2e}. In addition to those the emission-free alternatives mentioned in the section above include fossil-free alternatives using bio-based fuels, including pellets, bioethanol, biodiesel, HVO and biogas.*

CO_2-equivilant (CO_{2e}) is a term used for describing different GHG in a common unit. For any quantity and type of GHG, CO_{2e} signifies the amount of CO_2 which would have the equivalent global warming impact. GHG entails carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluor gasses (HFK, PFK and SF_6). The CO_{2e} unit is the equivalent CO_2 in a determined unit of measurement (typically in tonnes) in order to show how much global warming effect the gases has over a determined unite of time (typically 100 years). The above mentioned GHG has a much higher global warming potential (GWP) than CO_2, and emission of these gasses is therefore calculated to CO_{2e} to show the GWP (Fufa, et al., 2018, p. 9).

4 Industrial drivers, market research, and technology trends

The project has identified some of the main drivers for green construction and the demand for fossil and emission-free construction machines that are relevant for the case study company. The main drivers are international political agreements, trade agreements, national and regional policies and ambitions (Fufa, et al., 2018; Fufa, et al., 2019). As a subsequent result of these main drivers, the market has become a key driver for the implementation of green construction. Both public and private building and infrastructure developers are incorporating green construction into their requirements for contract awards (Fufa, et al., 2018). These main drivers are further reviewed in this chapter.

4.1 International political agreements

In 1992, The United Nations Framework Convention initiated the Kyoto Protocol (UNCC, 2005), it was adopted in 1997 and entered into force on 16. February 2005. The Kyoto Protocol committed industrialized countries and economies to adopt policies and measures on mitigation to accordance with agreed individual targets and to report on greenhouse gas emission.

During the United Nations Climate Change Conference in 2015, the Paris Agreement (UNCC, 2015) was negotiated and entered into effect on 4. November 2016. The Paris Agreement is a legally binding international treaty on climate change, where the parties agreed to reduce the global warming to 2°C compared to pre-industrial levels. The Paris Agreement provided a pathway for developed nations to assist developing nations in their climate mitigation and adaptation efforts, and it created a framework for the transparent monitoring, reporting, and ratcheting up of countries' individual and collective climate goals.

In December 2019, the European Union Commission presented the European Green Deal (EGD) (European Council, 2019), a new growth strategy aiming to set Europe on the path or transformation to a climate-neutral society. The European Council confirmed its commitment in December 2020 (European Council, 2020) to the EU's green transition, and in July 2021 the Commission presented the "Fit for 55" package, a set of proposal and initiatives with the aim to reduce CO_2 emission by 55% compared to 1990 levels, and to become carbon-neutral by 2050. The European Green Deal and the "Fit for 55" package was the framework for achieving the goals set by the Paris Agreement. The green deal "Fit for 55" package is a set of proposals to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU politics are in line with the climate goals agreed by the Council and the European Parliament. "Fit for 55" refers to the at least 55% emission reduction target which the EU has set for 2030. The EU is working on the revision of its climate, energy, and transport related legislation with the "Fit for 55" package in order to align current laws with the 2030 and 2050 ambitions (European Council, 2021).

4.2 Greenhouse Gas Protocol

The Greenhouse Gas Protocol Initiative is a multi-stakeholder partnership of businesses, NGOs, governments, and others convened by World Resource Institute (WRI), a U.S.-based environmental NGO, and the World Business Council for Sustainable Development (WBCSD), a Geneva-based coalition of 170 international companies. The GHG Protocol Initiative comprises two separate but linked standards, GHG Protocol Corporate Accounting and Reporting Standard and GHG Protocol Project Quantification Standard. (WRI & WBCSD, 2015)The GHG Protocol Corporate Accounting and Reporting Standard is used by companies worldwide for accounting and reporting of GHG emissions of their own production and activities. The standard use three scopes for companies to calculate emissions, the definition of these scopes is shown in Table 4-1 and Figure 4-1.

Table 4-1 GHG-protocol scope definitions (WRI & WBCSD, 2015).

Scope 1: Direct GHG emissions	**Scope 2: Electricity indirect GHG emissions**	**Scope 3: Other indirect GHG emissions**
Direct GHG emissions occur from sources that are owned or controlled by the company, for example emissions from combustion in owned or controlled boilers, furnaces, vehicles, et.; emissions from chemical production in owned or controlled process equipment.	Account for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.	An optional reporting category that allows for the treatment of all other indirect emissions. Scope 3 emissions are consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.

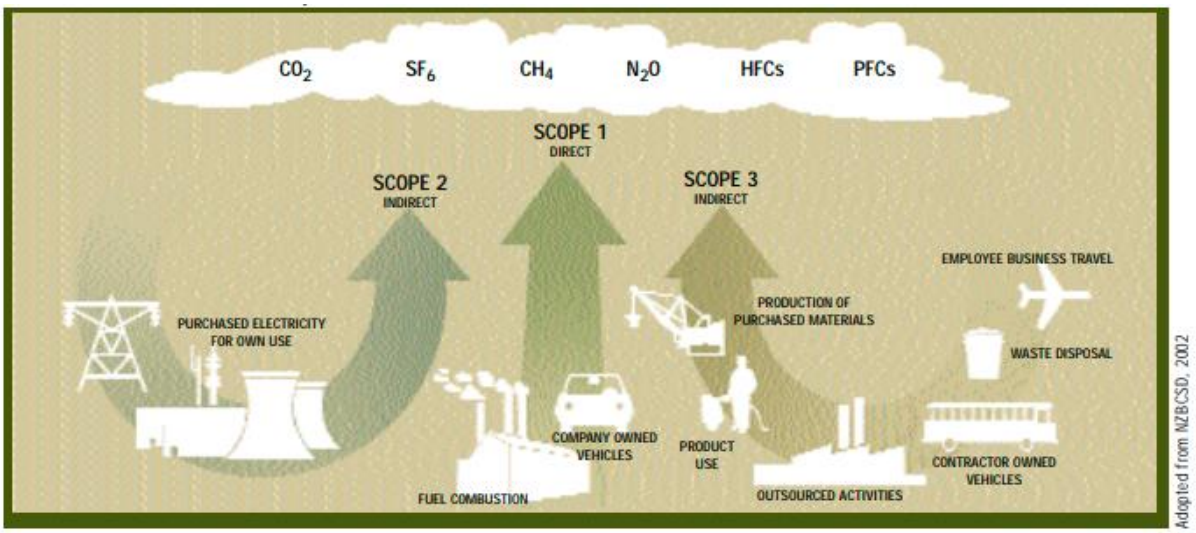

Figure 4-1 Overview of scopes and emissions across a value chain (WRI & WBCSD, 2015, p. 26).

4.3 National, and regional ambitions

The Norwegian government has implemented their own ambitious goals to become a sustainable, fair and prosperous society. These goals are a result from the Paris Agreement and the cooperation with the EGD. Through the National transport plan (Meld. St. 20, (2020-2021)) and Climate plan (Meld. St. 13, (2020-2021)), the Norwegian government have put in place a substantial plan to reduce the environmental and societal impact of activities within the Norwegian boarders. The National transport plan is produced every four years and sets forth the Government's transport goals, strategies and priorities in a long-term perspective. Among these goals, the National transport plan aim for 50% of all new lorries to be zero-emission vehicles, and that all goods distribution in the larger city centres shall be virtually emission-free by 2030 (Meld. St. 20, (2020-2021)). The Climate plan aim for all emissions related to sectors not subjected to quotas, such as transport, agriculture, and construction, shall be reduced with 45% by 2030 relative to emission levels of 2005. A report developed by Byggenæringens landsforening (BNL) (2019), concluded that the Norwegian

construction sector is responsible for around 2 million tonne CO_{2e}. This is approximately 3,3% of total GHG emissions in Norway. The National climate plan will also introduce climate requirements in all public procurements in civil engineering and construction. The government aim to facilitate for construction sites to be fossil-free by 2025 (Meld. St. 13, (2020-2021)).

The four most populated municipalities in Norway have introduced their own ambitious goals to reduce GHG emissions through climate strategies and regional policies. These municipalities represent some of the largest developers in Norway in construction projects with development of new infrastructure projects, public building projects and urban development projects. This project has reviewed these municipalities goals and ambitions for green construction sites and other general activities within their borders. An overview of the goals and ambitions from these municipalities is showed in Table 4-2.

Table 4-2 Regional goals and ambitions in Norway's four largest municipalities.

Municipality	Goals and ambitions	Reference
Oslo	The Oslo municipality climate strategy aim for a reduction of GHG emissions to be reduced by 95% by 2030, compared to emission levels of 2009. Among the many goals set in the climate strategy, Oslo municipality aims for all goods distributions in Oslo to be emission-free, and all heavy transport shall be fossil or emissions free by 2030. All construction sites will be fossil-free from 2021, and emission-free by 2030.	(Oslo kommune, Klimaetaten, 2016)
Trondheim	The Trondheim municipality climate plan for 2017-2030 aim for all direct GHG emissions is reduced with 30% by 2023, and with 80% by 2030. All construction sites will reduce GHG emissions with 80% by 2030, based on 1991 levels.	(Trondheim kommune, 2017)
Bergen	In march 2021, the city council decided to update the climate strategy from 2016, with the overall aim to become virtually emission-free by 2030. It is expected in the new strategy plan, the municipality will have higher ambitious goals than the previous strategy plan from 2016.	(Bergen kommune, 2021)
Stavanger	The Stavanger municipality climate plan for 2022-2026 aim for all direct emissions of GHG from building and construction sites will be reduced with 80% by 2030, based on 2015 levels, and with 100% by 2040. All construction sites in Stavanger city will be emission-free by 2030, and in within. All municipality owned construction sites will be fossil-free by 2021, and emission-free by 2025. All emissions directly from transport will be reduced with 80% by 2030, based on 2015 levels, and 100% by 2040. GHG emissions from heavy transport will be reduced with 20% by 2030, and 100% by 2040.	(Stavanger Kommune, 2021)

These goals and ambitions may change as the policies changes due to political changes and from the result of learning experiences within and between the municipalities. Other municipalities may also follow this trend as the market adapt to these changes and the price of green construction reduces. However, municipalities with less urban environment, lower population density and lower budget may not follow this trend and will weigh the cost of development projects higher. For some municipalities, green construction may only be applicable when it is deemed more cost effective than traditional construction methods.

The goals and ambitions in the larger Norwegian municipalities may have a profound effect on climate strategies for private developers and contractors as much of these activities are based in these municipalities. Private developers and contractors may need to adapt similar goals and ambitions to their company policies to get new development projects approved, and to win contracts through public procurements.

A major part of the Norwegian governments plan to contribute to sustainable innovation and sustainable technology development is through financial and capital support. Financial and capital support organisations such as Innovasjon Norge, Enova, Forskningsrådet and others provide competence, advisory services, promotional services, network services and financial support for innovative development projects. Innovation Norway and Forskningsrådet provide expertise and financial support for innovation projects that develop sustainable solutions. Enova provide financial support for companies that invest in emission-free transport and construction machines, where they can contribute to a lower investment cost. These support organisations are vital drivers towards sustainable innovation and development projects.

4.4 Construction sector market as driver

The market has also become a main driver for the requirement of fossil and emission-free solutions in the Norwegian construction sector. This project has reviewed the climate ambitions, goals, and policies of several of Norway's larger contractors and the case study companies' larger clients in the construction sector.

Table 4-3 Review of climate ambitions, goals, and policies in the construction sector market.

Company	Role	Climate ambitions, goals, and policies	Reference
Veidekke	Contractor	Veidekke has set a goal of reducing CO2 emissions by 50% by 2030 and aims to achieve climate neutrality by 2045. The ambition is to cut GHG emissions from both its own business and value chain to a net zero before 2045. Veidekke has committed itself to setting climate goals that are verified in accordance with the Science Based Target initiative (SBTi). Veidekke climate targets are based on scenario RCP 2.6, IPCC AR5, which limits the global temperature increase to well below 2°C.	(Veidekke, 2021) (Veidekke, 2021)
Skanska	Contractor	Skanska has set a goal of reducing GHG emissions with 50% by 2030 and to become climate neutral by 2045. Skanska measure their emissions by the GHG-protocol and has committed itself to include all three scopes in the GHG-protocol.	(Skanska, 2021)
HENT	Contractor	HENT has committed to a long-term goal of becoming climate neutral by 2045, and intermediate goal of reducing GHG emissions with 50% by 2030 and 75% by 2040. HENT will use annual target goals to reach these strategic long-term goals. HENT use all three scopes in the GHG-protocol for calculating GHG-emissions.	(Hent, 2021)
Contiga	Building material supplier	Contiga is part of the Heidelberg Cement group and is committed to the "Sustainability commitments 2030" in the Heidelberg Cement group. Part of the "Sustainability commitments 2030" is to reduce the	(Contiga, 2022) (HeidelbergCement group, 2020)

		supply and transport related GHG emissions of their finished products and to support the decarbonation of relevant industries along the whole value chain and increase alternative fuels rate to 43% by 2030.	
Consto	Contractor	Consto uses the "Veileder for tilrettelegging av fossilfrie og utslippsfrie løsninger på byggeplassen" from DNVGL (2018), and aim for all construction sites to be fossil-free by 2025.	(Consto, 2021)
Optimera	Contractor and building material supplier	Part of Optimera's sustainability policy state that they will use transport solutions with lowest possible emissions, supply building materials that contribute to reduced energy consumption, ensure that their products does not contain environmentally hazardous chemicals and sort 80% of waste at source.	(Optimera, 2020)
Kruse-Smith	Contractor	Kruse-Smith Environmental policy commit the company to comply with all environmental requirements and obligations set by laws, regulations, contracts, and other rules that govern their activities. The policy also commits the company to monitor their environmental impact and work to reduce their impact.	(Kruse Smith, 2021)
Mesta	Contractor	Mesta climate ambitions are to reduce CO2 emissions with 50% by 2030, reduce waste with 20% by 2030, and 50% of all new vehicles will be electrical by 2025.	(Mesta, 2021)
Statens vegvesen	Developer	Statens vegvesen aim to reduce GHG emissions with 50% for all construction sites and 50% of all other activities by 2030. Statens vegvesen will require Environmental Product Declaration (EPD) for all procurements of concrete, steel and asphalt. In several of new climate pilot projects, Statens vegvesen will add a bonus in the contracts for materials that has EPD and the use of emission-free construction machines.	(Statens vegvesen, 2021)
OBOS	Developer	By 2019, will all new building projects be planned with BREEM-NOR certification and OBOS aim to reduce CO2-emissions with 45% from new development projects by 2026.	(OBOS, 2021; 2019)

The review of ambitions and goals from a selection of developers, contractors and building material suppliers show that the market is at an agreement on reducing GHG emissions and the importance of having a sustainable business model. Key milestone periods are 2025, 2030, 2045 and 2050, where the ambition level is increasing for each milestone period. It is therefore important for suppliers in the value network to implement strategies to meet the growing market requirements. If these companies listed in Table 4-3 are to meet the set ambitions and goals, they are reliant on having suppliers and subcontractors that incorporate similar sustainability innovations.

4.4.1 BREEM-NOR

BREEM (Building Research Establishment's Environmental Assessment Method) s an internationally recognised measure and mark of a building's sustainable qualities. BREEM launched in 1990 and has been used in more than 70 countries around the world. BREEM certified buildings are planned, designed, constructed, and operated in accordance with the best-practice sustainability principle. BREEM use independent licensed assessors to review the building project with issues such as energy and water use, health and wellbeing, pollution, transport, materials, waste, land use ecology and management processes. Buildings are rated and certified on a scale of "Pass", "Good", "Very Good", "Excellent", and "Outstanding" (Grønn Byggallianse, 2019).

BREEM is managed and developed by BRE Global and supported in certain countries by National Scheme Operators (NSOs). In Norway, Grønn Byggallianse is an NSO, whom is an independent organisation that has developed BREEM-NOR, a country specific local schemes that is affiliated to BREEM. BREEM-NOR is the Norwegian adaptation to BREEM and is widely used in Norwegian construction projects for new buildings and renovation projects. A BREEM-rating enables clients and other stakeholders to compare a building's performance with other buildings with BREEM rated at the same life cycle stage of assessment. The ratings are based on a total scoring of the building project, where the use of fossil-free or emission-free technology during construction is a contributing factor to achieving high BREEM rating (Grønn Byggallianse, 2019). For ambitious project this is central to achieving the top ratings.

Developers have several incentives to comply with the BREEM certification because these projects reduce risk for investors and will ensure cost savings during the lifespan of the building. Sustainability activities include resource efficiency, waste management, and energy efficiency. BREEM certification influence brand recognition for developers with social responsibility and focus on positive reputation. According to a report from the UK Green Building Council (UKGBC, 2018), tenants are more likely to pay more when the building are BREEM certified, and there is an increase in financial support for projects with environmental and social factors. These sustainable and responsible projects attract customers and investors that value sustainability and environmental effect higher.

As a supplier of lifting and transport services to the construction industry, the case study company must be able to supply services with fossil-free and emission-free solutions. The company has currently good opportunities to supply fossil-free solutions with biofuel, but there will be an increase in the demand for emission-free solutions for construction projects. Hybrid and electrical cranes and trucks may soon be a high demand from customers who require emission-free solutions.

4.5 Influence from other sectors

Although there is a clear development in the demand for green construction sites, the case study company have several clients in other sectors than construction and civil work. It is therefore important to look at the fossil and emission-free requirements in other sectors that require heavy lifting cranes and specialized transport.

This project analysed the sales distribution among the different sectors the case study company had between 2017 and 2021. The analysis use sales from each client company then categorizing the client company into sectors such as (1) Oil & gas, (2) EPCM, (3) Construction, (4) Marine, (5) Shipping & transport, (6) Energy, (7) Recycling, (8) Industrial production, (9) Other. The analysis was limited to the top 81% of the case study company's largest clients in this period. The analysis excludes sales of older machines because these are not relevant to this analysis. Although sales of older machines are revenue to the company, these are often replaced by purchase of new machines. The analysis also

excludes internal rental between the companies in the cooperation because these rental sales is considered revenue to one company but expenses to the sister company in the cooperation.

The analysis shows that the top rating sectors the case study company had in this period was construction, oil & gas, and EPCM (Engineering, procurement, and construction management). These sectors result for 78,8% of all sales and can influence the case study companies' strategy and processes. The construction sector result for 41,2% of all sales, this category includes all activities in the supply chain of construction from transport of building materials and lifting at construction sites. Oil & gas sector result for 17,9% of all sales. EPCM sector result for 19,7% of all sales, this category includes all client companies that work with engineering, procurement, construction, and management of projects most of these are oil & gas service providers, but also include service providers to other sectors such as marine operations and offshore wind power. The analysis was not able to divide this category into these separate categories.

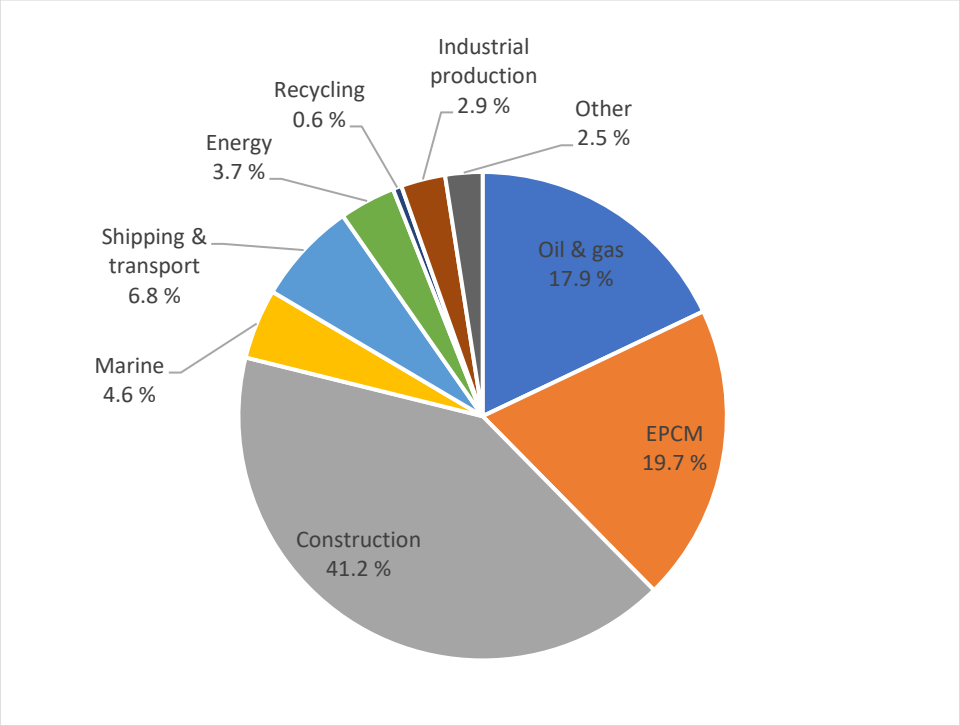

Figure 4-2 Sales distribution case study company 2017-2021

This thesis project has reviewed the sustainability or climate action plan of some of the larger clients in oil & gas and EPCM the case study company had in this period. The result of this review show that the clients plan to include or increase the emission requirements for suppliers. It is however uncertain if these requirements will affect the case study company in short term, but it is likely that these requirements will affect the company at a later date. According to Equinor sustainability report from 2020 (Equinor, 2020), Equinor's sustainability ambitions include reduction of GHG emissions in their processes, investment in renewable energy production and further development in carbon capture technology. The sustainability report shows an intent to work with partners and suppliers to provide carbon efficient services, but it is uncertain when or if emission-free or fossil-free construction machines will be required by their lifting and transport suppliers. The EPCM company Aker Solutions have a different approach to their Climate action plan. According to their Sustainability report from 2021 (Aker Solutions, 2021), the Climate action plan show that supplier framework agreements will be revised in 2023 to include emission requirements and by 2030 Aker Solutions aim to reduce CO_2 emissions by 50%. There is however no mentioning of emission-free or

fossil-free requirements for construction machines such as lifting and transport services. These companies in the oil & gas and EPCM sector highlight their effort in investment and technology development in renewable energy, electrification of operational processes, and carbon capture technology.

4.6 Technology trends

4.6.1 Biofuel cranes and trucks

Biofuel is liquid or gas combustion fuel that is produced from biological material, often called biomass. Biomass is renewable organic material that comes from plants and animals. It is common to distinguish between conventional and advanced biofuel depending on the source material or production method. Conventional biofuel is produced from materials that can also be used in food production, also called 1st generation biofuel. Advanced biofuel is mainly produced from waste material that cannot be used in food production, also called 2nd generation biofuel (Miljødirektoratet, 2021). There are several types of biofuel, such as bioethanol, bio-nafta, FAME (fatty acid methyl ester), HVO (hydrotreated vegetable oil), and biogas. FAME and HVO are biodiesel, that can also be combined with petroleum-based diesel.

Biofuel is not emission-free, but a fossil-free alternative, and is considered a temporary solution in the transition from diesel powered machines in road transport and construction to emission-free alternatives. The use of biodiesel technology may be considered a better alternative when there are little to no development in emission-free technology. Biodiesel has the benefit of using the same infrastructure as regular diesel and most of engine manufacturers allow the use of biodiesel without any modifications for newer engines.

Norwegian regulations on use of health and environmental hazardous chemicals and other products regulate the amount of biofuel that is required to be distributed. Those who sell fuel must ensure that a minimum amount by volume of the total amount of fuel sold for road traffic per year consists of biofuels, excluding biogas. (Produktforskriften, 2004). This minimum requirement started in 2008 in Norway and started at 2%. It has since increased and in 2021 it was 24,5%. Distributors mix biofuel with conventional fuel to meet these requirements in addition to selling biodiesel such as HVO and FAME. The global demand for biofuels is expected to grow by 28% over 2021-2026. Government policies are identified as the main driver of the expected growth, but other factors such as overall transport fuel demand, costs and specific policy design influence where growth occurs and which fuels grow quickest (IEA, 2021). The price development of biofuels has long been linked to the development of crude oil price, but this changed around 2017 (SSB, 2017). According to IEA (2021) the price of biofuel increased by between 70% - 150% across the United States, Europe, Brazil, and Indonesia, depending on the market and fuel, from average 2019 prices. While crude oil prices increased by 40% over the same period (IEA, 2021).

There has been a development in the last five years in the use of biodiesel in mobile cranes. Some of the crane manufacturers did not allow for the use of biodiesel in their engines due to warranty issues, but this has changed. Initially there was a concern that the biodiesel did not have enough lubricating effect in the diesel engine, but this is no longer a concern. All cranes and trucks with Euro 5 and Euro 6 class engines can now use biodiesel as well as petroleum-based diesel. Some crane manufactures, such as Liebherr have even begun filling their new machines with biodiesel during manufacturing.

Truck manufacturers such as Scania and Volvo allow the use of HVO biofuel in their Euro 5 and Euro 6 class engines. Within the transport sector, biofuel can be used immediately to reduce GHG emissions

and contribute to fossil-free construction. The Pathways Study (Scania, 2018) initiated by Scania concluded that achieving a fossil-free commercial transport system by 2050 may be possible and financially attractive from a societal perspective. Biofuels offer the highest CO_2 emission reduction and electrification is the most cost-effective according to the study from Scania.

Lifting and transport companies can therefore supply cranes and trucks with biodiesel, but they do this only on request from clients at the present. Due to higher price for biofuel compared to petroleum-based fuel, it is not deemed competitive viable to use biofuel unless clients are willing to pay for the cost difference. However, if the price difference between biodiesel and petroleum—based diesel reduces, there may be a competitive advantage by converting to biodiesel. With higher taxes on petroleum-based fuels and more production of biodiesel, this may be the case in the future.

4.6.1 Battery power

Electrically powered cranes and trucks are mostly limited to the power supply. Where trucks require batteries, cranes can use power grid or external generators for power supply. The development of battery technology has been driven by the electric car industry. According to Bloomberg NEF's annual battery price survey (2021), the price for lithium battery packs has been declining for the last decade. The price for lithium battery packs was above $684 /kWh in 2010 but have fallen to $132 by 2021. The survey conclude that the price may continue to fall but the rate is uncertain due to constraints within global supply chain and rising demand, however companies such as Renault and Ford have publicly announced price targets of $80 /kWh by 2030.

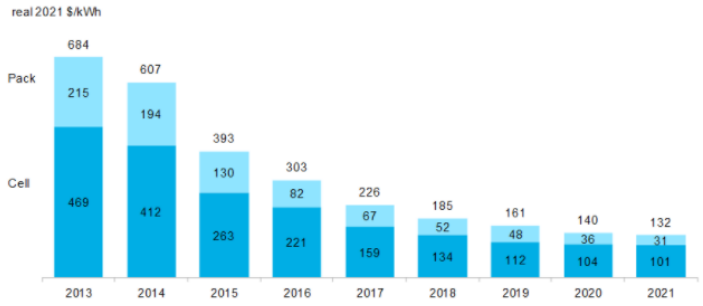

Figure 4-3 Battery price (BloombergNEF, 2021)

Predicting the price development for batteries and battery powered machines is uncertain. The fallen battery prices have made early investment in battery powered machines costly up until now. Prediction in future battery prices suggest that investment cost will not decrease significantly in a short-term perspective, one to five years.

4.6.2 Hybrid electric cranes

Cranes with more mobility such as mobile cranes, crawler cranes and truck mounted cranes mostly use diesel powered internal combustion engine as their main power source. These cranes are typically used at sites and facilities that need more mobility or low operation time. These types of cranes can move without limitation to existing infrastructure such as rail tracks, structures, or access to the power grid. Cranes with more mobility are often used for single lifting operation projects before they are moved to the next project site. This mobility requires an energy source that is equally mobile, and diesel power have been the most efficient and cost-effective method.

For mobile cranes, crawler cranes and truck mounted cranes to maintain their mobility these machines need a power supply that is equally mobile. It is not possible for these machines to only use power from the power grid or any other external power supply. If cranes are to become emission-free, battery power may be a viable solution. There are currently no fully electric mobile

cranes on the market, but there are some hybrid solutions on the market. Tadano has developed an external electro-hydraulic power unit (HPU) featuring an integrated 32kW electric motor, which is intended to connect to 400V outlet with 63A or 32A (Tadano, 2021). This unit can be plugged into a conventional mobile crane at the jobsite. The crane will need to drive to the jobsite with the internal combustion engine, but once it is positioned it can switch to fully electrical power and not use the internal engine to power the hydraulics. This unit is currently only usable with crane size up to 80 tonne lifting capacity, which is relatively small for construction sites. Mobile cranes and crawler cranes are rated by their maximum lifting capacity. In an interview with a Tadano sales manager, Tadano is developing larger external HPU's that is designed to be used for larger cranes. These units are not currently on the market but is expected to be released by 2023.

4.6.3 Fully electric cranes

Electric cranes have been around for a long time, but only some types of cranes have utilized electric power. These cranes have typically low mobility such as gantry cranes, tower cranes, harbour cranes and alike. These types of machines have a long operation time at their respective job sites, allowing them to use local infrastructure and electrical power from the power grid. A gantry crane inside a building will have access to the power grid and will not be moved from one construction site to another. Harbour cranes are similar but are located on a quay for loading and off-loading cargo vessels. These are typically installed on a rail track and have a fixed mobility range. Tower cranes on the other hand is often moved from one construction site to another, but these are used at construction sites that need crane service for a long period, such as several months.

Liebherr launched their first battery powered crawler crane in 2020, the Unplugged series (Liebherr, 2021). The first crane Liebherr launched was the LR1250.1 Unplugged, which is driven by an electric motor with a power rating of 225kW. The crane has a battery power pack that can be recharge in 4 ½ hours or 2 ¼ hours depending on the power supply. The capacity of the battery is designed for 4 hours lifting operation when it is unplugged, or it could be plugged to a power supply for continuous operations. This type of machine may be a viable option for construction sites that lower requirements for mobility at the construction site and have access to local electric power supply. The machine is unlikely to operate at remote sites without electrical infrastructure and access to the power grid unless the machine is powered by a generator.

Comparing to mobile and crawler cranes with traditional internal combustion engines, cranes usually have an engine power of 200-500 kW depending on the size of the machine. The existing hybrid or fully electrically powered solutions are not readily available for all crane sizes and types. Many jobsites do not have the required infrastructure to supply electrical power to the cranes, such as new wind turbine projects, new road projects, and early-stage construction sites. The current battery capacity is in many cases not sufficient for the power demand that these machines need to complete a project that lasts for more than a day's work. The Liebherr Unplugged cranes are lattice boom crawler cranes that in most cases require assistance from a mobile crane or similar for assembly at the job site, these cranes also need several trucks to transport the crane parts. Since there are no mobile cranes that can operate on zero emission technology, it is not practical to execute a project with zero emission when we look at the total scope of the project with mobilization of equipment, assembly at the jobsite, execution of all the operations during the project, disassembly, and demobilization of equipment. With this solution, crane companies are still reliable on diesel fuel. However, with the use of biofuel and electrical power, projects can be fossil-free. It is likely that mobile and crawler cranes will develop further, and more options will likely be available in the foreseeable future. The technology is available, but the products are not readily available on the market.

4.6.4 Hybrid electric trucks

In the transport sector, there has been more development in the use of electrically powered trucks. Options such as hybrid and fully electrical solutions. Hybrid electrical trucks use a combination of battery powered electrical engine and diesel-powered engine. For transport with a combination of urban and rural environment, this solution can provide an emission-free solution when the truck drive with the electrical engine and deliver reliability and range with the use of the diesel engine.

Hybrid trucks can use plug-in technology, where the battery pack may be recharged from the power grid when standing still as well as recharge with the onboard diesel engine. With new procedures and required infrastructure, trucks can be recharged at every location where it is stationary. If infrastructure is available, trucks can be recharged when the truck driver has their regulated resting time, during loading and unloading, and when the truck is parked at the end of the shift. The combination of electrical power and diesel fuel can reduce GHG emissions and noise emissions. According to Scania, hybrid trucks thar use biodiesel can reduce CO_2 emissions by 90% compared to fossil-based diesel.

4.6.5 Battery electric trucks

Fully battery electric trucks are readily available on the market, but with some operational limitations such as transport range and load-capacity compared to fossil-based diesel trucks. Volvo and Scania have developed a range of electric trucks that are mostly designed for urban environments but are also developing long range electric trucks. Volvo estimate that by 2030 50% of all Volvo trucks sold in Europe will be electric, using their battery or fuel cell technology (Volvo, 2022).

The battery-powered electric trucks available on the market do not have the required load-capacity and range to completely replace diesel-based trucks for long range heavy haulage transport. The case study company use their trucks to transport many different types of cargo. However, the company transport a lot of mobile crane parts and concrete elements for the construction industry. These transports are usually done with tractor-based trucks with semi-trailer and a load-capacity of 30 tonnes. There are no readily available options with battery-powered trucks for these transport operations. For urban transport with less weight requirements, there are several options available from most of the truck manufacturers.

The fully electrical trucks available on the market is mostly designed for urban environments. The benefit of electrical trucks are they have low noise emissions and are emission-free. They can be operated in zero-emission zones or at hours of the day where diesel trucks have restricted access. Just as the hybrid electrical trucks, these can be recharged every time the truck is stationary. With a developed charging infrastructure, these trucks can be recharged when the driver has their required resting time, during loading and unloading, and when the truck is parked at the end of the shift. When the charging infrastructure develop further, electrical trucks will have more flexibility. Fully electric trucks will develop further and truck manufacturers such as Volvo and Scania are developing new electrical trucks with longer range and more load-capacity.

5 Review of current business model and state of practise

The case study company does not have a formal description of its business model related to the literature review of this thesis project. The current business model is a result of developed practices and not a result of business model analysis or study as described in academic studies discovered in the literature review. This project has reviewed the practices of the case study company and developed a description of the business model. The current business model is described using the business model canvas from Osterwalder and Pigneur (2010). Osterwalder and Pigneur present a blank canvas that organisations can use to describe their business model. This gives a clear understanding of the layout of the business model and the relationship between elements.

5.1 Business model canvas

The business model canvas of the case study company presented in Figure 5-1 has been developed for this thesis project by reviewing the current practices. The canvas is divided into these elements: Key partners, Key activities, Key resources, Value proposition, Customer relationship, Channels, Customer segments, Cost structure, and Revenue stream.

The business model canvas can be used as a strategic management tool for developing new business models, document existing models, and for innovating and exploring new opportunities. Key partners describe the main partners in the supply chain and the processes the business outsource to others. Key activities are the processes company execute to create the value proposition. Key resources are assets the company use to sustain and support the business. Value proposition is what the company provide to its customers. Customer relationship is the relationship the company has with its customers. Channels describe how the company deliver the value proposition to its customers and the communication method used to reach customers and receive sales. Customer segments describe the customers the company work with and deliver the value proposition to. Cost structure is the company's operational costs. Revenue stream is the company's income from asset sales, rental agreements, service sales, and product sales.

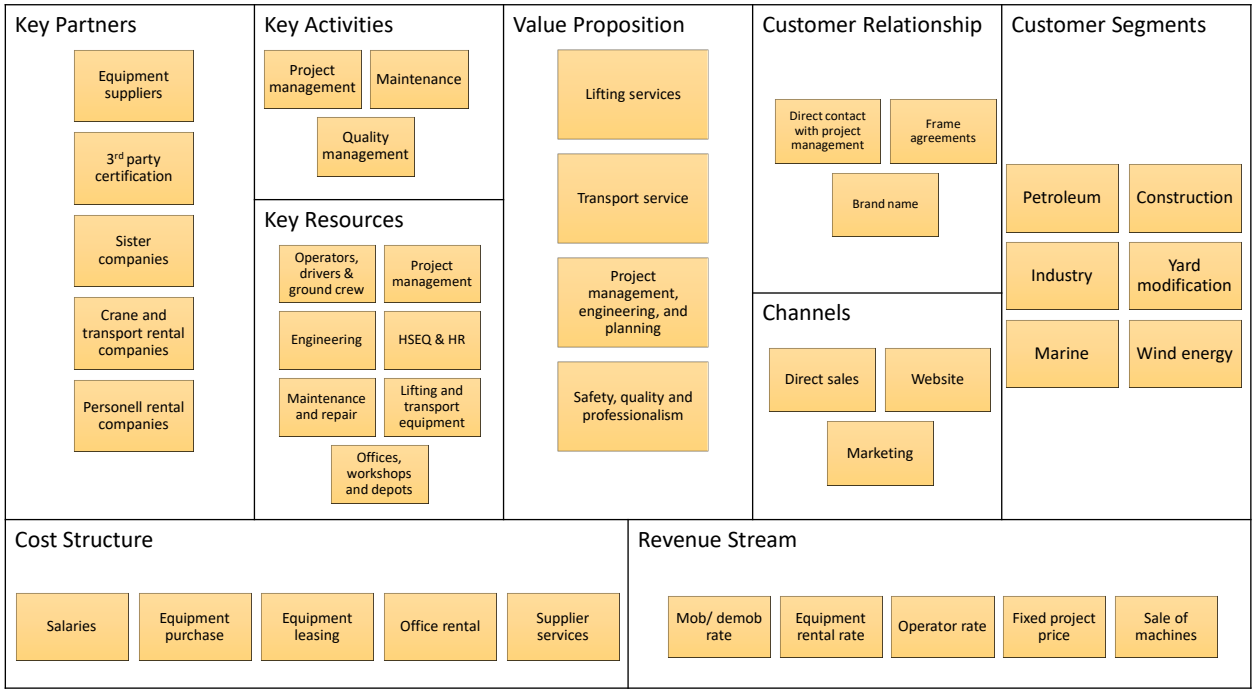

Figure 5-1 Current business model canvas

The case study company business model is a use-oriented PSS business model where the main activity of the company does not sell physical products but instead makes the product available under rental or leasing agreements. PSS business models provide both products and services to the company's customers. The product, cranes and transport units, are not sold to the customer rather the company use these products to supply a service to its customers. The company guarantee for a certain availability for a certain period and the company is paid periodically. The ownership of the product is not transferred to the customers. The risks and responsibility in owning and operating the machines is placed on the company. PSS business models are capable of providing customers' needs in an integrated and customized way and allowing customers to concentrate on their core activities, build relationships, and enhancing customer loyalty.

The developed business model canvas will be the basis for further discussing sustainable business model innovation that the company may need to develop to meet the emerging demand for sustainable solutions. The business model canvas is a visual representation of the business model. Each of the elements in the current business model is further explained in the following chapters.

5.1.1 Key partners

The case study company key partners consist of important suppliers in the supply chain and the key resources these suppliers provide to the company. These partners provide some key activities that the company require to fulfil the value proposition.

The company purchase or lease equipment such as cranes, trucks, trailers and lifting equipment. The company use multiple suppliers for the equipment the company use.

The company use 3rd parties for their annual certification of lifting equipment such as cranes and rigging equipment.

The case study company is a cooperation of several sister companies located in different regions in Norway, these companies share their resources between each other by renting their equipment and personnel to each other. Each company in the cooperation is defined as key partners in the business model of the cooperation.

In some cases, the demand for crane and transport services are greater than the collected resources in the cooperation. Therefor the companies purchase services from competing regional and national companies. This is a necessity to meet the demand.

For some projects, there are too few operators, drivers, and ground crew such as signallers, banksmen, or other personnel in the cooperation to supply the required demand for personnel. The companies purchase these services from personnel staffing agencies.

5.1.2 Key activities

Project management includes sales, planning, project managing and risk assessment. This activity is performed by coordinators for smaller projects, project managers for larger projects and site managers for long-term projects.

Maintenance of equipment is a vital part of the company activities. There is a high consequence factor in heavy lifting and specialized transport, good maintenance procedures are important to reduce risk during operations.

Due to the high consequence factor of heavy lifting and specialized transport, quality management is a key activity. The company use daily inspections of all lifting equipment that is operating. This is performed by the operator of the applicable cranes. These are complex machines that require

continuous monitoring for some key features to avoid downtime during operations. In addition to these inspections, all lifting equipment have an annual certification inspection by a 3rd party.

5.1.3 Key resources

Crane operators, truck drivers, and ground crew personnel are key resources for the company. It is vital for the safety and quality of operations to have skilled, trained, and experienced personnel executing the lifting and transport operations. Having a high degree of skill, training, and experience is important when operating the machines and working with the heavy equipment. There are many risk factors that can only be avoided by the necessary knowledge of the operations. Several of the sister companies have a trainee program for crane operators and drivers that work on getting their Craftsman certificate.

Project management is performed by different roles in the companies depending on the scope of work. Project management include the sale process, planning, project managing, risk assessment, and follow up of project. For smaller projects and regional work, this is performed by coordinators. Project managers are responsible for larger or complicated projects where there is more resource demand, project managers are also used for national projects. Site managers are stationed at customers site and coordinate local activates directly with the customer. They are responsible for long-term projects on a building site, project site or process site.

The company has engineers to preform detailed planning of lifting and transport projects, design and development of customized equipment, risk assessment of operations, and method descriptions. Lifting and transport engineering is necessary to complete complicated lifting and transport operations and to utilize the equipment capacity in a safe way. This can reduce cost and price of operations and give the company a competitive advantage.

HSEQ and HR department develop and improve on safety and quality procedures, quality management system, environment policies and procedures, and training and education. The HSEQ and HR is responsible for all the companies in the cooperation, so that every company use the same quality management system.

Maintenance and repair make sure that all the machines are maintained and serviced. The department make repairs on machines in the field and in workshops located at different regions in the country. Maintenance and repair ensure reliability of the machines. For special projects, the workshops preform modifications and upgrades to machines when special equipment is needed for specific projects.

All companies are equipped with a wide spectre of lifting and transport equipment that can be rented to lifting and transport projects. All lifting equipment is serviced and maintained by the companies and periodically controlled by 3rd party certification. It is important that companies have good quality procedures with pre and post project control to ensure reliability of the equipment. Many clients are not themselves equipped with special lifting equipment and rely on crane companies to have this in stock for hire. For some projects, lifting and transport equipment can generate a high cost to the project. If this equipment can be rented instead of purchased for single lifting operations, clients can save cost to the project.

The company is located in many different regions, and it is important for the company to have facilities for administration, workshops, depots, and site depots to maintain regional presence. For many national clients, with projects and sites all over the country, it is important that the company can provide lifting and transport services with close proximity and short mobilization time. These facility ensure that there are shorter distances to workshops for maintenance and repair.

5.1.4 Value proposition

The company is built around providing lifting services with mobile cranes, crawler cranes, mini cranes, and truck mounted cranes. The company focus their machine stock to these types of machines but has a wide spectre within these categories. Mobile cranes are as the name suggest, mobile. These cranes drive on the road to their jobsite and preform lifting services to any type of project. Larger mobile cranes will require assistance from trucks and trailers for transport of counterweights and equipment and is not always self-reliant. Crawler cranes are typically lattice boom cranes and are usually larger cranes. These cranes are less mobile and require additional support during mobilization and demobilization. Mini cranes are smaller cranes that can be operate inside buildings, on rooftops as well as outside on lifting projects. Mini cranes must also be transported to the jobsite. Truck mounted cranes are also relatively smaller cranes but are mounted on trucks and trailers. These machines are highly mobile and completely self-reliant. Truck mounted cranes can transport loads and preform the loading and unloading operations themselves. Truck mounted cranes are increasing in size, just as any of the other types of cranes on the market and is also used for specific lifting operations instead of using mobile cranes or mini cranes. The company is not necessarily limited to their own stock of machines and can provide all sizes and types of cranes by using partners and sub suppliers.

The transport services the company supply are mainly trucks with open flat trailers. The company specialize in the transport of large and heavy equipment and specialized transport. The company transport crane parts during mobilization and demobilization of their own cranes. The company also supply transport services for building materials in the construction sector, prefab parts, basket and containers, and other large and heavy equipment. This requires heavy machinery with maximum allowable weights according to the Norwegian road laws, which is 50 tonnes total weight without use of dispensations. The company has a wide range of size and types of trailers for specialized transport on road with total weight up to 200 tonnes but do not limit their value proposition to their own equipment. By using sub suppliers, the company can supply any size and type of transport equipment.

For large or complex projects, the company provide project management with logistics management, engineering, and project planning of lifting and transport services. The company provide project manager, site manager or supervisors when the project require more follow up during planning and execution of projects. The company provide these lifting and transport services with a focus on safety, quality, and professionalism. The company has developed and continuously improve on their safety and quality management system. This reduces risk, increase reliability and give a higher degree of customer satisfaction.

5.1.5 Customer relationship

The company customer relationship is mostly based on direct personal contact with coordinators, project managers, and site managers located at regional locations. For each project or job, the customer has a single point of contact that is responsible for the coordination of work and provide the customer with the services they require.

Some clients purchase crane and transport services for each specific project by requesting quotation from several different competing lifting and transport companies. Other clients use frame agreement to reduce resources in the procurement processes by contracting frame agreement with specific suppliers. Frame agreements can build up a solid customer relationship where the supplier and client continuously improve their processes.

The company is also well known a brand name that is recognized in the industry. The company is over 40 years old and has a long-standing relationship with many of the larger clients in the industry. The company also has a recognizable branding of their machines, where all the machines and equipment is painted in the same green and blue colours that can stand out at any jobsite.

5.1.6 Channels

The main channels the case study company has towards their clients are direct sales through e-mail and phone communication, where clients can contact the respective company, regional office, or depot. Coordinators, project managers, and site managers communicate directly with the client by phone call and e-mail depending on the customer relationship and preference.

The contact information for each of the regional offices, depots and departments can be found on the company website. The website is also used as a marketing tool to communicate what services the company provide. Other marketing tools are social media, sponsorship with commercial, presence at industry exhibitions, active participation in national and international association organizations.

5.1.7 Customer Segments

The company provide their services to anyone that require lifting and transport services in petroleum, construction, general industry, yard modification, marine services, wind energy and other. There is no limitation to segments the company supply its services. The company focus their supply to the Norwegian market and does not have many operations outside the Norwegian borders.

5.1.8 Cost structure

The main cost the company has are salaries, equipment purchases and leasing contracts for machines, office rentals, and rental of equipment and personnel. The company has around 400 employees, 350 machines, 12 offices, and 7 depots at different locations in Norway.

Supplier services are mainly rental of equipment and personnel, certification and quality control, fuel, maintenance supply. In order to supply a fluctuating demand for lifting and transport services, the company is reliant upon using competing companies for renting equipment and personnel. The company also use personnel rental companies to for projects that need additional personnel.

5.1.9 Revenue stream

The company revenue stream is based on rental prices for machines and personnel. Machines are supplied with a mob/ demob rate, a fixed price for mobilizing, installation, and demobilization of equipment. Larger cranes require support from trucks, trailers, and sometimes additional cranes for the crane to be operational on site. While the running cost of any project is the rental price for machines, equipment, and personnel. Other projects use a fixed price for the completion of the work, this requires a detailed description of the scope of work.

The company usually purchase new machines each year and sell older models in order to keep the average age of the machines lower. Machines are continuously developing new solutions to increase efficiency, capacity, and safety. The sale of older models generates a revenue to the company and reduces the cost of updating the machine stock.

6 Analysis and recommendations on business model innovation and green transition

6.1 Sustainable business model archetype

This thesis project explores the use of sustainable business model archetype "Substitute with renewables and natural processes" as described by Bocken, et al. (2014). Bocken, et al. use the framework for business model from Richardson (2008). Figure 6-1 show the correlation between Richardson's framework and the business model canvas from Osterwalder & Pigneur (2010).

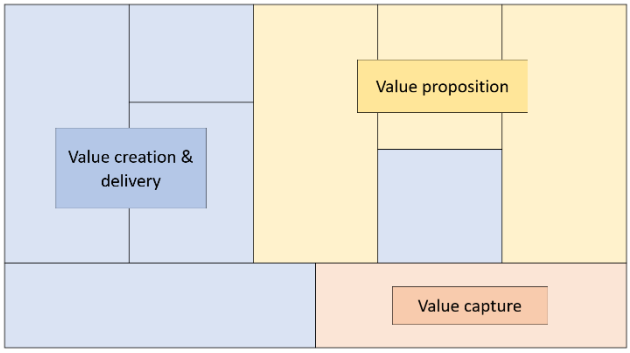

Figure 6-1 Business model canvas and Business model framework (Bocken, et al., 2014)

The business model archetype "Substitute with renewables and natural processes" from Bocken, et al. seeks to reduce environmental impact of industry by substitution with renewable resources and natural processes to create more environmentally friendly industrial processes. Bocken, et al. describe the archetype through value proposition, value creation & delivery, and value creation. This archetype can be used as a tool for business model innovation in creating a sustainable business model. Figure 6-2 describe the value profile the case study company can use to create a sustainable business model. The value profile in Figure 6-2 is an adaptation from Bocken, et al. to better suit the case study company's transition towards green construction.

Value proposition	**Value creation & delivery**	**Value capture**
Reduce environmental impact and increase business resilience by addressing resource constraints and offer fossil- and emission-free technology.	Innovation in products and services by exploring processes and products to reduce GHG emissions and increase use of renewable energy and resources.	Create revenue associated with fossil- and emission-free products and services. Value for the environment is captured through reducing use fossil-based fuels, reducing emissions through new processes, and reducing synthetic waste.

Figure 6-2 Value profile for sustainable business model archetype "Substitute with renewables and natural processes"

6.2 SWOT Analysis

The thesis project has performed a SWOT analysis of the current business model with a focus on green construction. The perspective of the analysis is the current practices of the business model with a view of how the company will be able to handle the increased demand for green construction with a status quo approach, i.e. without changing their business model or investment strategy. The purpose of the analysis was to discover parts of the business model that may need to change for the company to transition towards green construction.

The SWOT analysis was performed through observations of current practices and interviews of key personnel in the case study company. The analysis reviewed the business model and explored strengths, weaknesses, opportunities, and threats. The analysis was divided into three main elements, Value proposition, Value creation and delivery, and Value capture in correlation with the value profile.

6.2.1 Value proposition

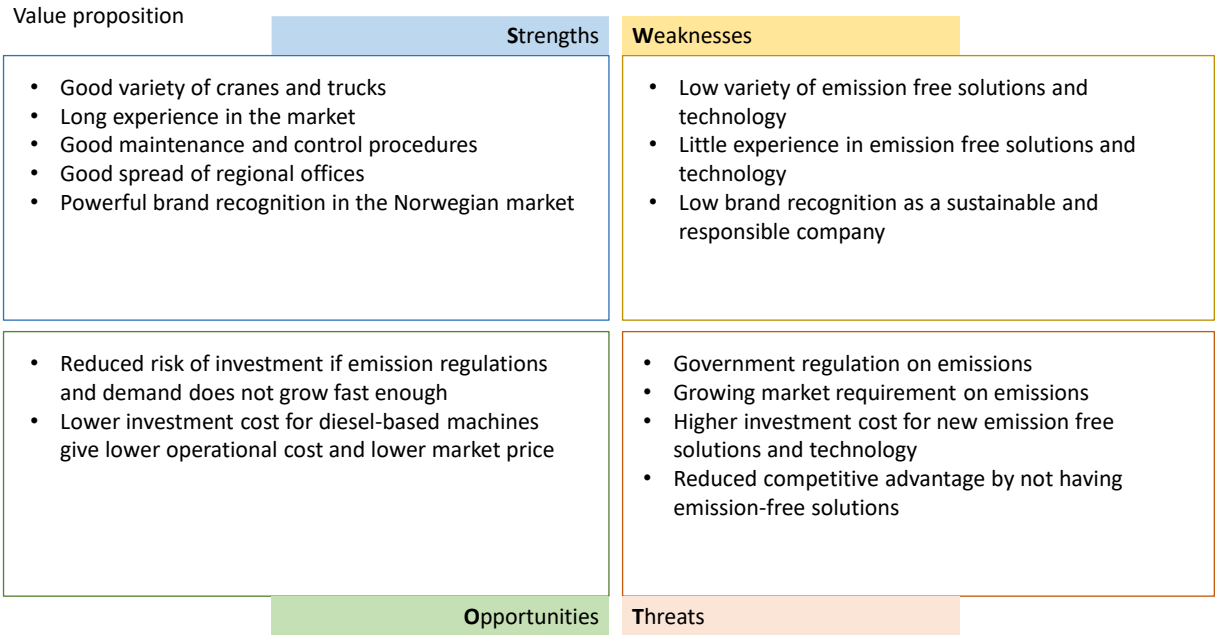

Figure 6-3 SWOT analysis for value proposition

Strengths – The company has a good variety of cranes and trucks with mobile cranes, crawler cranes, mini cranes, truck mounted cranes, semi-trucks, and lorries. As the company has over 40 years of experience in the lifting and transport sector, it has long experience and a developed maintenance, quality control and HSE procedures. The company has a good spread of reginal offices, depots, and workshops around the country, this gives the company a strong position in the market with availability and deliverability to clients with regional and national delivery requirements. The company also has a good reputation and brand recognition in the market as a reliable and quality driven company.

Weaknesses – However, the company has little variety with emission-free solutions and technology and lack experience within this market segment. Although the company is not considered as a resistance to green construction, it has not focused its effort into developing a brand recognition as a sustainable and responsible company with a focus on green construction.

Opportunities – By waiting with investing into emission-free solutions, the company has reduced its risk with having costly emission-free technology that may be difficult to be sold. Especially since these machines may not be suitable for many projects that does not have the necessary infrastructure with access to a high electrical power output. By investing into diesel-based machines, the company lower its investment costs and can in turn maintain a lower market price.

Threats – Future threats may be an increase in governmental regulations and growing market requirement on emissions. As the market research indicate, governmental regulations seem to

increase in scope gradually and the construction market seems to follow the same requirements as the governmental regulations. By waiting to long with investing into emission-free solutions, the company may miss out on contract opportunities. As the demand for emission-free technology may increase in the future, there may be long delivery waiting time for new machines as well as higher investment cost for emission-free machines.

6.2.2 Value creation & delivery

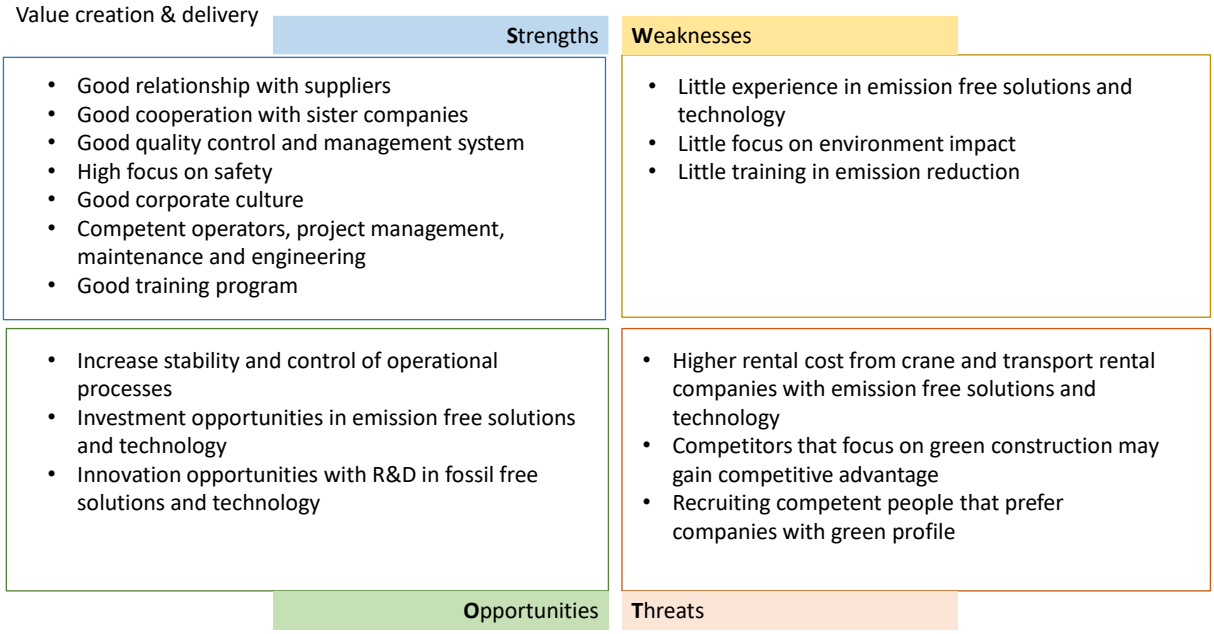

Figure 6-4 SWOT analysis for value creation & delivery

Strengths – The company has a good working relationship with its suppliers of machines, equipment, supplies, and 3rd party certification suppliers. According to interviews with key personnel from the company, there are several suppliers who the company has had prosperous and long-term working relationship with. The company is built of several sister companies and there seems to be a good working relationship within these companies. As the companies trade machines and personnel to assist each other with delivery of services to customers. The company also has a high focus on safety, quality, and maintenance. The HSEQ department has developed and is continuously developing the HSEQ management system. Based on statistics from provided by the company, the management system seems to be well established and a part of the operational practices of the company.

The company has a high number of operators with professional certificate in crane and lifting study as well as in transport and logistics studies as this is a requirement for operating as a crane operator and truck driver within the Norwegian onshore oil and gas sites under the NORSOK standard. Project managers, site managers, maintenance and engineering also have long experience and relevant education within the lifting and transport field. The company also has a training program for certified apprenticeship and is working closely with education facilities.

Weaknesses – The company has operational weaknesses by not having experience working with emission-free solutions and technologies. The HSE and quality management system have not implemented challenges related to emission-free solutions and may not be ready for the transition towards green construction. The education and training programs do not currently have emission-

free technologies as part of the curriculum. Employees may not have the required knowledge of operating and managing emission-free machines with the current practices.

Opportunities – By continuing the current practices, the company can increase stability and control of operational possesses. The company can build and maintain relationships with key partners, increase efficiency of key activities and increase stability and control of key resources. As the company does not have many emission-free solutions, it still able to invest in new machines that fulfil these emerging requirements. The company may also increase innovation with R&D in green construction by focusing on fossil free solutions.

Threats – By waiting in investing in emission-free technology, competitors that focus on green construction may gain competitive advantage earlier than the company. This may result in missed opportunities for contracts. Recruiting competent people may be difficult since more and more people value working with companies that has a green profile and a modern view of sustainability and responsibility.

6.2.3 Value capture

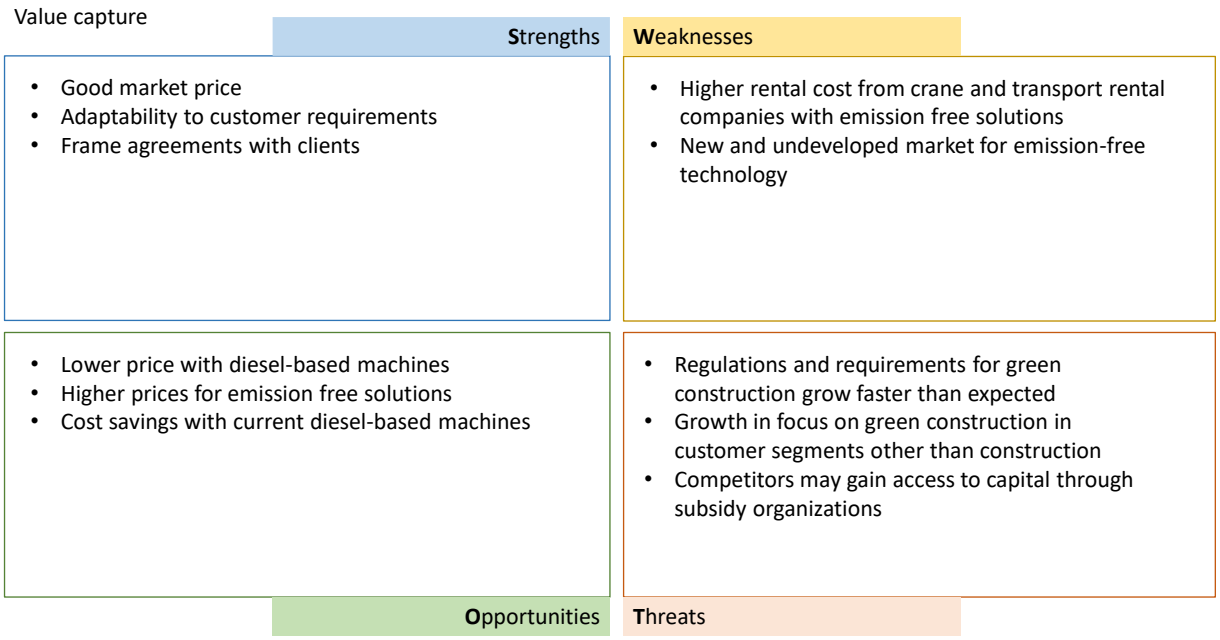

Figure 6-5 SWOT analysis for value capture

Strengths – The company has long experience in the market and a large market share. It can provide competitive market prices due to its well-established market share. The company is adaptable to customer requirements due to its organisational structure and methodology when working closely with customers and using its experience and expertise. Frame agreements with larger clients provide a basis for a profitable relationship with customers. Working closely with customers over a long period seems to gain valuable knowledge and system developments. Frame agreements give a steady revenue stream with predictability.

Weaknesses – If the company is required to supply emission-free solutions in short term, it may be required to use competitive companies to supply these machines. This may in turn result in higher rental cost. As the green construction market is relatively new and undeveloped, there is little

available machines with emission-free technology. It may be difficult for the company to supply these machines to customers.

Opportunities – Lower investment cost for diesel-based machines provide lower cost to the company and give a competitive advantage on price for projects compared to emission-free solutions. Even if clients request emission-free solutions, fossil-free solutions with diesel-based machines may be more competitive for many projects. Diesel-based machines may be cost saving to the company,

Threats – Regulations and requirements for green construction may grow and evolve faster than expected, if this happen much of the construction market may be unavailable to the company without having emission free technology available. With long delivery time for emission-free machines the company may not be able to supply cranes and transport services to the construction market. Also, if other customer segments such as wind energy, petroleum, and general industry increase their focus on green construction, the company may need to catch up with competitors that has already started investing in emission-free technology. Competitors that have a heads up on investing in emission-free technology and infrastructure may have gathered a large part of capital through subsidy organizations.

6.3 Recommendations to sustainable business model

The business model archetype “Substitute with renewables and natural processes” described by Bocken, et al. (2014) with the value profile from Figure 6-2 can be used to focus the case study company’s effort to create a sustainable business model. The result from the SWOT analysis has identified parts of the current business model that may need to change and new elements that may need to be included.

For the company to transition towards green construction, it may need to change the value proposition by focusing on exploring new fossil-free and emission-free technology. By gradually increasing the amount of hybrid and fully electrical machines when the company invest in new cranes and trucks.

As the company periodically change out old machines with new machines, the company strategy could include a percentage or number of new machines to be hybrid or fully electrical. This investment strategy may create a learning curve for the company to gather necessary new experience and knowledge with this new technology and be ready when the emission-free market expands further and the demand increases. Investing resources in innovation may create new opportunities for the company to gain competitive advantage. By changing the lifting and transport service value proposition, the company may be ready for the emerging demand for green construction.

As part of the new business model, the company could implement a new element of emission-free solutions, this may include both new technology, but also new processes. By focusing on emission-free solutions to its customers, this will maintain customer relationships with customers that require these solutions and may create new opportunities for emerging markets from new customer segments that may emerge in the future. If the market is on the verge of a new paradigm shift, there this may result in new customer segments that is currently unknown. It is difficult to predict how the market may change due to the rising demand for green constructions.

The company could explore the opportunity to increase the use of biofuel by including this option in every sales offer delivered to clients. By informing clients of this option even if they do not initially request the information, this may encourage some clients to include this in their sales order. By

investing resources to exploring methods to increase the use of biofuel, the company may discover other solutions and create new opportunities.

The company could also explore how they can create a brand recognition as a sustainable and responsible company. Even if some investment and operational cost increase, this may create more sales opportunities for certain customer segments. A green brand recognition improve attraction from customers and may increase market share. It may be difficult in the long term to recruit and hold highly competent people that prefer to work at a company with a green profile. Both customers and employees are increasingly looking for companies with green profile brand recognition (Gupta & Gupta, 2013). If the company focus its effort to convey their work on green construction, sustainability, and social responsibility to increase a green brand recognition it may both benefit its opportunity to gain customers as well as competent employees. According to Gupta & Gupta (2013), young job seekers are seized with environmental issues and seek companies that take a responsible approach to their businesses.

By changing the value proposition, the company will also need to change the value creation and delivery of the business model. Most of the current key equipment suppliers the company use is working on research and development for hybrid and fully electrical machines. However, there may be new equipment suppliers that can supply the company with new machines and solutions. By continuously exploring the market of hybrid and fully electrical the company may also include new key partners.

As new technology is implemented in the company, some of the key activities will also need to evolve with the changes. Maintenance, and quality control will need to include new processes and procedures to include hybrid and electrical components of the machines. The new systems in the machines may create new short term and long-term challenges.

Emission-free technology is relatively new for mobile cranes and specialized transport, many companies lack experience and training in using emission-free technology. Since the case study company use competitors to ensure supply of machines and personnel when their own machines and personnel are unavailable or occupied with other projects. When these companies in the supply network lack experience and training in emission-free solutions, this may be a threat to the case study company.

The business model may need to change its approach to how lifting and transport services are performed, since the technology changes processes, procedures, and requirements from operators and managers. The SWOT analysis show that the company lack experience and knowledge of using emission-free solutions. Operators and managers may need to gain additional knowledge and experience to fully utilize the potentials of the new technology. This knowledge and experience can be gained by exploring new technology such as electrical and hybrid solutions. Maintenance and repair activity and resources will need to gain knowledge about hybrid and electrically powered machines, battery packs and control systems. The department may even need to employ new positions with this expertise. Offices, depots and workshops will need to invest in charging infrastructure, tools, and equipment to maintain and operate hybrid and electrical machines.

From the SWOT analysis, sustainability archetype, and technology trends, a new business model is proposed. The business model canvas in Figure 6-6 show the new business model. The green boxes are the parts of the business model that could be changed to create a sustainable business model and transition towards green construction.

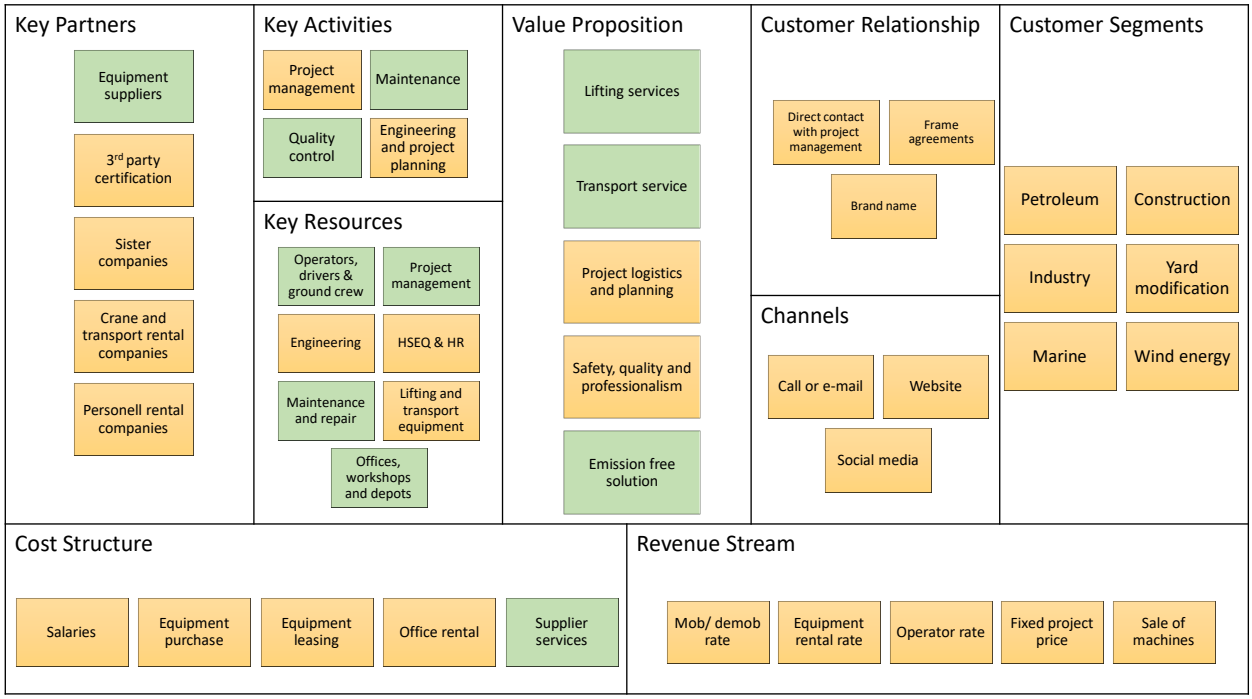

Figure 6-6 Sustainable business model canvas

6.4 Preferable technology focus

From the evaluation of technological trends this thesis project has identified preferable technologies that the company may focus on. The company should consider having a strategy for short-term, mid-term and long-term strategy approach when considering what technological solutions to invest in. Short-term solutions could be implemented into the company value proposition immediately without any large changes to the business model. The mid-term solutions will require more changes to the business model and incorporate more knowledge and infrastructure. The long-term solutions will require larger changes to the business model and substantial changes to the business model, knowledge, experience, and infrastructure.

For the short-term the company should focus its effort into fossil-free solutions by increasing the use of biofuel. This technology only requires the company to limit its investments to machines with Euro 5 and Euro 6 class engines. These engines are factory ready to use biofuel without any modifications. Biofuel is already an integrated part of the infrastructure on a national scale in Norway. Most fuel suppliers offer biofuel and is readily available on most parts of the country. Using biofuel for projects does not require any changes part of the business model.

For the mid-term the company should focus its effort into hybrid technology. Hybrid technology may be used for customers that require reduced emissions, fossil-free, or emission-free solutions. Trucks and transport units using hybrid trucks can maintain the load requirements that diesel-based machines can perform while at the same time reducing emissions and for short distances operate emission-free. For a combination of urban and rural operation area, these trucks could operate emission-free in city centres and operate with diesel engines outside the city centres. As requirements for emission-free operations in city centres increase, this technology may give the company significant competitive advantage in and around larger cities.

Mobile cranes, crawler cranes, and truck mounted cranes does not have a usable hybrid solution, however external electrical hydraulic power units are available and are under development. It is

expected that these units can be operational for most crane sizes within 2023 or 2024. Cranes can then be mobilized to the construction site with the onboard diesel engine, and then the crane can be operated emission-free at the construction site. This will require enough electrical power supply at the construction site which limits this usage at some construction sites. As this is an external unit that is plugged in the crane, the cranes can also be used at any construction site using the onboard diesel engine. However, the cranes will need modifications to include an interface between the unit and the machine. The operators, managers, and maintenance will require new knowledge and experience operating this technology. Quality control procedures will also need to be updated as well as HSE procedures working with high voltage and hydraulic cables exposed to the working environment on a construction site. Other risks that is unknown without necessary knowledge and experience may also need to be managed. Workshops may also need new equipment and infrastructure when preforming maintenance and repair to the new technology.

For the long-term the company should focus its effort into battery electrical machines. Cranes and trucks have an expected operation time of approximately 10 years. The market for emission-free technology is under development and the amount of construction projects that require these machines are currently limited. Investing in battery electrical machines will create a financial risk for the company as it risk having machines without contracts and not create any revenue. But, in the long-term, the company should invest in these machines as the demand increases. Battery electrical machines will require changes to key partners, key activities, key resources, value proposition, cost structure, and revenue stream. Most of the changes are the same as for hybrid systems but may also require changes to infrastructures at the regional offices, depots, and workshops.

6.5 Expected impacts

Creating a sustainable business model with a goal to transition towards green construction can directly improve the company's triple bottom line, i.e. financial, environmental, and social impact. With a sustainable business model, the company can expect to reduce business costs, improve reputation, improve employee satisfaction, reduce environmental impact and gain new customers who value sustainability.

Transitioning towards green construction may increase some costs such as investment cost due to higher prices for these machines. The company could reduce this by utilizing financial and capital support form organizations such as Enova and Innovasjon Norge. However, use of electrical machines and improved processes and procedures can deliver significant cost savings to both the company and its customers. Improved processes, better planning and new technology can contribute to reduce operational costs.

A report from SINTEF shows an analysis of life cycle cost (LCC) of construction machines, including investment cost, operational and maintenance cost, and energy cost. They compared the LCC of diesel-based, bio-fuelled, and electrical construction machines. The analysis was based on current situation from 2022 and for the year 2025 and 2030. The result of the analysis shows that the LCC of electrical and bio-fuelled construction machines are higher than diesel-based machines for today's situation. However, by 2030, electrical construction machines are predicted to have lower LCC compared to diesel-based and bio-fuelled machines (Gjersvik, et al., 2022). This analysis is not based on cranes, but based on construction transport and excavation machines, and is not directly comparable to the case study company business model, but the analysis show that although investment costs will increase, running cost will decrease in the coming years.

GHG emissions and cost can be reduced by optimising transport systems, improving planning, load management and routines. According to whitepaper from Scania (2018) CO_2 emissions can be

reduced by as much as 20% by reducing unnecessary idling of machines, better planning of transport routes, driving style and load efficiency. By including hybrid solutions, electrical and battery electrical solutions, the company can expect to reduce operational costs. The whitepaper from Scania (2018) suggest that operational costs can reduce to as much as 20% compared to business-as-usual by 2050 if transport companies transition towards emission free technology and improve their processes and procedures.

Green construction may also increase the revenue stream for the company as fossil-free and emission-free solutions have a higher rental cost than traditional diesel-based solutions. If requirements from political ambitions and market drivers for emission-free solutions continue to grow, the company can expect that these solutions will have a higher demand in the near future. Since the technology is relatively new, and there are few options available, the price for emission-free solutions can in short term be higher than traditional diesel-based solutions.

If the company investment strategy includes emission-free solutions, it can expect to have a positive effect on the company reputation. The company can expect a positive influence on customer relationships, employee satisfaction, and improved recruitment opportunities by increasing brand recognition as a green, sustainable, and societal responsible company. The company can utilize this transition to create a brand recognition as a green and responsible company in the industry. And become a pilot company in the focus on green construction. With a familiarity to the brand, customers are more likely to choose the company as a supplier for their lifting and transport services.

The company can expect to improve its company reputation by focusing its image as a green and responsible company. The topic of global warming, climate change and energy crisis are an increasing concern for many, and people are attracted to brands that share their values. Successful brand recognition leads to new customers, more sales, customer loyalty, and employee loyalty. With a green brand recognition, it may both benefit its opportunity to gain customers as well as competent employees. The company can expect that young job seekers are more attracted to the company if it is conveyed as a sustainable and safe company.

6.6 Critical success factors

6.6.1 Balancing innovation and risk

Innovations can be considered as the implementation of an idea - whether pertaining to a device, system, process, policy, or service – that is new to the organization at the time of adoption (Gurd & Helliar, 2017, as cited in Damanpour, 1987, p. 676). One of the challanges the company may face when innovating and changing parts of the organization is managing risk. As changes to the organizations may create positive and negative consequences. The central risks can be that resources may be squandered, and the project will be marshaled through launch and then fail in the market. Although other risks are less easily identifiable, within the organization; the challange is to draw out that knowledge and make those risks measurable (Hartwig & Mathews, 2020, p. 19).

The case study company could benefit from using risk analysis when innovating. Risk analysis may be a valueable tool to inform decision makers when considering whether or not to pursue innovation projects (Hartwig & Mathews, 2020). The company could use a strategy of risk management to set milestones for innovation projects. Osterwalder, et al. (2020) propose a process of exploration and exploitation of new innovations through The Portfolio Map. The idea is to explore new innovation projects with high uncertainty and turn these into value propositions that matter to customers, embeded in scalable and profitable business models and exploit these ideas with reduced uncertainty.

The process of exploration should encourage innovation that show potential high expected return and low innovation risk, while discourage promoting ideas that show low expected return and/or high innovation risks. Expected return is the financial potential of a business idea if it is successful. Innovation risks can be desirability risk, viability risk, feasibility risk, and adaptability risk. The process of exploration, as described by Osterwalder, et al., is a method of searching, testing, preserving, investing, or retire ideas. The exploration of innovation projects could have incremental milestones that reduce risks of squander resources and launching a project that may fail in the market. As the idea through incremental testing continue to show high potential expected return and low innovation risk it is moved to the exploitation phase.

The exploration phase is all about keeping the existing business model on a growth trajectory. This includes scaling emerging business models, renovating declining ones, and protecting successful ones. Exploitation tries to ensure growth by improving disruption and risk. This can best be achieved by shifting the company's business models from outdated ones to stronger ones. (Osterwalder, et al., 2020, p. 12).

6.6.2 Green construction market growth

The market research from this thesis project show indicators that the green construction market will continue to grow and has the potential to be a paradigm shift in the construction industry. The green construction market seems to be an attractive and profitable market for the case study company. Major drivers in the construction sector such as municipalities and large development companies show an increased focus in requiring fossil-free and emission-free solutions towards 2030.

The construction sector is incentivised to invest in green construction projects because these projects reduce risk for investors and will ensure cost savings during the lifespan of the building. Green construction also influences brand recognition for developers with social responsibility and focus on positive reputation. These sustainable and responsible projects attract customers and investors that value sustainability and environmental effect higher.

Developers for construction projects can be faced with a challenge to acquire emission-free machines as there are few machines on the current market and the growth rate of these machines may not increase at the same rate as the demand. When projects are faced with conflicting decisions, either upholding progress or failing to deliver emission-free machines, the projects are more likely to value progress higher. Because the cost of delaying progress may be higher than not upholding the emission-free requirements for the project. It can be argued that this influences the rate in which the market actually grows.

Although other sectors such as petroleum, general industry, EPCM, and wind energy has shown less focus in green construction, these sectors may follow the same trend as the construction sector in the future. As the operational cost for fossil-free and emission-free machines is higher than regular petroleum-based machines, customers will need incentives to choose green construction.

The market growth is an external factor that the company may have little opportunity to influence. However, by changing the value proposition and exploring innovative ideas, the company could make fossil-free and emission-free solutions more attractive to customers. By informing customers of the potential emission reductions when choosing fossil-free or emission-free solutions it may encourage customers to include these solutions in their purchases.

6.6.3 Resistance to change

Transitioning towards green construction technology may create some resistance to change within the organization. There may be several reasons resistance to change occurs in the organization.

Burnes (2015) explored the nature of resistance to change and the notion that individuals may be the prime source of such resistance. Although some individuals are more disposed to resist change and defend the status quo, Burnes found that the context plays an important role in whether individuals resist or accept change, regardless of dispositional resistance (Burnes, 2015, p. 105). It is however virtually impossible to predict how an organization behave to change. The method the company implement change and a focus on change readiness can reduce risk of failure.

The topic of green construction, and reducing GHG emissions in general, is a political topic with sometimes polarized views. Public opinions and political views may influence the organization's resistance to change when transitioning towards green construction. The context of which the change is implemented may play an important role to whether the organization accept the changes.

Senior management should also be aware of the possible psychological impact of changes and the degree to which they might clash with or violate existing values and expectations. The transition to the new technology may introduce new challenges to the organization and individuals. These challenges may cause a reluctance to accept the new technology. For example, electrical machines will introduce charging time and additional processes during lifting and transport operations. This may cause irritation and stress to operators, managers, and clients.

It is the author's opinion that a gradual exploration of new technology may increase change readiness. If the company gradually invest and explore new technology and solutions in green construction, the company and clients will experience a learning curve of challenges and solutions. The company should encourage participation from operators, maintenance, and managers in the decision process when investing in the new technology. Processes may evolve over time and create change readiness when the new technology increase its presence in the supply chain.

7 Conclusion

7.1 Review of project

The purpose of this thesis project was to discuss sustainable business model innovations for the case study company and the process of transitioning towards green construction. The project has identified several drivers for green construction from international, national, and regional political ambitions and market drivers. Governmental regulations and customer requirements for green construction technology will require the company to change its value proposition to meet these demands. The market research indicates a growth in green construction and an opportunity for the company to exploit through innovation in sustainable business model.

Developers are incentivised to certify their construction projects to certification such as BREEM-NOR. These projects focus on resource efficiency, waste management, energy efficiency, GHG emissions, and social responsibility. These projects reduce risk for investors and ensures cost savings during the lifespan of the construction. According to a report from the UK Green Building Council (UKGBC, 2018), tenants are more likely to pay more when the building are BREEM certified, and there is an increase in financial support for projects with environmental and social factors. These sustainable and responsible projects attract customers and investors that value sustainability and environmental effect higher.

Suppliers of cranes and trucks are developing new and improved technology for fossil-free and emission-free solutions that aim to reduce GHG emissions. The most attractive technological trends are biofuel, hybrid, and battery electrical solutions. Biofuel seems to be the recommended solution for a short-term strategy. This solution requires little change to value creation and delivery in the business model. The mid-term strategy should be to explore hybrid solutions as this seems to be a middle ground between current practices and fully electrical solutions. This will in turn reduce risk for the company while gaining valuable knowledge and experience when moving to the long-term strategy. In the long-term, the company should explore battery electrical machines. These machines seem to have some limitations compared to traditional diesel-based machines. For these machines to be successful as a value proposition, the suppliers need to develop the technology further, the market will need to grow, and requires substantial changes to the business model.

With business model innovations there are risks for the company. It may risk wasting resources, decreased revenue, and lose customers. By using a method of exploration and exploitation, the company can manage the risk of resources being squandered or value proposition fail in the market. An incremental investment strategy will give the company an opportunity for exploring the technology and gain valuable knowledge and experience and time to adjust for internal and external factors.

By transitioning towards green construction, the company can expect significant cost savings to both the company as well as customers. According to whitepaper from Scania (2018) CO_2 emissions can be reduced by as much as 20% by reducing unnecessary idling of machines, better planning of transport routes, driving style and load efficiency. Green construction may increase revenue stream for the company with higher rental cost for green construction solutions compared to traditional petroleum-based machines.

By transitioning towards green construction, the company can create a brand recognition as a sustainable and responsible company. A green brand recognition improve attraction from customers and may increase market share. It may be difficult in the long term to recruit and hold highly competent people that prefer to work at a company with a green profile. Not only customers are

attracted by a green brand recognition, but this may also create a positive effect on employee satisfaction and improved recruitment opportunities to recruit competent employees that value companies with a green profile.

7.2 Challenges and limitations

7.2.1 Market research and technology trend

The market research was limited to research in green construction with the demand for fossil-free and emission-free solution for construction projects. The demand for these solutions is relatively new or non-existing in other sectors. This thesis project found several studies made on fossil-free and emission-free projects. However, it could not find any studies on fossil-free or emission-free projects in any other market sector than the construction sector. It was difficult to find information related to current or future requirements for emission-free solutions other than the construction sector.

The research in technology trends was limited to the research in current activities and near future technological solutions from main suppliers of the case study company. As the focus on fossil-free and emission-free solutions are new to the industry, the range of the technology is limited. Information on research and development projects was restricted and confidential. Other solutions than what is mentioned in this thesis project may be under development, but it was difficult to confirm these solutions.

7.2.2 Business model

The case study company did not use the concept of business model that was obviously relatable to either the business model framework from Richardson or the business model canvas from Osterwalder & Pigneur. The company had descriptions of its processes, resources, products, customers, costs, and revenue streams, but not in a simple structure as proposed by Richardson or Osterwalder & Pigneur. This thesis project had to develop the business model canvas based on the information provided by the company and the authors own observations.

The review of business model and business model innovation in this thesis project was limited to the focus of green construction. Other aspects of the business model where not included in this thesis project. When changing aspects of the business model, it is important to review and assess the effect of these changes to the relationship between all aspects of the business model and company strategy. As any changes may affect relationships in the organization, customers, suppliers, and employees.

7.2.3 SWOT analysis

The SWOT analysis is often based on subjective views from participants. Statements made during analysis should be verified before the results of the analysis is implemented. The verification process is not only time-consuming, but some statements are difficult and sometimes impossible to verify.

The quality of the SWOT analysis is limited to the degree of commitment to the process. Participants must have a clear understanding of the purpose and objective of the analysis. Without a clear understanding of why the analysis is preformed, the results may not have information to affect change.

The organisation culture will have a large impact on the results from the analysis. Since the analysis is often based on subjective views from participants, the results may favour heavily on strengths and opportunities, or weaknesses and threats, depending on the organisation culture. If the culture has a positive mindset, the analysis may favour strengths and opportunities. If the culture has a negative mindset, the analysis may favour weaknesses and threats.

For the SWOT analysis to be an effective tool, it should be performed continuously and not just once to assess the relevant topic. The analysis should be updated at some predefined interval or at milestones. The SWOT analysis is only a snapshot in time. Due to changes in internal and external factors, the SWOT analysis becomes outdated. If the analysis is too extensive, this repetitive process may result in copying previous aspects of the analysis without a complete review and have lose its value. Information gathered from the analysis may also include information that has no real value to affect change. The repetitive process may be a risk in strategic planning, where decision makers are presented with outdated, unverified, and obsolete information.

7.3 Recommendations for further work

7.3.1 Market research

The company should continue to research the market development for green construction and the rate it changes. It should continue to monitor development for green construction requirements for all the customer segments. The construction sector is pioneering the development of green construction, but as the company has many more customers other than construction companies. As solutions and processes continue to develop, the requirements for green construction may grow in other customer segments as well. If the demand for fossil-free and emission-free solutions grows in other customers segments, this will influence the investment strategy of the company. It is important for the company to be ready for the rate of which the demand for green construction solutions grows.

7.3.2 Technology trend

The technology for green construction is developing in a fast rate. Several suppliers show an interest in researching and developing new technological solutions. Existing concepts are developing and improving, and new technological solutions are introduced to the market. The company should monitor the technological trend from existing suppliers as well as researching alternative suppliers that may introduce new concepts that the company could include in its value proposition.

7.3.3 Sustainable business model innovation

The company should continue its work to improve the sustainable business model through innovations. With a focus on the triple bottom line, managing social, environmental, and financial implications of their actions. Allowing the company to become more resilient and to seek win-win situations where they search for profitable activities that also benefit society and environment. Creating and maintaining a sustainable business model is not a one-time work process, this is a continuous work effort that requires a never-ending commitment.

7.3.4 Studies and research

Although green construction is a new topic of studies, there have been several studies on the effect, requirements, and appropriate methods in the construction sector. However, there is little studies on this topic outside the construction sector. This thesis project call for more research and studies for green construction in all sectors that use fossil-fuel based material handling machines such as heavy lifting cranes and specialized transport.

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