New Service Development:
Energy Efficiency Consultancy Service

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New Service Development:
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Abstract

For a longer period of time, manufacturing was the core business activity and hence service has gained lesser attention. However, a time came when manufacturers faced a huge challenge to stay profitable which apparently gave service to get more attention. The reason to this can be classified in to three categories: economic reasons, customer satisfaction and competitive advantage (Oliva et al., 2003). Understanding this, Volvo Group has set high target for revenues from soft products including service. In order to achieve this it is necessary to expand existing service offerings and explore more new service offerings. As part of this goal, Volvo Technology has been working on several projects.

One of the projects which are closely related to this thesis is the Hauler Development Service (HDS) which started in 2008 for the trucking (Hauling) industry. HDS has two versions; HDS Green Field and HDS Efficiency and Effectiveness. HDS Green field focuses on starting up new road transport operations and establish business processes including system support on emerging markets. HDS Efficiency and Effectiveness focuses on performing assessments and improvement programs on already established firms on mature markets. These business offerings started to get their orders from customers and thus proving their functionality. However, unlike the trucking industry, the construction equipment business area within Volvo Group is lacking such business offerings today. Volvo Construction Equipment is the second largest business area within the Volvo group generating about 16 % of the total sales. Volvo CE is mostly offering hard products and wants to expand its service offerings and assume a better position as a professional service solution provider. The development of HDS for the trucking industry and the need for Volvo CE to expand its service offerings laid the background for this thesis.

One of the market segments Volvo CE provides equipments is to the quarry and aggregate business segment. Customers with in this business area were successfully contacted and collaborated in this study. This master thesis investigated what the customers in the quarry and aggregate business area needs and problems are and developed a service concept which Volvo CE can offer while at the same time solving customer problems. This service concept was found out to be Energy Efficiency Improvement Service intended to help lower production costs of the customer by eliminating or lowering energy wastes and improve environmental impacts by lowering carbon emissions.

Moreover, customer energy performance measures were studied and analysed if they are robust enough to be used as measures to the improvements inevitable by the new service offer, the Energy Efficiency Improvement Service. Results show that the energy performance measures currently in use are not robust enough, and suggest further development of energy performance measure system. In order to realize the service offer in a practical manner, the five lean principles (define value, identify value stream, floe, pull and continuous improvement) were tested if they can be used as tools to identify and measure energy wastes at the customers operation site and proved to be useful.

Key words: New service development, Service, Performance Improvement
Acknowledgements

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1. Introduction
This chapter introduces the thesis project by stating the thesis background, project directives, purpose statement, problem statement, project limitations and company introduction.

1.1 Thesis background
The background for this thesis project can be viewed from two perspectives; industry trends and corporate (Volvo Group) perspective. This section presents what the driving reasons for the initiation of this master thesis project are.

1.1.1 Industry trend
For a longer period of time manufacturing was the core business activity and hence service has gained lesser attention. However, a time came when manufacturers faced a huge challenge to stay profitable which apparently gave service to get attention. Wise and Baumgartner (1999) on Harvard business review put it as “The 1990s have been a great time to be in business- unless, that is, you happen to be manufacturer” to explain how manufacturing was challenged economically in the US during the 1990s. It also discusses that the successful manufacturing companies who made it through that challenging situation followed similar methods of getting closer to the customer and offering service which expanded the business portfolio and hence profit; “The thriving companies are a diverse lot, ranging from Honeywell and General Electric to Nokia and Coca-Cola, but they've all taken a similar route to success; they've gone downstream, toward the customer”. This being true, what are the important features of service which helped these manufacturing companies pass the hurdle?

Several scholars suggest product manufacturers to offer services in addition to products (Gadiesh and Gilbert, 1998 cited in Oliva and Kallenberg, 2003) and Wise and Baumgartner (1999). The reason to this can be classified in to three categories: economic reasons, customer satisfaction and competitive advantage (Oliva and Kallenberg, 2003).

Economic benefits of service
One of the reason for a growing importance of offering service is to gain a financial benefit through selling service on its own right, not only to support the functionality or selling of a product. Services, in general, have higher margins than products (Anderson et al., 1997 cited in Oliva and Kallenberg, 2003). This is because they often involve relatively lesser capital investments.

It is common to see business portfolios growing around a certain brand product which have no direct financial benefit for the manufactures. Examples are installation firms, operation management firms or consultancy firms. However, manufacturers can expand further along the supply chain and provide these service offerings using their accumulated product expertise to their advantage. An example to this is stated in Wise and Baumgartner (1999); "Boeing has broadened its view of the value chain and now offers financing, local parts supply, ground maintenance, logistics management, and pilot training”. That is expanding down the value stream and capturing all the business opportunity available.

The other benefit of service from economic perspective is that service provides a more stable source of revenue as they are resistant to the economic cycles that drive investment and equipment purchases (Quinn, 1992 cited in Oliva and Kallenberg, 2003). Moreover, it is also possible to get a substantial profit from offering services supporting installed base products of the manufacturing companies.

Customer satisfaction
The rise of customer demand is also another driving reason to go in to service. Through offering service, manufacturers can satisfy customer demand creating closer relationship with the
customer. A rather new trend in the manufacturing industry is the interest of many manufacturers in transforming themselves into a total solution provider. A good example can be Atlas Copco (an industrial equipment manufacturer) selling compressed air instead of air compressors. This is considered an attractive offer as the customer will not bother in managing a compressor and focus on its core business activity instead. And for the manufacturer, it means selling the product and also a service.

**Competitive advantage**

Service can be used as a tool to compete in the ever increasing tough market conditions. There is an increasing trend of products turning into equally performing commodities, shifting the basis for competition from the product’s functional performance to price. If the basis for competition shifts to price, it is challenging for reputed brand manufacturers to withstand the competition as their product price is significantly high as a consequence of high product quality and overhead costs. In such cases, service can be used as a tool for differentiation. This is to mean, manufacturers can offer services specifically tailored to meet their customer demand in a way competitors cannot offer similar service. In this way, manufacturers benefit from the service on its own right and also from increased product sales resulting from customer relationship and loyalty. Moreover, services, by being less visible and more labour dependent, are much more difficult to imitate, thus becoming a sustainable source of competitive advantage (Heskett et al. 1997, cited in Oliva and Kallenberg, 2003).

1.1.2 **Volvo Group perspective**

Volvo Group has set high target for revenues from soft products. In order to achieve this it is necessary to expand existing service offerings and explore more new service offerings. As part of this goal, Volvo technology has been working on several projects. One of the projects which are closely related to this thesis is the **Hauler Development Service (HDS)** which started in 2008 for the trucking (Hauling) industry. HDS has two versions; **HDS Green Field** and **HDS Efficiency and Effectiveness**. **HDS Green Field** focuses on starting up new road transport operations and establish business processes including system support on emerging markets. **HDS Efficiency and Effectiveness** focuses on performing assessments and improvement programs on already established firms on mature markets. These business offerings has started to get their orders from customers and thus proving their functionality.

However, unlike the trucking industry, the construction equipment business area within Volvo Group is lacking such business offerings today. Volvo Construction Equipment is the second largest business area within the Volvo group generating 16% of the total sales (Volvo Group presentation 2010). Volvo CE is mostly offering hard products and wants to expand its service offerings and assume a better position as a professional service solution provider. The development of HDS for the trucking industry and the need for Volvo CE to expand its service offerings laid the background for this thesis, posing the question ‘is it possible to offer such development and improvement services for the construction industry also?’ This thesis is a part of an ongoing project at Volvo Technology with a bigger purpose of investigating the business potential in developing and commercializing a site performance improvement service to apply within the construction equipment business area.

In summary, the background to this thesis is an increasingly importance of services within the manufacturing industry, Volvo Group’s vision towards increasing economic benefits from services, and Volvo Technology’s success in developing similar service offer for the trucking industry.

1.2 **Project directives**

1.2.1 **Project disposition**

It was the company’s wish to run two thesis projects in parallel. The two thesis projects had partly common and partly separate focus areas, which when put together made up the overall
project purpose. The overall purpose of the two thesis projects were to investigate the business potential in developing and commercializing a site performance improvement service to apply within the construction equipment business from a lean perspective.

This overall project purpose has two distinct perspectives; (1) the development of the service and (2) the commercialization of the service. Accordingly, the two thesis projects made their focus on each: This thesis (thesis A, by one student from Mälardalen University) focused on developing the “service concept”, identifying key performance indicators currently used by the customer and what tools and methods to use while delivering this service. The other thesis (thesis B, a team of two students from Chalmers University of Technology) focused on developing the “service concept”, how to price and how to commercialize the service.

As can be noticed, both thesis projects had a common part which is developing the “service concept”. A more precise description of the parts of the thesis carried out together with the other thesis workers and the parts that were carried out individually is presented in the methodology section of this report, table 3.3.

1.2.2 Strategic planning
Volvo Construction Equipment has recently made a new market driven and customer focused business area segmentation. By segmentation it means dividing the market into groups of customers with similar needs. The reason behind the market segmentation is to ensure right decisions about resource investments. That is to make investments in areas where the profitability is higher and at the same time meeting the overall strategic objective of the company. The steps followed by the company in creating the market segmentation are; grouping the customers according to similarities in needs and industry, ranking the groups according to their size, profitability and growth potential and finally ranking the groups against the company’s competence in serving each segment.

The business area segmentation resulted in three segments which are presented as segment one, two and three. The business areas in segment one are where the company sees business growth potential and hence where it will develop strongly. The business areas in segment two are where the company already holds a strong market position but further growth is at a slower rate. And finally, the business areas in segment three is where market competition is too fierce, market growth is slow, and the company’s competence is not at the best. The quarry and aggregate business area is one of the segments the company wants to grow further. Based on this market segmentation, this thesis project focused on the quarries and aggregates business area for its growth potential and the company’s wish to grow in this segment.

1.2.3 Introducing the Quarry and aggregate business area
Quarry is a place where aggregate materials are mined. By aggregate materials it means sand, gravel and crushed rock. Quarrying involves activities such as extracting of aggregate material, crushing of the extracts to desired grain size, screening of crushed material, loading of extracted or crushed material on to the crushing equipments or trucks. So it involves a collaborative works between different equipments and production planning. Figure 1.1 shows an example of a quarry site.

Aggregate materials are used in the construction of roads, production of concrete, filling and more. In the year 2008, Sweden had a total consumption of 101.2 million tons of aggregate material (SGU report, 2009). Most of this consumption was towards road constructions, while concrete and filling purposes were also satisfied. Figure 1.2 shows the percentage consumption of aggregate materials in regards to the construction area.
Of the three aggregate materials, crushed rock makes the higher percentage of the total aggregate extraction. The natural deposit for sand and gravel is observed to be of declining order in Sweden (SGU report, 2009). This encouraged an increase in production of crushed rock which can substitute the sand and gravel aggregates. Figure 1.3 shows percentage of each aggregate production during the year 2008.

In the year 2008, there were about 2124 licensed quarrying pits in Sweden (SGU report, 2009). These pits are owned by big construction contractors and individuals as well. The major players in the Swedish quarry and aggregate business sector are the big construction contractors such as Skanska, NCC Roads (Ballast), SVEVIA, SWEROCK, and JEHANDER. These construction
contractors together own almost half of the licensed quarrying pits in Sweden and hence accounted for almost half of the yearly production of aggregate materials.

Volvo Construction Equipment is one of the major suppliers of construction equipments to be used in the quarry and aggregate business area; both for the big construction contractors and individuals as well. Some of these equipments are excavators, wheel loaders and articulated haulers. As mentioned in project directive section 1.2.2 of this report, Volvo Construction Equipment wishes to grow in the quarry and aggregate business area.

1.3 Project Purpose
The purpose of this master thesis is to develop a service concept towards a site performance improvement service, and tools and methodology to use while offering this service for selected customers in the quarry and aggregate business area by studying their operational process from a lean perspective. In addition, key performance indicators currently used by the customers will be identified in order to help visualize improvements which the service can bring about.

1.4 Problem statement
The project purpose is further divided into smaller and manageable research questions. Three research questions were formulated whose answers satisfied the project purpose. These are:

1. What service solution provides a business opportunity for Volvo Construction Equipment in the quarries and aggregates business segment?

In order to answer this research question, this thesis investigated the operational business process of selected customers within the quarry and aggregate business segment. A service concept which is a good business opportunity for Volvo Construction Equipment and also a solution or improvement for the customer is selected to take further into the development of the service. The service concept was evaluated against three criteria. These are customer desirability, organizational feasibility and business viability. The following research questions are based on the result of the first research question. The result of research question one showed that the Energy Efficiency Consultancy service as a service concept.

2. What are the key performance indicators currently in use by the customers to measure their energy efficiency?

The service concept is intended to improve performance, and hence it is necessary to identify how to measure this improvement and which performance indicators to use. This will help the customer to visualize its improvements. The customer performance measure system was studied if it is robust enough to be used to measure the performance improvement inevitable by the new service offer.

3. What tools and methods can be used while delivering this Energy Efficiency Consultancy service?

In order to turn the service concepts into practicality, it is necessary to develop tools and methods to use while delivering these services. Lean principles were studied and tested if they can be used as tools while offering the new service.

1.5 Project limitations
This study was entirely geared towards a selected target group and a few customers within the selected target group which limited its potential application of the results obtained to this selected group. Time was also a limiting factor which stopped the project at a build level, and not a test pilot launch. While studying the business processes, only the operational process was analyzed. Some of the information used while conducting this thesis might be of higher
confidentiality. However, a great attempt was made to satisfy the academic expectations of the thesis work and the company’s confidential information.

1.6 Company introduction

The Volvo Group

Volvo as a company was originally founded by two visionary gentlemen, Assar Gabrielsson and Gustaf Larsson. The Volvo group dates its origin back to 1927 when the first Volvo car left the production line in Gothenburg. Starting from the date of foundation, the company set its view on safety and quality to a higher bar. The founders expressed this view as “Since vehicles are driven by people, safety is – and must always be – the basic principle in all design work” (Volvo group broacher 2010). This view has extended in the company till today as the core values (figure 1.4) of the company: Quality, Safety and Environment.

![Volvo Group’s core values](image)

Figure 1.4 Volvo Group’s core values

Over the years, the Volvo Group developed from a local industrial company to one of the world’s largest manufacturer of trucks, buses, construction equipment, marine engines and engine components for the aircraft and aerospace industries. The group has grown to the stage it is today both organically and through acquisition of other reputed brands. With the acquisition of Renault Trucks and Mack in 2001, the position in the truck market was further strengthened, and the Group’s roots branched out to France and the US. During 2006 and 2007, the Volvo Group acquired the Japanese truck manufacturer UD Trucks, the US company Ingersoll Rand’s division for road machinery and majority of the shares in Lingong, one of China’s largest manufacturers of wheel loaders. In May 2008, an agreement was signed regarding the manufacture of trucks and buses with the Indian company Eicher Motors (Volvo group brochure 2010). Today, Volvo group is one of the world’s leading suppliers of transport solutions for commercial use and also financial solutions and services (Volvo Group presentation 2011). As most successful companies, Volvo Group is derived by a strong mission and vision.

The Group’s mission is stated as “By creating value for our customers we create value for our shareholders. We use our expertise to create transport-related hard and soft products of superior quality, safety and environmental care for demanding customers in selected segments. We work with energy, passion and respect for the individual” and the Group’s vision is “to be valued as the world’s leading supplier of commercial transport solutions” (Volvo Group presentation 2011).

The Volvo Group is divided in to different business area and business unit segments as seen in figure 1.5. More over, it has about 100, 000 employees, production facilities in 19 countries and operations in more than 180 countries in the world (www. Volvogroup.com). The Group’s business segments and areas are illustrated in the following figure.
The major business areas for the Volvo Group are trucks, busses, construction equipment, marine engines (Volvo Penta), aircraft components (Volvo Aero) and financial services. These business areas are supported by the business units Volvo 3P, Volvo Power train, Volvo parts, Volvo logistics, Volvo Business Services, Volvo Information Technology, Volvo Group Real Estate and Volvo Technology as indicated figure 1.5. This master thesis is proposed by Volvo Construction Equipment and Volvo Technology in collaboration. For this reason, a brief company description of Volvo Construction Equipment and Volvo Technology Corporation is given in the following sections.

**Volvo Construction Equipment**

As a member of the Volvo Group, Volvo Construction Equipment (VCE) is built on the three corporate values safety, quality and environment. Volvo Construction Equipment manufactures equipments for the construction and related industries. It is one of the world’s largest manufacturers of articulated haulers, wheel loaders, excavation equipments, road construction machines and compact construction equipment. Construction Equipment is the second largest business area next to trucks with in the Volvo Group as far as net sales is concerned and it employs over 16,000 people (Volvo CE corporate brochure, 2008).

Over the past years, Volvo CE grew both organically and by acquiring other brands. Some of the other brands acquired by Volvo CE are Ingersoll-Rand in 2007, lingong in 2006, Skat trak 2003, Samsung in 1998, Champion in 1997, Åkerman in 1991, and Zettelmeyer 1990 (Volvo CE corporate brochure). This helped Volvo CE’s product range to expand to the limit it has reached today. Some of the products included in Volvo CEs product range are wheel loaders, compact wheel loaders, Backhoe loaders, Excavators, Compact Excavators, Wheeled Excavators, Crawler Excavators, Articulated Haulers, Motor Graders, Milling Equipment, Pavers, Asphalt Compactors, Soil Compactors, Tracked Forestry Carriers and Pipelayers.

Volvo Construction Equipment provides customers around the globe in different industry segments. These major industry segments Volvo Construction Equipment provides equipments and services are: heavy infrastructure, road construction, quarries and aggregates, mining, agricultural and landscaping, building, Industrial material handling, recycling, forestry, oil and gas and demolition. The first four industry segments make up about 76 % of Volvo CE’s offer according to Volvo CE’s global website. This master thesis put the focus on the quarry and aggregate industry segment for reasons discussed in the section 1.2 project directives in this report.
Volvo Technology Corporation
Volvo Technology Corporation (VTEC) is considered as the centre of innovation in the Volvo group. VTEC has about 500 employees working located in Sweden, France, North America and France. VTEC supplies the Volvo Group business areas with research functions, advanced engineering, and product and service development.

Some of the innovation areas of VTEC are vehicle technologies and transport solutions, soft products, Electrical and Embedded systems, propulsion, process and manufacturing technologies and new technology innovation. Some of the specialist areas in the soft product development are professional services (customer development and expert consulting service), uptime systems and services (maintenance and repair and workshop services), intelligent transport systems and services, services supply chain and fleet management related services. This master thesis is part of VTEC’s soft product innovation area.
2. Theoretical framework
This chapter discusses about the necessary theoretical understandings in conducting this thesis project.

2.1 Understanding “service”
Nowadays, “service” has become one of the most mentioned words in the manufacturing and marketing industries. Also, it will be mentioned several times in this thesis work as well. This section will discuss several service definitions by different scholars and finds one definition which better suits the definition of service in this master thesis context.

2.1.1 Defining service
Several scholars have been contributing to the definition and characteristics of services. Few definitions are summarized in table 2.1.

<table>
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<tr>
<th>Author</th>
<th>Definition of Service</th>
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<tr>
<td>Vargo and Lusch (2004, cited in Edvardsson et al., 2005)</td>
<td>The application of specialized competences (skills and knowledge), through deeds, processes, and performances for the benefit of another entity or the entity itself</td>
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<tr>
<td>Grönroos (2001, cited in Edvardsson et al., 2005)</td>
<td>An activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems</td>
</tr>
<tr>
<td>Rathmell (1996, cited in Edvardsson et al., 2005)</td>
<td>A deed, a performance, an effort</td>
</tr>
<tr>
<td>SGD-P manual Volvo Technology</td>
<td>An activity or a series of activities, performed in interaction between a provider and a customer to fulfil a certain need</td>
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</table>

Table 2.1 Definitions of service

Edvardsson et al., (2005) states that service definitions available in the literature have different meanings depending on whether they are viewed from value-creation perspective or as an activity. In this master thesis, the major intention of developing the “performance improvement service” is to increase the customer satisfaction by co-creating value to/with the customer (which requires interaction between the customer and the service employees and/or physical resources). As a result, the definition presented by Grönroos (2001) can define service as far as it is referred in this master thesis project; “Service is An activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems”.

2.1.2 Characteristics of service
Another way to define service can be through studying characteristics of service. Zeithaml, Parasuraman and Berry (1985) state there are four distinct characteristics often used to define service, namely: intangibility, inseparability, heterogeneity and perishability. On the other hand Vargo and Lusch (2004) argue that these characteristics do not characterise services in general. They also argue that these characteristics only have meaning if services are being viewed from a
manufacturing perspective. Even so, it is interesting to know how service has been characterised for a long period of time until recently and what the new paradigm of service characteristics is. For that purpose only, these characteristics will be presented here.

- **Intangibility** is one of the most mentioned characteristics of service (Berry 1980; Lovelock 1981; Rathmell 1966; cited in Zeithaml et al., 1985) and that intangibility is the critical goods-service distinction. Intangibility refers to something that can not be seen, felt, tasted, or touched in the same manner in which goods can be sensed.

- Often the production and consumption of service happens simultaneously which is referred as Inseparability characteristics of service (Regan, 1963 cited in Zeithaml et al., 1985). This implies that the customer must be involved during the production of service.

- The other characteristic of service is heterogeneity. Heterogeneity concerns the potential for high variability in the performance of services (Zeithaml, Parasuraman and Berry, 1985). The fact that service often involves interaction between many service employees with as much customers raising a problem of consistency of behaviour and hence service. Heterogeneity describes the fact that services are of high variability and less standardised as a result.

- **Perishability** is the other characteristic of service which referees to that service can not be saved or inventoried (Thomas, 1978 cited in Zeithaml et al., 1985). This is believed so as a result of the intangible characteristic of service. It is intended to imply that because services are intangible, unlike goods, they can not be produced at one point in time, inventoried, and sold at a later time when demanded.

In contrary to this, Vargo and Lusch (2004) state that much of the discussion of the relationship between goods and services has focused on how they characteristically differ from each other, while these (Intangibility, Inseparability, Heterogeneity and perishability) characteristics fail to delineate services from goods adequately. Some of the new perspectives where these characteristics fail to hold are exemplified in the following section.

- Though intangibility is the most commonly used service characteristic, some authors’ works display that by these criteria, there are no pure services or goods (Swartz, Bowen, and brown 1992 cited in Vargo and Lusch, 2004). This is to mean that all goods or products have some service component attached to them and at the same time services have a possibly tangible representation. An example can be a hospital service where one gets operated which the results might be getting better, worse or dying (Gummesson, 2000 cited in Vargo and Lusch, 2004). In this case the service can really be made tangible or with tangible results. Also, goods are desired by customers to extract service. And hence there are circumstances where characterizing services as intangible in general does not hold.

- Inseparability, as distinct characteristics of service, does not hold in cases where manufacturers are involving customers in the development and production of goods. Also, some or parts of service can be produces away from the customer as in financial and entertainment services (Lovelock 2000 cited in Vargo and Lusch, 2004).

- Heterogeneity, as to mean none standardised fails to characterize all services today. An example is presented in Vargo and Lusch (2004) as “at least parts of many services, such as airline transportation, medical procedures, or the provision of information through commercial databases, are as standardized and homogenized as the production of the airplanes, medical instruments, and computers on which they rely”.

- Perishability as to mean service can not be produced now and sold at a later time does not hold all the time according to Gummesson (2000 cited in Vargo and Lusch, 2004). It gives
examples on how services are stored in systems, buildings, machines, knowledge and people. Also, it discusses that goods can be perishable too, having a limited life span.

Looking at the two perspectives of characteristics of services, it can be understood that these characteristics do not describe service at all times. Rather, it is possible to examine goods and services closely and decide where they lie in the characteristics continuum. This is to mean some services may be more tangible than others, can be saved in some way, and standardized.

### 2.2 New service development

New service development is a relatively new area of research when compared to the new product development. This has put a challenge on managing new service development. The need to have a well structured service development model is a necessary factor in order to realize a launch of successful service. However, some studies (Shekar, 2007) show that majority of service firms have no or use an informal process to develop service products.

Service development and product development processes obviously have similarities but with different relative importance of each activities with in (Shekar 2007). An example for this is presented in Shekar (2007) as “The critical factor for services- the importance accorded to innovation activity in the service firm’s human resource strategy- ranked third in importance for manufacturers. Service innovation and quality ranked third in importance for service firms”. Marisa et al. (2009) claim that many organizations use the new product development models to new service development and thus a possible point of failure as services have innate differences with products which need to be considered during the design stage. Shekar (2007) has put it in another way as “Services differ from goods in some important way and these differences present special challenges to service developers”. Literature review on new service development resulted in the following models.

Studying the different service development models presented in the literature, it is easy to notice the resemblances between all though they differ in how explicitly their activities are stated. Adopting from the new service development models indicated in figure 2.1 and 2.2, the model in figure 2.3 is used for the development of the service in this master thesis. The major reason to adopt the service development model is due to the fact this master thesis objective is limited to creating the service concept and building few components of the service offering.

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<td>Exploration</td>
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<td>Screening</td>
<td>Idea generation</td>
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<td>Comprehensive</td>
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Figure 2.1 Service development process models cited in Shekar (2007)
Outcome of new service development processes

Edvardsson and Olsson (1996) explain that the outcome or end product of following new service development process is a “service prerequisite” and not the service itself. The service prerequisites are all the necessary concepts, technical resources and administrative processes which will create the media for the service provider and the customer to interact and hence create the service. The important thing to note here is that it needs a customer activity in order for the service to be realized. This prerequisite for service contains three basic components: service concept, service process and service system (Edvardsson and Olsson, 1996). Each of them is explained in the following section.

The service concept

An organization offering a service can only do it after integrating a number of assets, processes, people and materials. The service concept is considered the heart of the service development as much of the service components are decided or influenced by the basic service concept the service organization defines at the very beginning of the service development.

Different authors and service developers define the service concept in several ways. Heskett (1986, cited in Susan et al., 2002) defines it as the way in which the organization would like to have its services perceived by its customers, employees, shareholders and lenders. This is similar

Figure 2.2 Service development model referred in Marisa et al., (2009)

Figure 2.2 service development structure followed in this master thesis
to saying the organization’s business proposition. Edvardsson and Olsson (1996, cited in Susan et al., 2002) define the service concept as the detailed description of what is to be done for the customer and how this is to be achieved. The “what” answers the needs and wishes of the customer to be satisfied and the “how” refer to the service system and process which enables the service provider fulfils the customer’s needs and wishes. In another work, Edvardsson et al., (2000 cited in Susane et al., 2002) define the service concept as a detailed description of the customers needs to be satisfied, how they are to be satisfied, what is to be done for the customer, and how this is to be achieved. Another definition of the service concept by Johnston and Clark (2001 cited in Susan et al., 2002) divides the service concept in to four segments which together make up one whole concept. These are the service operation, service experience, service outcome and value of the service. The service operation is the way in which the service is delivered, the service experience is the customers’ direct experience of the service, the service outcome is the benefits and results of the service for the customer and the value of service is the benefits the customer perceives as inherent in the service weighed against the cost of the service. Edvardsson (1997) refers that the service concept covers both the description of the customer needs to be satisfied and how they are to be satisfied in the form of the content of the service package. Smith, Fischbacher and Wilson (2007) refer the service concept as the utility and benefits provided for the customer.

It can be understood from the above definitions that the service concept creates the scope, defines every event and unit in the scope and a process communication with both the customer and the service provider. Significance of having a clearly defined service concept is to make it clear for the customer what to expect from the service provider, and also for the service provider to make sure to satisfy the customer. In other words, the service concept creates a clear media where the intent of the service provider and the customer needs meet. In another dimension, it also mediates between what to deliver and how to do it. The service concept plays a core role for service design decisions in the later stage of the service development. In figure 2.3, a simple service concept model is presented as explained by Susane et al., (2002).

![Service Concept Model](image)

**Figure 2.3** the service concept model (Bo Edvardsson and Jan Olsson, 1996)

Taking a look at all the definitions presented above, it is clear to see that what to deliver and how to deliver the service is common to most. As a result of that, in this thesis, the service concept is defined as constituting of the value of the service, the service operation or “the-how” and the service outcome or “the-what”. By value, it means the benefit the customer perceives as inherent in the service weighed against the cost of the service. The service operation can be explained as the way in which the service is delivered and the service outcome is explained as the benefits and results of the service for the customer. The service concept identifies the customer needs to be satisfied and in what way, which is used in designing the service system and service process which are defined in the following two sections.
The service system
A service is a result of integration between activities, technical prerequisites, administrative processes and customer interaction. For a successful integration of these components, a stable system is required capable of providing all competences and technologies required. This system is often referred as the service system. Smith et al., (2007) explains it as “The service system incorporates the resources available to the process for realizing the service concept”. Edvardsson and Olsson (1996) identify some of the resources which should be included in the service system as follows: “The various sub-system of the service system is made up of the service company’s staff, the customers, the physical/technical environment and organization and control”.

The customer is part of the service system as it puts a significant influence on the service prerequisite. Factors from the customer side which influence the service prerequisite are the customer’s knowledge, equipments, information flow systems and administrative systems. For a successful service, understanding the customer need and expectation is vital.

Often services are assisted by products or they will be based on some sort of equipments. The physical or technical environment in the service system includes the premises, computers and other technical systems.

One of the most important components of the service system is the service company’s staff. The commitment and knowledge of the staff is easily sensed by the customer and hence influencing the customers perception about the service quality. This implies that setting high quality technical prerequisites and service process is not just enough to guarantee successful service offering.

The organizational and control of the service system includes the organizational structure, administrative support systems, information and feedback flow systems and finally the marketing activities. Figure 2.4 shows a service system model.

![Service System Diagram](image_url)

Figure 2.4 the service system model (Bo Edvardsson and Jan Olsson, 1996)

The service process
Sequences of activities need to be performed between the service provider and the customer for the service to be experienced. These chains of activities are referred as the service process. The service process includes interfaces between departments, customers and suppliers and requires detailed consideration of processes and activities contributing to the service (Smith et al., 2007). A note should be made up n the difference between the service process and the customer process. The service process is a stable process which can handle several customer processes. This means the customer process with in the subset of the service process and does not necessarily trace all the steps in the service process. This implies that the customer process is customized. Edvardsson and Olsson (1997) explain the service process as “Service process refers to the prototype or model for various customer processes. It must be able to handle a number of customer-specific processes”.

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Development of the service process includes a detailed description and specification of sequences of activities, employee responsibilities, customer responsibilities, quality standards, standard service, times, equipment etc. Computer simulations and service blueprints can be used to assist the development of service processes. In both computer simulations and service blueprints, a clear flowchart of activities is displayed along with visual lines of interaction, visibility, and internal interaction. Both the employee and customer should understand the service process in order for the service to be efficiently realized.

In general, the prerequisites to service are summarized in figure 2.5. The deliverables of this thesis project are the service concept and parts which make up parts of the technical and physical environment of the service system (tools and methodologies to use while offering the service).

![The service concept](image)

**Figure 2.5** The service prerequisite model (Bo Edvardsson and Jan Olsson, 1996)

### 2.3 Incremental and radical new service development

Incremental service development implies to improvements or small stepwise extensions of existing service offerings while radical service development implies the introduction of new service offerings. In radical service development, the new service offerings may be new-to-the-world or new-to-the-service offering company. This master thesis was intended to explore new service offering which the company had not been offering before and device methods on how to deliver this service. As a result, it is worth studying the factors influencing success of developing new service concepts and use them throughout the service development.

The degree of innovativeness (ranging from incremental to radical or the extent to how “really new” the service is), shades certain influence on the success of new service development. One of these influences is on the rate of success of the new service. Incremental new service uses an already existing company resource and experience which lowers the risk and effort required in developing them (de Brentani, 2001). This results in a higher rate of success when compared to highly innovative new service. As far as profitability of the new service is concerned, both incremental and highly innovative services have support to each other. This is because, though service companies can make a great deal of revenues from a highly innovative new service, in order to remain competitive it is necessary to support these highly innovative service with continuous incremental service which enables the service match to changing customer needs. This implies that profitability can be earned from both incremental and highly innovative new services and also both types of service developments are necessary for overall performance of the company. This necessitates knowing success factors in developing new service. These success factors can be categorized into four distinct groups (de Brentani, 2001) as: *product related (product implies the service and not goods), market related, company related and process related.*
**Innovativeness and product (implying the service) related success factors**

Examples of success factors related to the newly developed service are service superiority and complexity (de Brentani, 2001). Service superiority refers to comparative advantage of the new service over previously existing services. In order to have a successful new service offer, service providing company should be able to demonstrate the differentiating factor of the new service from other competing ones so that the customer can realize the value. Different approaches to demonstrating this differentiation should be taken depending on the degree of innovativeness of the new service. In the case of incremental services, the customer is already involved in the value creation by the basic service offer. Thus, providing the customer with more satisfying experience using the incremental new service can provide a good way to demonstrate the differentiation of the new service offer (Berry 1995, Edvardsson 1995, Gummesson 1993 cited in de Brentani, 2001). However, in the case of radical service innovations the fact that the new service is totally unfamiliar to the customer poses a challenge to the service provider to demonstrate the value of the new service. In this case, a strong interaction and dialog with the customer is necessary (Berry 1995, Edvardsson 1995, Gummesson 1993 cited in de Brentani, 2001).

The other success factor is complexity of the new service. Complexity of the new service refers to how complex the service process, system and technologies used are. Both incremental and radical innovations can result in highly complex or simple service innovations. The complexity of the new service imposes a challenge in a way that new complex service innovations can create customer system downtime because of the unfamiliarity and the need for new skills of service employees (de Brentani, 2001). Also due to complexity and unfamiliarity a higher degree of customer faith and trust is required in collaborating to the value creation which can pose a negative effect in the success of the new service.

**Innovativeness and market related success factors**

Some of the market related success factors when introducing new service are competitiveness, market attractiveness and customer need fit. Competitiveness refers to how strongly the new service competes against similar services offered by other service providers. Services are easy to directly imitate and are less protected by corporate patents which makes it more difficult for the service offering companies to benefit from initial competitive advantage (Terrill 1996 cited in de Brentani, 2001). This implies that radical service innovations are more affected by competitive conditions as firms take their time and effort to develop new radical service innovations only to be easily competed by other firms developing similar service soon after.

The other success factors are market attractiveness and customer need fit. This refers to the potential of the service to be demanded in the market or the market size and customer need fit refers to the ability of the service to solve specific customer problems and needs. For incremental service innovations, vary large market size is less important because they build up on previously existing base services and lesser resource and investment requirement resulting in lesser investment risk for the customer (Clark, 1993 cited in de Brentani, 2001). The fact that incremental service innovations use already existing services and resources also implies the possibility to offer the new service to an already existing customer market with an ease of demonstrating the value of the new service offer. To go along with this, incremental service innovations can easily continue successfully as long as the customers are made aware of the value they are getting because it is not easy for the customers to change service providers due to its cost and potential delay to get it up and running.

**Innovativeness and company related success factors**

Some of the company related success factors are strategic and resource fit. A service offering company needs a well defined new service strategy to guide the new service innovations in to the market. As a consequence, the degree to which the new service innovation fits the service offering company’s strategy is a success factor (de Brentani, 2001). If the new radical service
Innovations are out of the market domain in which the service offering company is operating, then a higher challenge is faced to guide the new service in the market due to lesser trust from the customer and thus higher investment risk for the customer to buy the service and also for the service provider to develop the service.

The other company related success factor is resource fit. Resource fit refers to the extent to which the new service innovation uses the company’s core competences, skills, physical resources and experiences. Since incremental service innovations use already existing base service offers, they have a better opportunity to use an already accumulated core competence, skills and resources and hence a better success (de Brentani, 2001). An example to this can be services which require a high skill and knowledge as in professional services benefit from an existing skill in the service offering company resulting in lesser risk of errors and higher trust from the customers. And that has a positive influence in the success factor. On contrary, if a service company moves in to totally new radical service innovations a challenge arises in developing as well as marketing the new service. This is also supported by Giffin et al. (1997 cited in de Brentani, 2001), and Khurana et al. (1998 cited in de Brentani 2001) and is stated in de Brentani (2001) as “Discontinuous (to mean radical) ventures typically have a lower resource fit than product improvements. In cases of really new service, these firms are usually operating in uncharted areas where prior experience is limited or inapplicable; they face significant threats due to high level of uncertainty, error, and a longer, more costly development process”.

**Innovativeness and process related success factors**

Process related success factors refer to following well defined service or product development processes. Companies who achieve a great success in introducing new goods or services use a well defined development process with gates between each process steps to ensure the new innovation meets company and market success factors. When applied to the relative importance of these development processes to incremental and radical service innovations, de Brentani (2001) poses a question if the same formal development processes could be applied for both incremental and radical innovations. Some authors suggest following well defined development processes are of more merit to incremental innovations than radical innovations as the gates in these development processes might not let the development project precede as market condition to radical innovations can be vague while once the new service is developed it can hit the market so high.

The above success factors in developing new service or products are taken in to consideration while doing this thesis project. That is made by including the success factor perspectives in to consideration while setting the idea screening criteria and actually screening the new service concept ideas.

**2.4 Manufacturers going in to service**

Service has become increasingly important in the manufacturing industry for economic, customer satisfaction and competitive reasons (Oliva et al., 2003). According to Gebaur (2006), “The rationale for extending the service business proceeds along three lines: financial, marketing and strategic opportunities”. Also, as Brax (2005) put it, “manufacturers have several reasons to include more services in their total offering to: facilitate the sales of their goods, lengthen customer relationship, create growth opportunities in matured markets, balance the effects of economic cycles with different cash-flows, and respond to demand and raise customer satisfaction”. However, manufacturers for a longer period of time were focused on only providing goods and the all sudden shift of wanting to provide service has not proved to be easy. Moreover, manufacturing companies who have successfully made the shift to pure service providers are observed following a certain pattern of transition. Volvo Construction Equipment as being mainly of a manufacturer has the possibility to face some of the challenges of becoming a service provider similar to the service developed in this master thesis project. For this reason, it
makes it interesting to know what challenges manufacturers face in the path towards becoming a service provider and how did some successful manufacturers made the shift.

2.4.1 Mix of manufacturing companies offerings
Manufacturing companies today offer different mixes of offerings, including services more and more. Some authors have derived a classification of the mix of offerings by manufacturing companies. Two examples are summarized table 2.2.

<table>
<thead>
<tr>
<th>Author</th>
<th>Mix of offerings by manufacturing companies</th>
</tr>
</thead>
</table>
| Kotler (2003 cited in Brax 2005) | 1. pure tangible good  
2. Tangible goods with accompanying services  
3. Hybrid  
4. Major service with accompanying minor goods and services  
5. pure services |
2. Goods and services- Goods dominant  
3. Service and goods- Service dominant  
4. Service only |

Table 2.2 Mix- of manufacturer’s offerings Brax (2005)

From the two mixes of offerings above, the increasing intensity of service offerings is noticeable. The continuum stretches from pure goods to pure services. The common type of offering in the manufacturing companies is a mixture of goods and services. Brax (2005) put it as “Today, a typical manufacturing company has a total offering of tangible goods with accompanying services, but the trend is toward the hybrid, and for some, the major service focus”. Since goods dominated the offerings of manufacturers before and services are getting more importance today, there is a clear indication that there has been a certain transition path towards becoming more service oriented presented in section 2.4.3.

2.4.2 Challenges of manufacturers going in to services
Oliva et al. (2003) states that there are three challenges manufacturers need to overcome in making he transition from goods provider to service. These believing the economic potential, building the competence required to deliver the services and deploying successful service strategy. Also, Brax (2005) identified and categorized challenges in to the following clusters: “marketing, production, delivery, design, communication and relationship”. The challenges mentioned by Oliva (2003) can be included in the ones presented by Brax (2005). The marketing and design related challenges are the basic ones and is discussed below.

Marketing related challenges
In order for the customer to realize the value of the service offer, it is necessary to have a good cooperation between the customer and service provider. This implies that, the traditional transactional based relationship which worked for the goods dominant business model does not work fine in cases of marketing services (Brax, 2005). This brings about the need to have a clearly understandable concept of the service which motivates the customer to the service co-production in a continuous manner.

The other marketing related challenge for manufactures is that making the paradigm shift from thinking services as a mere add-ons to goods just to facilitate the sales of goods. As Brax (2005) explains it, “In order to become a service-focused total offering, services can not be merely added on top of original goods-dominated total offering, but a more radical approach is necessary to question the implicit view of the world in which the company operates”.

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Design related challenges
Services have a higher heterogeneity than goods products. This implies that services need to be
adjusted to different cultures and applications specific to each customer. In order to have a
highly customized service to each customer, a distinct new service development process is
necessary which puts much attention on the study of the customer’s needs and business process.
Brax (2003) explains, “Knowing the customer’s business context and operational conditions is
fundamental”.

2.4.3 Success factors for increasing income from services
Though the economic benefits of service is known, there are challenges faced by manufacturers
in an attempt to increase service revenues successfully (Gebaur et al., 2006). According to a
result of a survey research conducted mainly over German and Swiss machinery and equipment
manufacturing industries, by Gebaur et al. (2006), many manufacturers fail to obtain a high
return from their service offerings. Figure 2.6 summarizes this study.

Figure 2.6 service revenue in manufacturing companies (Gebaur et al., 2006)

Three major success factors are presented by Gebaur et al., (2006) responsible for increasing
revenues from service in manufacturing companies. These are market oriented service
development and clearly defined service development process, sequential transition from product
related services to services supporting the customer and relationship marketing.

Market oriented service development benefits the service provider in understanding of the
customer needs (De Brentani, 2001). This will ensure the fact that the service offer will
successfully satisfy the customer needs which in turn guarantees the success of the service offer
in the market. In order to develop a service offer highly accepted in the market requires
following a well defined service-development process (Gebaur et al., 2006).

The other success factor is making a sequential transition from product related services to
customer process oriented service offers. Equipment manufacturers offer products which usually
have a longer life in operation. These kinds of products usually consume various kinds of service
(repair, maintenance, spare parts etc.) as they go along their life cycle (Gebaur et al., 2006).
Oliva and Kallenberg (2003) state that durable products have owning cost beyond the purchase
price due to their consumption of services during their life cycle. One term used in the literature
to describe these services is installed base services. Installed base services are “the range of product or process related services required by the end user over the useful life of a product in order to run it effectively in the context of its operating process (see table 2.3 below). Product manufacturers have an advantage when offering installed based services which contribute to the success of the manufactures as a service provider. These advantages are lower customer acquisition cost (since manufacturers have information about the customers using the products), lower knowledge acquisition cost and lower capital requirements.

The study by Oliva and Kallenberg (2003) conducted over 11 German capital equipment manufacturers suggest a stepwise transition of manufacturers in to service offerings, learned from the manufacturers who successfully made the transition. These steps are:

1 Consolidating the product related service offering: This is to collect services under the same organization, which traditionally grow in different parts of the organization, and follow the effectiveness and efficiency of each service on its own.
2 Entering the installed base service: “This implies identifying a profit opportunity with in the service arena and setting up the structures and process to exploit it”, Oliva and Kallenberg (2003).
3 Expanding to relationship based services: This require the change in interaction from transaction-based to relationship-based service offer. In other words, the service is prices with respect to availability of the equipment and not by counting man hours and parts consumed every time a service is offered.
4 Expanding to process-centered services
5 Taking over end user’s process: This stage marks becoming a pure service organization where the service provider takes an entire responsibility of the end-user’s process (Oliva and Kallenberg, 2003).

All the above success factors need to be considered while attempting to become a service provider.

<table>
<thead>
<tr>
<th>Transaction-based services</th>
<th>Product- oriented services</th>
<th>End user’s process oriented services</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic installed base services</td>
<td>Professional services</td>
</tr>
<tr>
<td></td>
<td>Documentation</td>
<td>Process-oriented engineering</td>
</tr>
<tr>
<td></td>
<td>Transportation to client</td>
<td>Process-oriented R&amp;D</td>
</tr>
<tr>
<td></td>
<td>Installation/commissioning</td>
<td>Spare parts management</td>
</tr>
<tr>
<td></td>
<td>Product-oriented training</td>
<td>Process-oriented training</td>
</tr>
<tr>
<td></td>
<td>Hotline/Help desk</td>
<td>Business-oriented training</td>
</tr>
<tr>
<td></td>
<td>Inspection/diagnosis</td>
<td>Process-oriented consulting</td>
</tr>
<tr>
<td></td>
<td>Repair/ Spare parts</td>
<td>Business-oriented consulting</td>
</tr>
<tr>
<td></td>
<td>Product updates/ Upgrades</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Refurbishing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Recycling/machine brokering</td>
<td></td>
</tr>
<tr>
<td>Relationship-based services</td>
<td>Maintenance services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preventive maintenance</td>
<td>Operational services</td>
</tr>
<tr>
<td></td>
<td>Condition monitoring</td>
<td>Managing maintenance function</td>
</tr>
<tr>
<td></td>
<td>Spare parts management</td>
<td>Managing operations</td>
</tr>
<tr>
<td></td>
<td>Full maintenance contracts</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.3 Service offer space by equipment manufacturers (Oliva and Kallenberg, 2003)
2.5 Performance measurement

One of the challenges in introducing innovative new service is to be able to communicate the value of the new service concept and create customer trust on the functionality of the new service offer. One helpful method to do this is helping the customer visualize the potential improvement to his/her business performance. This also applies to the new service offer developed in this master thesis project. This raises the interest to study performance measurement systems and performance indicators.

Tangen (2003) states that performance measurement has become a popular research topic lately. This is because appropriate performance measures can help allocate resources to the most effective improvement activities. Neely et al., (1995) defines performance measurement as “the process of quantifying the efficiency and effectiveness of action”. In the same manner, Neely et al., (1995) defines performance measurement system as “the set of metrics used to quantify both the efficiency and effectiveness of actions”. Effectiveness refers to the limit to which customer requirements are satisfied, and efficiency refers to how economically resources are used when providing a given level of customer satisfaction.

There are several reasons to the use of performance measure systems. Fawcett (1991 cited in Toni and Tonchia, 2001) state two reasons for the use of performance measure systems: “to compare one’s own competitive position with that of the competitors and to check on the accomplishment of one’s own objectives”. Neely (1998 cited in Toni and Tonchia, 2001) states three different roles of performance measurement systems: “to comply, to check, and to challenge”. In their study carried out on 115 firms, Toni and Tonchia (2001) found out three different types of general use of performance measurement systems: “(1) planning, control and coordination of activities (2) Control, evaluation and involvement of human resources and (3) benchmarking”. This implies the importance of having a set target or benchmark (internal or external) in performance measurement systems to motivate improvement.

Performance measurement systems can be classified in to two broad categories (Toni and Tonchia, 2001) as measuring Cost performances and Non- cost performances. Table 2.4 summarized the two categories of performance measures.

The cost related performances are easily linked to the final results of the firm as in net income or profitability (Toni and Tonchia, 2001). It is also possible to define them in a mathematical relation. Cost performance measures can further be classified in to production costs (costs of materials, labour and machinery) and productivity measures (the overall productivity of the firm which is the total productivity and specific productivity which is productivity of a segment of the firm as is labour productivity or equipment productivity). Non-cost performance measures can be measured by non-monetary units of measure (Toni and Tonchia, 2001).

<table>
<thead>
<tr>
<th>Performance measures</th>
<th>Non-cost performance measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost performance measures</td>
<td>Non-cost performance measures</td>
</tr>
<tr>
<td>Production costs</td>
<td>Time</td>
</tr>
<tr>
<td>• Materials, labour and machinery</td>
<td>• Internal</td>
</tr>
<tr>
<td>Productivity</td>
<td>• External</td>
</tr>
<tr>
<td>• Total</td>
<td>Quality</td>
</tr>
<tr>
<td>• Specific</td>
<td>Flexibility</td>
</tr>
</tbody>
</table>

Table 2.4 classification of performance measurement systems adopted from Toni and Tonchia (2001)
One of the non-cost performance measures is time performance measurement which is further divided into internal (run times, set-up times, wait and move times) and external (system times, delivery seed and time-to-market) (Toni and Tonchia, 2001). In the same study, Toni and Tonchia (2001) identified four types of quality measures: produced quality (counting defects), perceived quality (customer satisfaction), in-bound quality (vendor quality rating) and quality cost (“quality system” costs and the amount of reworking).

Each of the above performance measures need to be designed in a way that they are simple to understand, have visual impact, focus on improvement and be visible to everyone (Neely et al., 1997). In the same work, a framework of what a good performance measure should constitute and constructed as a performance measure record sheet and is presented in table 2.5.

In this specific master thesis, there is the need to measure the performance of the service offer. The approach used it to check if the customer already has a performance measure system which the operational improvement inevitable by the new service offer can be measured by. Therefore the case company’s performance measure system was studied from this theoretical perspective.

<table>
<thead>
<tr>
<th>Details</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>A good title is one that explains what the measure is and why it is important.</td>
</tr>
<tr>
<td>Purpose</td>
<td>A clearly defined purpose of the measure is important.</td>
</tr>
<tr>
<td>Relates to?</td>
<td>Performance measures should relate to a business objective of the company, and it should be made clear to which business objective each measure is connected to.</td>
</tr>
<tr>
<td>Target</td>
<td>An appropriate target for each measure should be recorded.</td>
</tr>
<tr>
<td>Formula (indicator)</td>
<td>A carefully selected performance indicator is necessary.</td>
</tr>
<tr>
<td>Frequency</td>
<td>How often the performance needs to be recorded?</td>
</tr>
<tr>
<td>Who measures?</td>
<td>The person who is to collect and report the data should be identified.</td>
</tr>
<tr>
<td>Source of data</td>
<td>The source of data should be identified.</td>
</tr>
<tr>
<td>Who acts on the data?</td>
<td>The person who is going to act on the data should be identified.</td>
</tr>
<tr>
<td>What do they do?</td>
<td>Define a management process that will be followed should the performance measure result shows a need for some changes to be made. This is where improvement activities are initiated.</td>
</tr>
</tbody>
</table>

Table 2.5 the performance measure record sheet (Neely et al., 1997 pp. 1138)
2.6 Introducing lean Principles
One of the deliverables of this master thesis was the tools and methods to use while delivering the site performance improvement service. As can be recalled from the project purpose definition, these tools and methods are to be inspired from lean thinking. As a result, it was necessary to study what lean principles are and how tools from lean thinking can be used to complement the technical environment of the service system. Literature search on the application of lean principles in the quarry and aggregate operation resulted in too little relevant information. The search strings used were: lean quarry operation, lean principles in mining and lean tools in quarrying. The databases used were Google scholar, Science Direct and Scopus. Instead, any search around lean showed ample application within the manufacturing industry. Searches using a search string lean resulted in many hits. Two of the most popular hits were the books “Lean thinking- Banish Waste and Create Wealth in Your Corporation” by Womack and Jones and “The Toyota Way- 14 management principles” by Liker. Mainly these two books are used to discuss the Lean principles and identify which tools and methods can be used to improve performance in the quarry and aggregate operational process.

Lean thinking and principles
Lean thinking provides a way to specify value, line up value- creating actions in the best sequence, conduct these activities without interruption whenever some one requests them, and perform them more and more effectively (Womack and Jones, 2003). Lean thinking sets its base on identifying and eliminating waste from a business process (A waste is any process or action which consumes resources but does not add value to the product). This means lean thinking helps in doing more and more while using less and less resources and hence providing customers with exactly what they want. In general, lean thinking is constructed by putting together five lean principles: specify value, Identify value stream, create flow, pull and perfection (Womack and Jones, 2003). Each of these principles are discussed in the following sections.

Specify Value
Value is what customers regard as important part of a product (good or service) and which they are willing to pay for. Womack and Jones (2003) claim the critical starting point for lean thinking is to specify value and this value should be defined by the ultimate customer. This is because the producer is in its place to create these values for the customer and should not waste any resource on activities which do not add these values required by the ultimate customer. Therefore, organizations which strive to take a lean path must start to define the value of their offerings by asking “what does the customer want from this process?” As Womack and Jones (2003) put it, “lean thinking therefore must start with a conscious attempt to precisely define value in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers”. This sets the base line for what is needed and what is a waste or the value stream, which is discussed next.

Identifying the value stream
Often, business processes are combinations of several actions connected sequentially. The set of all specific actions, required to bring a specific product (goods or services) to the customer is called the Value stream (Womack and Jones, 2003). These specific actions in the value stream starts from a concept for a product to design, production launch, information flow, actual physical transformation in manufacturing and etc. Value stream identification and analysis is the act of mapping the all the actions or processes and identifying which steps in the process are value adding to the final product, while value is defined from the customer viewpoint.

Womack and Jones (2003) assert that value stream analysis almost always display three categories of processes occurring along the value stream. These are:
1. Processes which create value
2. Processes which create no value but which can not be avoided with current technology and production assets
3. Processes which create no value and which can be avoided immediately

Processes (2) and (3) are wastes and need to be eliminated or minimized as much as possible in order to create a leaner process. Value stream mapping reveals wastes in the process. Liker (2004) presents seven types of wastes identified by the automaker Toyota in business or manufacturing processes which are listed below:

1. Overproduction: producing items for which there is no immediate use and hence causing wastes such as overstaffing, storage and unnecessary transportation costs of moving around excess inventory.
2. Waiting: employees waiting for resources, machines waiting for items to process and equipment down time. Waiting causes waste of time and other resources (e.g. Waste of energy when equipment is idling and waiting for work).
3. Unnecessary transport or conveyance: carrying work in progress long distances, creating inefficient transport, or moving materials, parts, or finished goods in to or out of storage or between processes.
4. Over processing or incorrect processing: taking unneeded steps to production or even providing higher quality of products than necessary.
5. Excess inventory: Excess raw material, work in progress, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay.
6. Unnecessary movement: Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools etc.
7. Defects: production of defective parts which require rework or scrap.

In traditional production systems where there is overproduction and large inventory, these wastes are not easily visualized and eliminated. Womack and Jones (2003) state that the key technique to eliminate waste is to create flow, which is presented in the following section.

**Create flow**

After the value stream for the process or production is identified and all the unnecessary steps avoided, the next step is to create flow (Womack and Jones, 2003). Liker (2004) states that flow is at the very centre of a lean message that shortening production time (from raw material to finished good) leads to best quality, lowest cost and shortest delivery time. Creating flow means to make value flow in a continuous manner or avoiding batch production. The reason to avoid batch production is as there is always waiting between batches which is a waste. Moreover, when products flow in smaller batches or one-piece (if applicable) defects and wastes surface out easily which leads to better quality in the end.

Flow requires a different arrangement of equipments than a batch production system. In batch production, equipments are arranged by department where similar equipments are grouped together under the same workstation (Liker, 2004). This raises the need for transporting work-in-progress inventories from department to department which is waste. Whereas in a production system where there is flow, equipments are grouped according to the product value stream, and not the process (Liker, 2004).

One important factor in creating flow is to make sure all work stations or equipments work at a similar rate so that there would not be bottle necks or waiting. And this rate should be similar to the rate at which the customer orders the product. Creating flow and moving products faster in the value stream does not guarantee becoming lean. It should be followed by being able to
provide the customer with what and when they want them. The technique for this is called pull system, which is discussed in the following section.

**Pull system**

Liker (2004) presents how pull system is interpreted by Toyota, one of the largest automakers, as “the ideal state of Just-in-time manufacturing: giving the customer (which may be the next step in the production process) what him or her wants, when she or he wants it, and in the amount he or she wants”. Similarly, Womack and Jones (2003) define the pull system as “Pull in the simplest terms means that no one upstream should produce a good or service until the customer downstream asks for it”. This means no product is produced and pushed downstream creating unnecessary inventory and work-in-progress causing waste. Rather, the customer pulls the flow of value.

**Perfection**

Combining specifying value, identifying the value stream, creating flow and pull system helps remove waste in an organization and achieve better performance. The implementation of these four lean principles brings about a radical improvement in an organization and also helps realize that improvements are continuous and endless (Womack and Jones, 2003). Through continuous improvement of the value flow makes it possible to deliver exactly what the customer wants, to a near perfection. And thus, perfection through continuous incremental and radical improvement of the business process makes the fifth lean principle.

These lean principles are used to complement the technical environment of the Energy Efficiency consultancy service in the quarry and aggregate business area. These principles are tested if they can be used in identifying and eliminating wastes related to energy consumption.
3. Research methodology
This section presents the research approach, the research design (how the research purpose, research questions and data collection techniques are created), and what is done to ensure the validity of the research is presented.

3.1 Research approach
There are three possible approaches to a research design. These are qualitative, quantitative and mixed approach. It is necessary to make a choice from the three approaches listed above in order to have a well structured research design and hence outcome. In order to do that, perhaps the first step is to learn what constitutes each method. Creswell (2006, pp. 3) suggests three framework elements of each approach to consider while learning qualitative, quantitative or mixed approach. These are: philosophical assumptions about what constitutes knowledge claims, general strategy of research called strategies of inquiry, and detailed procedure of data collection, analysis and writing called methods. After assessing these elements of framework, the research approach is selected. Bryman et al. (2007, pp 28) described the basic characteristics of qualitative and quantitative research approaches as follows:

Quantitative research can be constructed as a research strategy that emphasizes quantification in the collection and analysis of data and that entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories.

Qualitative research can be constructed as a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data and that predominantly emphasizes an inductive approach to the relationship between theory and research in which the emphasis is placed on the generation of theories.

This thesis is mainly about exploring, conceptualizing and building a potentially new service in the construction business area which does not involve testing of a pre-existing theory. The expected result of the thesis is more inclined to be expressed in a qualitative manner than quantitatively. For this reason a qualitative research approach is used in this thesis. Table 3.1 shows generic steps taken in selecting the research approach and design.

<table>
<thead>
<tr>
<th>Approaches to Research (step 1)</th>
<th>Design process of research (step 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative</td>
<td>Research purpose</td>
</tr>
<tr>
<td>Qualitative</td>
<td>Research Questions</td>
</tr>
<tr>
<td>Mixed Methods</td>
<td>Theoretical framework</td>
</tr>
<tr>
<td></td>
<td>Data collection</td>
</tr>
<tr>
<td></td>
<td>Data analysis</td>
</tr>
<tr>
<td></td>
<td>Write-up</td>
</tr>
<tr>
<td></td>
<td>Validation</td>
</tr>
<tr>
<td>(Approach selected)</td>
<td>(Design according to the selected approach)</td>
</tr>
</tbody>
</table>

Table 3.1 Choosing research approach and design process, adapted from Creswell (2006, pp. 5)

It should be noted, however, that the difference between qualitative and quantitative research approaches is not always strict. This is to mean that, though a research can be predominantly approached in either of the two methods but it can also contain some characteristics of the other. This is also supported by Bryman et al., (2007, pp. 29) as “However the distinction (between qualitative and quantitative research approaches) is not a hard- and- fast one: studies that have the broad characteristics of one research strategy may have a characteristic of the other”. After
the selection of the research approach (qualitative), the design of the research components is made. These are the purpose, research questions, theoretical frame work, and data collection.

3.2 Research Design

3.2.1 Defining research purpose

The purpose statement establishes the overall direction of the study. The purpose of the thesis work was initially stated prior to selection of research strategy as qualitative approach, and then was fine tuned to fit the qualitative research approach. Locke et al., (cited in Creswell, 2006, pp. 87), defines the purpose statement as describing “why” the researcher wants to study and “what” he/she intends to achieve. After learning about how to create research purpose for qualitative research approach, the project purpose was defined as follows:

The purpose of this master thesis was to develop a service concept towards a site performance improvement service, and tools and methodology to use while offering this service for selected customers in the construction business area by studying their operational process from a lean perspective. In addition, key performance indicators currently used by the customers were identified in order to help visualize improvements which the service can bring about.

3.2.2 Creating research questions

The research purpose statement depicts the general sailing direction for the research. But it does not say much about what specific questions to answer. And the scope of the research is rather wider when interpreted only from the purpose statement. So it is necessary to narrow down the focus further. This is possible by identifying relevant research questions. There are in general two forms of research questions. These are central questions and associated sub questions. A central question is a statement of the question being examined in its most general form (Creswell, 2006, pp. 105). This means that a research question is more specific towards the research goal but yet does not limit the inquiry. Care should also be taken when designing research questions in a way to align them to the research approach, in this case, a qualitative research approach. Some characteristics of qualitative research questions are:

- Exploratory in nature: qualitative research questions are intended to discover, understand, and report.
- Open ended, and usually formulated as “what” and “why” questions.

Understanding these characteristics of qualitative research questions, three general research questions are formulated. They are all open ended, and exploratory in nature to meet a qualitative research approach. The three general research questions are listed below.

Q 1: What service concept provides a business opportunity to Volvo Construction Equipment and a solution to the customer, in the quarry and aggregate business segment?

In order to answer this research question, this thesis investigated the operational business process of selected customers with in the quarry and aggregate business segment. A service concept which would be a good business opportunity for Volvo Construction Equipment and also a solution which increases customer satisfaction was selected to take further in to the development of the service. This service concept was identified to be Energy Efficiency Consultancy service.

Q 2: What are the key performance indicators currently in use by the customers to measure their energy efficiency?

The service concept is intended to improve efficiency, and hence it is necessary to identify how to measure this improvement and which performance indicators to use. The customers were interviewed in order to identify what kind of performance measures and indicators they currently use. And these performance indicators were analysed if they are robust enough to use in
measuring improvements the service concept (*Energy Efficiency Consultancy service*) is intended to bring about.

**Q 3:** What tools and methods can be used while delivering this *Energy Efficiency Consultancy service*?

In order to turn the service concepts into practicality, it is necessary to develop tools and methods to use while delivering these services. As defined in the project purpose, the tools and methods to use in offering this service were the “lean principles”. Literature study of the five lean principles (defining value, identifying the value stream, creating flow, introducing pull system and continuous improvement) was carried out and studied on the customer site if they can be used as tool to identify energy related wastes.

### 3.2.3 *New service development structure-Theoretical framework*

Since this thesis project was a new service development, literature study on New Service Development was carried out (presented in the theory section). Then after, a new service development structure to be followed in this project was adopted.

![New service development structure used in this master thesis](image)

**Developing service strategy**
This was to identify the market segment and the customer type to focus while building this service. The market segment was decided by Volvo Construction Equipment to be the quarry and aggregate segment. The search for suitable customers with in this market segment showed that most of the quarry and aggregate sites are owned by the five big construction contractors in Sweden. These were SKANSKA, NCC Roads (Ballast), PEAB, SVEVIA, and JEHANGER. As a result, these companies were contacted and asked for their willingness to cooperate in the service concept development. As a result, it was possible to get access to three quarry and aggregate sites presented as company A, B and C. A brief introduction of these companies is presented below.

Case company “A” is a company providing crushed rock material to customers in the construction business area such as Skanska, NCC and private customers as well. The crushing site has been active since 1969. Currently, it has a licence to extract up to 6 million tons of rock material. It has a production capacity of about 500 000 tons per year. The crushed rock material it provides is of enough quality to be used in production of concrete. The crushing activity is on
4 days in a week and 1 day is assigned to maintenance of equipments. However, customers are welcome 5 days a week.

Case company “B”, in collaboration with Skanska is a company providing gravel and sand to customers in the construction business area. It has been operating since 1989 and had its licence to extract rock material renewed four times since then. It has a production capacity of 300,000 tons per year from its three pits located around Gothenburg. Currently, the company had a licence to extract 2.5 million tons of gravel and rock material which would take about 8 to 10 years to extract with the current production capacity.

Case company “C” is a quarry and aggregate business segment of NCC Roads AB. Gravel, Sand, crushed materials, and washed stone products are among the main product supplies its customers. This company currently operates in Sweden, Finland, Denmark and Norway with a total production capacity of 24 million tons per year. The company has about 21 sites around Stockholm area. The customers for case company C include all the major construction companies such as NCC, Skanska, PEAB, etc and also individual customers. The company has a standard 40 working hours in a week.

**Idea generation**

Once the business segment and the customer focus were decided, these customers were contacted. This is in order to learn about the business process of the customers and identify their needs, problems and operational challenges. Interviews and site visits were made to achieve these (interview protocols are attached in the appendix). As a result, areas of needs and problems were collected. In order be able to address as much needs and problems as possible, a brainstorming session was prepared. Three students (from both thesis projects) participated in the brainstorming session. Connecting the needs, problems and operational business challenges, potential service solutions were suggested which then were passed through an idea screening process.

**Idea screening**

After literature study of Service Global Development Program manual in Volvo, a total of 16 screening criteria were set. The service concepts were then passed through the screening where points either high (+) or low (-) were assigned (See appendix 7.2). The challenge faced here was that was not always enough information to motivate the high or low points assigned. The screening criteria used were clustered in to three main criteria namely; customer desirability, technological and organizational feasibility and business viability. The sub-criteria under each main criterion are listed table 3.2.

The idea screening resulted in three service concepts on top. These were Teaching Services, Operational Incremental Improvement Consultancy and Energy Efficiency Consultancy services.

**Building the service concept**

The top three selected service concepts from the screening were further developed and defined in to the value they add to the customer, the way they are intended to be delivered and their outcome.

**Concept confirmation**

Then they were passed to different stake holders inside the Volvo group and outside for confirmation and to get more input to help choose one from the three. This process resulted in the Energy Efficiency Consultancy service to be the one with a higher business potential to Volvo Construction Equipment and at the same time with a good contribution to solving customer problems.
<table>
<thead>
<tr>
<th>Customer desirability</th>
<th>Technological and organizational feasibility</th>
<th>Business Viability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Customer willingness to pay for the service</td>
<td>5. Access to the right skills to offer the service</td>
<td>9. Satisfactory financial return of service</td>
</tr>
<tr>
<td>2. Customers process change</td>
<td>6. Access to the right technologies required to offer the service</td>
<td>10. Inline with current business</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13. Market development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Competition in the same trade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Competition from invaders</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16. Uniqueness of the service offer</td>
</tr>
</tbody>
</table>

Table 3.2 Idea screening criteria

**Building part of the service system**

A service system includes the service employees, customers, the “physical and technical setup” and the “organization and control”. The part of the service system this master thesis focused was a part of the technical set up. These are developing tools and methods to use while offering the service offer and finding ways to measure the performance of the improvements.

Key performance indicators currently used by the customers to measure their energy efficiency were identified and analysed if they are robust enough to be used in measuring the potential improvements inevitable by the energy efficiency improvement service offer. As for the tools and methods, lean improvement principles were studied and tested on a customer site (company A) if they are helpful in identifying and measuring energy related wastes.

**Literature study**

Literature study was used to lay the theoretical framework which gave a comprehensive understanding of all concepts to be reflected in the research area. In the theoretical frame work basic concepts such as new service development models, incremental and radical service development, performance measurement systems, lean thinking and challenges of manufacturers going in to service. The sources of the literatures were academically legitimate databases for electronic resources (science direct, Scopus, Google scholar, Emerald) and books for printed resources.

**3.3 Validity and reliability**

Several strategies are available to assure validity of results in qualitative research. Intensive (long term involvement), respondent validation, triangulation and company confirmation were used to ensure the validity of this thesis project. Each of these techniques and how they are used in this project is described below.

**Intensive, Long-term involvement**

Becker and Geer (1957 cited in Maxwell 2005) claimed that long-term participant observation provides more complete data about specific situations and events that any other method. Inspired from this, interviews and site observations were made in a repeated manner, clarifying the
subjects in discussion. Moreover, a good relationship was held with the interviewees which made it easy to have discussions in person and over the telephone which supported the long-term involvement. So the empirical data supplied in this master thesis are not from a single contact interview and site visit rather from a repeated interaction between the thesis student and the interviewees and sites.

**Respondent Validation**

After the interviews and site observations, the data collected were transcribed and discussed on the following meetings with the interviewees. It was possible to do this because of the repeated contact which resulted in the long-term involvement. This ensured that there were no misinterpretations or misunderstandings of the information supplied by the participants. The interview and site observation protocols along with the participant responses are attached in the appendix of this report as part of supporting the validity of this thesis project and the results attained.

**Triangulation**

Maxwell (2005) defines triangulation as collecting information from diverse range of individuals and settings. Site managers from three different companies were contacted and interviewed with the same interview questions in order to increase the credibility of the data collected. The operational settings of the contacted companies are also differing which gave the chance not to be dependent on the data only from one perspective. Apart from these, presenting study results to the company supervisors on a regular basis ensured that the results of this study are useful to the company as well.

Reliability is to ensure the fact that the same results could be found if this research is conducted in another time by another researcher. To facilitate the reliability of this thesis project, a detailed description of steps followed to reach the results is presented in section 3.2.3. Table 3.3 summarizes the research design and methodology.
## Project purpose

### Research Question one
What service concept provides a business opportunity for Volvo Construction Equipment and a solution to the customer, in the quarries and aggregates business segment?

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Steps followed</th>
<th>Method</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Develop Service Strategy</td>
<td>Project directive</td>
<td>Focus made on the quarry and aggregate business area and the big construction contractor companies (Skanska, SVEVIA, PEAB, NCC Roads (Ballast), and JEHANDER)</td>
</tr>
<tr>
<td></td>
<td>Idea generation</td>
<td>Site Visit (Case Company A)</td>
<td>Understood the nature of customer site condition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interview (Case company A, B, &amp; C)</td>
<td>Understood customer business process and challenges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brainstorming (Thesis A and B participated)</td>
<td>Identified customer needs, problems and eleven potential service solutions for these needs and problems</td>
</tr>
<tr>
<td></td>
<td>Idea Screening</td>
<td>Literature Study</td>
<td>Idea screening criteria were set</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Workshop (Thesis A and B participated)</td>
<td>Screened out the eleven potential service solutions and selected the final three service solutions</td>
</tr>
<tr>
<td></td>
<td>Formulate service concept</td>
<td>Literature Study</td>
<td>Further defined the three selected service solutions in to what value they add to the customer, how to perform the service and what the outcome of the service is</td>
</tr>
<tr>
<td></td>
<td>Confirm Service concept</td>
<td>Interview (Thesis B)</td>
<td>Collected feedback on which service concept (from the last three concepts) has a better business potential to Volvo Construction Equipment to offer.</td>
</tr>
</tbody>
</table>

### Research Question Two
What are the key performance indicators currently in use by the customers to measure their energy efficiency?

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Steps followed</th>
<th>Method</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Build parts of the service system- Key Performance Indicators</td>
<td>Literature study</td>
<td>Understood performance measure systems and performance indicators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Interview (Case company A and B)</td>
<td>Identified what set of Key performance indicators customers used, how they worked with them and if they can be used to measure performance of the Energy Efficiency Improvement service?</td>
</tr>
</tbody>
</table>

### Research Question Three
What tools and methods can be used while delivering this Energy Efficiency Consultancy service?

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Steps followed</th>
<th>Method</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Build parts of the service system- Tools and methods</td>
<td>Literature Study</td>
<td>The five lean principles: Define Value, Identifying value stream, create flow, using pull system and continuous improvement</td>
</tr>
<tr>
<td></td>
<td>Site observation (Case company A)</td>
<td></td>
<td>Tested if these five lean principles can be used to identify, visualize and measure energy wastes on customer’s site</td>
</tr>
</tbody>
</table>

Table 3.3 Summary of the research methodology
4. Results
This chapter presents the conducted empirical study, brainstorming and workshop results. It is organized in to three sections corresponding to each research question presented in the methodology section of this report. Interviews and observations have been made to collect relevant empirical data to help answer each research question.

4.1 Exploring the service opportunity
This section presents empirical study conducted and results found which support in answering research question one, “What service solution provide a business opportunity for Volvo Construction Equipment in the quarries and aggregates business segment?” The answer to this research question is the service concept. In order to answer this, interviews and observations have been made. Three companies in the quarry and aggregate business area were contacted. These companies are represented as company A, B and C as introduced in previous chapter.

Interviews and observations made at these companies resulted in understanding of the major operational business challenges, overall operational business process and core business activities, type of equipments used in the process and the value chain integrations. This information was used in order to generate ideas to create the service concept.

A. Major business challenges
The three interviewees made with the site managers responded quiet similarly to what they consider as the major operational business challenges. These are presented as follows as the interviewees put it themselves.

Interviewee at case company A
- “The rock material is of low value so lowering cost of production per ton is of big interest.”
- “Environmental regulations are of big attention.”
- “Currently, the blasting process is the most challenging. The reason is it produces a significant amount of big sized rocks which can not be fed to the primary crusher. As a result, these rocks need to be further broken down to smaller fractions by the use of hydraulic hammer mounted on an excavator taking so much man-hour and fuel.”

Interviewee at case company B
- “The rock material is providing is a low value product. And as a result, lowering cost of production and transportation is a major issue. As for lowering the cost of production, delivering to customers who are closely located is one option followed by the company.”
- “The other concern is environmental issues. The quarry site our company operates at is located close to two living areas, water body used as a source of drinking water, active traffic to an airport which needs not be disturbed, electric transmission lines. All together results in a higher environmental concern. “

Interviewee at case company C
- “Lowering the cost of the final product is the biggest challenge. We continuously strive to achieve this using different method as buying cheaper raw material, lowering transportation costs etc.” Table 4.1 summarizes the major business challenges and concerns of the three companies.

<table>
<thead>
<tr>
<th>Major business challenges and concerns</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
</tr>
</thead>
<tbody>
<tr>
<td>To lower the cost of production</td>
<td>Energy waste related to the blasting process</td>
<td>Environmental concerns</td>
<td>To lower cost of transportation</td>
</tr>
<tr>
<td>Environmental concerns</td>
<td>Lower cost of production</td>
<td>Environmental concerns</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1
Table 4.1 major business challenges and concerns

These major business challenges which are common to all the three companies are taken in to perspective while generating service concept ideas in a way each idea should help address either lowering cost of production or environmental concerns (such as reducing carbon emissions) or both.

B. The production process
This study revealed the fact that the three case companies followed similar production processes and activities. A slight variation is however observed about whether all the operational business process carried out by the respective companies is self contained or outsourced to external service providers. Learning these processes was important to identify what the customer’s needs and problems are in general. The customer’s operational business process is as follows.

The process starts with the production plan for the year. Then, trees and earth material on the surface is removed to expose the rock layer. This is a very expensive process which takes a significant amount of operational cost. It is dependent on the location of the site as different sites have different level of trees and earth material covering the rock surface. Figure 4.1 shows what the rock surface looks after the surface material is removed and ready for the next step.

![Figure 4.1 the rock surface after the surface material is removed](image)

Once the rock surface is exposed, it is drilled with a drilling machine (figure 4.2) in order to put in explosives (dynamite) for the blasting process. The depth to which the rock is drilled is an important factor to the average size of the blasted rock. The smaller the size of the blasted rock, the easier for the loading machines to feed the crushers and also for the crushers to crush which influences the amount of energy consumed by each equipment and equipment wear. But in contrast, to make smaller sizes of blasted rock, a stronger explosion in required which would mean higher vibrations to the surrounding earth, higher noise, and a wider radius of scattering blasted rock which eventually takes a lot of time and energy to collect. After drilling the rock surface, a plastic tube is inserted in the hole and then the explosive chemical coupled with the electric cables is used for ignition (figure 4.3).
After the blasting, the rock is excavated and fed in to the primary crusher (figure 4.4) which crushes down the blasted rock in to a smaller fraction size. After the primary crusher, the crushed rock is fed to the secondary crusher. This can be by means of a conveyor belt or using loading machines if primary and secondary machines are separated. Then the output from the primary crusher passes to a screen in order to separate the crushed rock in to different grain sizes. The grain sizes which could not pass the screen are fed back to the cone crusher by a conveyor mechanism.

After separation, the loading machines manage to pile up the inventory (figure 4.5). The final step is to load the crushed material to transport. The truck will be weighed on its way out for invoicing.
Studying the operational business process and finding out the fact that all the companies use similar production process helped in exploring potential operational activity areas where the service concept can be focused in general. This means the needs and problems at the customer site.

C. Value chain integration

The value chain integration explains which part of the business process the construction company owns and which it outsources. The three companies observed in this project have all different value chain integration (table 4.2) in their operational business process. This variance in value chain integration is summarized in the following table.

<table>
<thead>
<tr>
<th>Operational Business process</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production planning</td>
<td>own</td>
<td>own</td>
<td>own</td>
</tr>
<tr>
<td>Cleaning earth surface</td>
<td>outsourced</td>
<td>Not known</td>
<td>Not known</td>
</tr>
<tr>
<td>Drilling</td>
<td>outsourced</td>
<td>outsourced</td>
<td>outsourced</td>
</tr>
<tr>
<td>Blasting</td>
<td>outsourced</td>
<td>Outsourced</td>
<td>outsourced</td>
</tr>
<tr>
<td>Loading to feed primary crusher</td>
<td>own</td>
<td>outsourced</td>
<td>own</td>
</tr>
<tr>
<td>Primary Crushing</td>
<td>own</td>
<td>outsourced</td>
<td>own</td>
</tr>
<tr>
<td>Loading to feed secondary crusher</td>
<td>own</td>
<td>outsourced</td>
<td>own</td>
</tr>
<tr>
<td>Secondary crushing</td>
<td>own</td>
<td>outsourced</td>
<td>own</td>
</tr>
<tr>
<td>Loading to inventory</td>
<td>own</td>
<td>outsourced</td>
<td>own</td>
</tr>
<tr>
<td>Loading to customers</td>
<td>own</td>
<td>own</td>
<td>own</td>
</tr>
<tr>
<td>weighing</td>
<td>own</td>
<td>own</td>
<td>own</td>
</tr>
<tr>
<td>Transportation and delivery</td>
<td>outsourced</td>
<td>own</td>
<td>own</td>
</tr>
</tbody>
</table>

Table 4.2 Operational value chain integrations

The difference in operational value chain integration poses a difference where the specific areas of business challenges are for the companies. Though in section A above it is indicated that one of the common business challenge to be lowering cost of production, the specific areas where these improvements to lower the cost of production differs from site to site. In other words, each company has a better control on the activities it owns and hence easier to focus on these activities when looking for improvements. In the table above, the operational business activity marked with “own” is the ones which the respective company owns the process and the ones marked with “outsourced” are which are outsourced. So there is a variance to the operational processes which these companies have control over. This information was used in understanding
the fact that specific site study and overall business process study is necessary in order to develop the service.

**D. Production equipments used**

The interviews and site observations showed that these companies use similar equipments and processes to carry out the production process. These equipments are drilling machines, excavators, wheel loaders, and primary and secondary crushers. It was observed also that these equipments are supplied by different manufacturers. This information is used when screening ideas as in which service concepts Volvo Construction Equipment has the competence to deliver. Table 4.3 summarizes the outcomes of the empirical study and how they supported the new service idea generation.

<table>
<thead>
<tr>
<th>Empirical findings</th>
<th>Contribution to service concept development</th>
</tr>
</thead>
</table>
|重大业务挑战和关注点  
- 降低生产成本  
- 改善环境影响（碳排放） | 服务概念应该满足这两个关注点                                                   |
| 生产过程                                                      | 确定客户需求和问题                                           |
| 价值链整合  
- 从一个地点到另一个地点不同                          | 意识到需要做特定的现场研究来识别改进点以降低生产成本和改善环境影响 |
| 生产设备使用  
- 相同设备从一个地点到另一个地点：钻机、轮式装载机、破碎机、挖掘机和装载机 | 意识到什么服务提供沃尔沃建筑设备有提供在概念筛选阶段使用的竞争力 |

Table 4.3 outcomes of empirical study and how it supported service concept development

Keeping these empirical outcomes in consideration, a brainstorming workshop was carried out where three thesis students (from thesis A and B) participated. The results of the brainstorming session, the needs and problems at customer site, is presented below.

1. **Identified customer needs**
   (These identified customer needs are based on the thesis students site observations)

   **Improved inventory**
   - 一个良好的现场布局，允许简单和经济的移动处理库存的设备
   - 布局适合于客户移动
   - 平衡生产和客户需求来降低库存
   - 预测需求并根据需求控制生产

   **Obtain a long term business perspective**
   - 投资从长期利益考虑
   - 长期生产规划
   - 有一个计划去做已经开发的采石地
   - 管理一个持续变化的现场
Coordination between vehicles
- Avoid vehicles waiting to avoid lost production time and energy
- Logistics planning
- Reengineering of sites for continuous improvement
- Avoid waiting (machines and customer trucks) lines at site
- Use up to date machines

Knowledge of the business operators
- Visualize money at operator level
- Communicate a business mindset to operators

Energy consumption
- Continuous improvement
- Environmental measures (electricity used)

Cost savings
- Cost control of production
- Keep track of total cost of ownership (TCO) of all machines
- Cost savings from improved inventory
- Lower production unit cost

Production control
- Process control
- Calibration of machines
- Productivity measures
- Measure production per equipment hour

Business planning
- Keep track of the production
- Have a yearly goal on the basis for production
- Have realistic production goals
- Rules for vehicles or machine change (replacement theory)
- Help with marketing products (differentiation)
- Business models of the products (package with haulers)

2. Identified Customer Problems
- Expensive equipments
- Bad quality of roads
- Complex to measure result of business change
- Demand fluctuations
- Low value product Poor quality of earth material
- High profit margins which lowers motivation to change
- Conservative industry doing business in the traditional way
- Limited and varying demand
- High quality demand from customer
- End production variation limited to quality of rock
- Many environmental regulations to fulfil while running a quarry site
- Situated in non-attractive places increasing transportation costs
- Expensive labor cost
- Site conditions are continuously changing as the production continues
- Hard to get permissions to open sites (especially gravel)
- Many parameters to consider when running a site

Connecting the needs and problems, solutions were suggested. These solutions were formulated in to service concepts clearly stating what to offer, the value to the customer, the outcome of the service and the method to do it. This resulted in 11 consultancy service concepts in the following areas.

1. Teaching services
2. Incremental operational improvement
3. Production control consultancy service
4. Cost tracking consultancy service
5. Site layout design
6. Inventory management service
7. Production planning service
8. Business model development service
9. Investment consultancy service
10. Energy efficiency Consultancy service
11. Logistics planning consultancy service

The screening of these service solutions using the 16 screening criteria resulted in three top potential service offers; Teaching services, operational incremental improvement consultancy service and Energy efficiency Consultancy service. These service concepts are presented below as they were at this stage of their development (the point marks assigned to each service solution to each screening criteria is attached in the appendix).

**Teaching service**
This educational service is intended to offer the customer knowledge about quarry operations. These knowledge areas are categorized in to three themes:

Environmental aspects: Addressing the environmental issues inherent to quarry operation and raising awareness about how to lower these environmental threats like carbon emissions and other pollutions.

Production economy: Addressing what constitutes of production cost and how to lower it.

Best practices: Bench marking and facilitating the opportunity to learn from others about the first two areas of concern.

This teaching service can be customized to all levels in the organisation, from management to operator level. Table 4.4 summarizes the Teaching service in to its value to the customer, the method, and the outcome.

**Operational incremental improvement consultancy**
This consultancy service intends to incrementally improve customer site operating conditions by studying the customer’s operational business process from a lean perspective (eliminating waste). Through close relationship between the customer and Volvo CE, this consultancy service can create sustained operational improvement by eliminating or reducing waste from the operational business process. The potential operational aspects to be studied from a lean perspective are production planning, equipment selection and matching, vehicle routing and inventory management. The improvements are segmented in to small and incremental manner so
that they are easy to implement with no major capital investment. This operational incremental improvement service is delivered to the customer in two stages. The first stage is to measure current operational conditions and identify potential improvements. The second stage is to actually implement solutions to identified improvement areas and standardize these improvements.

This service requires management support and efficient communication and understanding of the need for the improvements across the organization. Moreover, specific site studies are used to deliver this service because of continually changing conditions of the site operations (e.g., Site layout changes frequently as the rock extraction advances). Table 4.5 summarizes the Operational Incremental Improvement Consultancy service in to its value to the customer, the method, and the outcome.

<table>
<thead>
<tr>
<th>The Service</th>
<th>Value to the customer</th>
<th>Method</th>
<th>Service outcome</th>
</tr>
</thead>
</table>
| Teaching service: Environmental, production economy, Best practices | • Improved production performance  
• Lowered environmental impacts  
• Better awareness to performance improvement | • Traditional teaching  
• Workshops | • A guideline to trace production economy  
• Environmental-friendly operation procedures  
• Benchmark to performance and performance improvement measures. |

Table 4.4 the “Teaching service” defined in to service concept artefacts

<table>
<thead>
<tr>
<th>The Service</th>
<th>Value to the customer</th>
<th>Method</th>
<th>Service outcome</th>
</tr>
</thead>
</table>
| Operational incremental improvement consultancy service | • Improved production performance  
• Lowered operational costs  
• Improved environmental impacts due to eliminated or lowered wastes | • Study customer process from lean perspective  
• Identify improvement areas  
• Two stage approach: Assessment and improvement | • Current status awareness  
• Standardized operational guides  
• Performance measures  
• Continuous and incremental improvement culture |

Table 4.5 the “operational incremental improvement consultancy service” defined in service concept artefacts

**Energy Efficiency Consultancy services**

The Energy Efficiency Consultancy service intends to optimize energy consumption in the quarry operation site helping decrease costs from energy inefficiency and lower environmental impact. This consultancy service is to be offered in two sages. The first one is to make energy consumption assessment as current state and identify energy related wastes related to equipments and crushers. This is possible by studying the operational process from a lean perspective focusing on energy utilization. The second stage is to develop solutions to improve identified sources of energy inefficiency.
The customer benefits from this consultancy service improved energy efficiency which lowers energy costs and improve environmental impacts. Table 4.6 summarizes the Energy Efficiency Consultancy service in to its value to the customer, the method, and the outcome.

<table>
<thead>
<tr>
<th>The Service</th>
<th>Value to the customer</th>
<th>Method</th>
<th>Service outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Efficiency Improvement service</td>
<td>• Improved energy efficiency</td>
<td>• Study customer process from lean perspective</td>
<td>• Current energy consumption awareness</td>
</tr>
<tr>
<td></td>
<td>• Lowered operational costs</td>
<td>• Identify improvement areas</td>
<td>• Identify causes of energy waste on site</td>
</tr>
<tr>
<td></td>
<td>• Improved environmental impacts due to eliminated or lowered wastes</td>
<td>• Two stage approach: Assessment and improvement</td>
<td>• Performance measures</td>
</tr>
</tbody>
</table>

Table 4.6 the “Energy Efficiency Improvement service” defined in to service concept artefacts

The screening resulted in the Energy Efficiency Consultancy service to get the highest rating (see appendix 8.2). Further business analysis carried out by “thesis B” also resulted in the Energy Efficiency Consultancy service to gain the most positive business potential and also a better solution to customer problem. As a result, the Energy Efficiency Consultancy service is taken further in to the development phase. That is to identify if the customers have performance measure systems robust enough to measure the performance inevitable by the Energy Efficiency Improvement service and the tools and methods to use while offering this service.

4.2 Measuring the performance
Since the purpose of this master thesis was to develop a service offer which helps the customer improve operational performance, it is necessary to identify how to measure these improvements. The approach used to identify these performance measures was to study what key performance indicators are used in the case companies currently and taste if the same Key Performance Indicators and performance measure system can be used to taste the performance improvement inevitable by the new service offer. Since the new service offer is Energy Efficiency Consultancy service intended to reduce operational cost and enhance environmental conditions from energy perspective, key performance indicators currently used by the companies to measure their energy consumption efficiency and related environmental impacts were studied. Interviews with site managers of two of the case companies (case company A and B) resulted in the set of key performance indicators used.

**Energy and operational Cost related key performance indicators**
Cost related Key Performance Indicators are used in these companies in order to keep track of the cost of production and transportation (in case of Company B only, since Company A is not involved in transportation operation). Depending on the value chain integration, there is a small variation in the specific cost related Key Performance Indicators used in the respective companies.

Since company B outsource the crushing operation, and pays the contracting crushing company a certain amount of money per ton of crushed material, they use cost/ton measures. Moreover, profit/ton and energy/ton measures are used. The cost per ton of crushed material is mainly calculated by summing up cost/ton transport, cost of inventory movement, cost/ton for crushing, and cost of extraction permit. Since the cost of energy (Diesel fuel and electricity) is included in the contract when outsourcing the crushing activity, there is no robust follow up of Key Performance Indicators specific for equipment used indicting cost of Diesel fuel or Electricity.
In the case of Company A, since most of the operational process and equipments are self owned, there are specific key performance indicators related to energy consumption specific to equipment. These are cost of diesel/ton crushed material, litres of diesel/ton of crushed material and Electricity/ton crushed material (in the winter when the crushers are run with electricity). Moreover, Key Performance Indicators such as ton produced/ employee is also used to measure employee performance. Table 4.7 summarizes sets of Key Performance Indicators used in the studied companies.

<table>
<thead>
<tr>
<th>Company</th>
<th>Cost related KPIs used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case company A</td>
<td>1. Litre Diesel/ton crushed material</td>
</tr>
<tr>
<td></td>
<td>2. Electricity/ton crushed material</td>
</tr>
<tr>
<td></td>
<td>3. Ton crushed material/employee</td>
</tr>
<tr>
<td>Case company B</td>
<td>1. Cost/ton crushed material</td>
</tr>
<tr>
<td></td>
<td>2. Profit/ton crushed material</td>
</tr>
<tr>
<td></td>
<td>3. Energy/ton crushed material</td>
</tr>
</tbody>
</table>

Table 4.7 KPIs used by case companies A and B

Energy and environment related Key performance indicators
Improvement in energy efficiency impacts the environment in two ways. One is in lowering the need to the extraction of new energy and the other reducing unwanted emissions (carbon) from using certain forms of energy (diesel fuel in this case). Both company A and B have concerns about the environmental effects of their operation. As a result, there are certain measures they follow. One is to train their equipment operators with Eco-driving. Eco Driving is an act of operating equipments and trucks in as much environmental way as possible to reduce the carbon emissions resulting from poor driving or operation conditions. In the case of company B, they insist using only environmentally certified trucks for transportation to lower the emission impacts. Apart from these, there are no specific Key Performance Indicators measuring the environmental impacts of their operation from an energy perspective.

In both case companies, the Key Performance Indicators are used as cost tracking mechanisms. There are no benchmarks which the companies strive to work towards. Moreover, environment related key performance indicators were not specifically defined. This implies the need to define more robust key performance indicators and bench marks towards measuring the performance of the Energy Efficiency Consultancy service. Table 4.8 summarizes the outcome of the study towards the key performance indicators.

<table>
<thead>
<tr>
<th>Key Performance Indicators</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy and operational cost related KPIs currently in use by the case companies (A and B)</td>
<td>These KPIs can be used to measure the performance of the Energy Efficiency Improvement service but there is a need to define benchmarks to work towards</td>
</tr>
<tr>
<td>• Litre Diesel/ton crushed material</td>
<td></td>
</tr>
<tr>
<td>• Electricity/ton crushed material</td>
<td></td>
</tr>
<tr>
<td>Energy and Environmental impact (carbon count) related KPIs currently in use by the case companies (A and B)</td>
<td>A new set of KPIs are necessary to track carbon footprints</td>
</tr>
<tr>
<td>• None</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8 Summary of the study of KPIs
4.3 Tools and methods to use while offering the Energy Efficiency Consultancy service

As indicated in table 4.6, the energy efficiency consultancy service is intended to be offered in two stages approach; assessment and improvement. The assessment phase is to study current energy consumption and identify energy wastes and hence pin point potential areas of improvement. Lean principles were tested if they can be used as a tool to identify energy related wastes and improve energy efficiency.

Defining Value
Value should be defined by the end user as in what the true value of a product is to them and how much they are willing to pay for a certain quality of a product. In this case, the attempt to define the price value from of crushed rock material from the end user was not successful because of a time limitation.

Identify Value stream
In the production of a crushed rock material, all the processes which bring physical transformation of the rock material from a bank size to crushed size can be considered as value adding activity. Taking this in to consideration, a value stream study was carried out in case company A’s site from energy point view. This is to mean, how much energy is consumed on each activity.

Each activity was classified as value adding (VA), necessary but not value adding (NNVA) and not value adding at all (NVA). The value stream is summarized in table 4.9. Moreover, the percent energy consumption of each activity was collected from a one year diesel consumption data supplied by case company A. For confidentiality of this information, only percent consumption is displayed in these report and not the exact litres of diesel consumed.

Some of the activities in the production process are outsourced and accurate data of energy consumption could not be found and are indicated as “Not available” in table 4.9. Studying the value stream of this specific site revealed that only about 38 percent of the yearly diesel energy consumption is spent on value adding activity. This implies that there is 62 percent of the yearly diesel energy consumption spent on necessary but non value adding activities pointing out the fact that there is a big room for optimization and improvement.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Equipment used</th>
<th>% energy consumed</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearing the earth</td>
<td>Excavator</td>
<td>Not available</td>
<td>NNVA</td>
</tr>
<tr>
<td>surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drilling</td>
<td>ROC D7C atlascopco</td>
<td>Not available</td>
<td>NNVA</td>
</tr>
<tr>
<td>Blasting</td>
<td>Chemical</td>
<td>Not available</td>
<td>VA</td>
</tr>
<tr>
<td>Hammering</td>
<td>Hydraulic excavator</td>
<td>(Up to 1.5 mil. SEK)</td>
<td>NNVA</td>
</tr>
<tr>
<td>Feeding crusher</td>
<td>Wheel loader</td>
<td>27</td>
<td>NNVA</td>
</tr>
<tr>
<td>Crushing and</td>
<td>Sandvic crusher</td>
<td>38</td>
<td>VA</td>
</tr>
<tr>
<td>screening</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading to inventory</td>
<td>Wheel loader</td>
<td>7</td>
<td>NNVA</td>
</tr>
<tr>
<td>Loading to customer</td>
<td>Wheel loader</td>
<td>28</td>
<td>NNVA</td>
</tr>
<tr>
<td>trucks</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.9 Percent Diesel consumption per year

Further study on the non value adding activities can display reasons of inefficiency. As an example, about 1.5 million SEK is spent on an activity called “Hammering”. One of the necessary non value adding activities in this specific case is “Hammering” (see figure 4.6).
Asking why this step is necessary showed that defective rock sizes (to mean too big rocks which can not be fed to the crusher) are corrected so that they can be further processed in the crusher. This activity is time taking and expensive. Having a better controlled blasting can improve this waste significantly.

Figure 4.6 a hammer excavator breaking big sized rocks one by one

**Flow**

The production flow was observed at case company “A” site and some flow discontinuities have been observed contributing to energy waste. These points of discontinuity were (1) at feeding the crusher and (2) at handling crushed rock inventory.

Figure 4.7 a crusher feeding wheel loader working idle

Figure 4.7 shows a wheel loader idling by the side of the primary crusher at customer site A. The reason was an oversized rock fed in to the primary crusher which the wheel loader operator needed to clime up the crusher to correct this incident. Moreover, moments when the primary crusher was not fully fed were observed implying the need to match crushing capacity and feeding capacity.
Figure 4.8 a wheel loader waiting to fill its bucket to take inventory

Figure 4.8 shows a wheel loader waiting to fill its bucket to take inventory to where it is kept. This shows a mismatch between the crushing capacity per hour and inventory loading capacity per hour. While waiting for the bucket to fill, the engine on the machine is running and hence resulting in an energy waste.

**Pull**

The inventory level at the customer site shows that a slightly push system is being used currently. The inventory level is estimated to be 15% of the annual demand and about 7 percent of the diesel consumption is spent on inventory handling. However, there still is possibility for improvement. Figure 4.9 shows a wheel loader climbing up hill of inventory causing higher diesel consumption. If the pile of inventory can be lowered using pull system, it will be a lesser load on the climbing machine lowering energy consumption and carbon emission.

Figure 4.9 piling inventory hill

**Continuous improvements**

The last lean principle is continuous improvement. This is to pin point all possible wastes and work continually to improve them. Table 4.10 summarizes the areas where these improvement studies should be initiated and which lean tool was used to pin point these improvement areas specific to case company A.
<table>
<thead>
<tr>
<th>Improvement area</th>
<th>Lean principle used</th>
<th>Measuring waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better blasting to avoid time and energy waste by “Hammering”</td>
<td>Defining value and Identifying value stream</td>
<td>Up to 1.5 mil SEK a year</td>
</tr>
<tr>
<td>Better production matching between crusher equipment and wheel loaders</td>
<td>flow</td>
<td>Not specified</td>
</tr>
<tr>
<td>Lowering inventory piles to lower energy consumption by the loading equipments climbing steep piles of inventory</td>
<td>pull</td>
<td>35 % of annual diesel consumption spent on managing inventory and loading finished product on customer trucks</td>
</tr>
</tbody>
</table>

Table 4.10 Improvement areas specific to case company A

This shows the possibility to use lean principles as a tool to identify and energy related wastes and point areas of improvement to be focused by the continuous improvement program.
5. Conclusion and recommendation

One part of the purpose of this master thesis was to develop a service concept towards a site performance improvement service. Up on interviewing customers and visiting sites, it was identified that the major business challenges to be lowering production cost and improving environmental impacts (specifically lowering the carbon emission). Production cost in the quarry and aggregate business area mainly constitutes of cost of licence to extract the rock, cost of equipment ownership (capital, parts and maintenance), labor costs and cost of energy (diesel and electricity). Following the structured new service development procedure resulted in the Energy Efficiency Improvement service to be the one which can address the tow major business challenges at the same time i.e. lowering production cost and lowering carbon emission.

One of the challenges in the service concept development process was the idea screening process. The method used to screen did not allocate weight difference on each criterion, and in addition there was not enough information about each criterion to decide on the points to allocate. Therefore, some screening point decisions had to be given based on the researcher’s judgement. However since energy consumption at typical quarry and aggregate site takes a significant share of the operational cost and also most of the energy consumption is by the construction equipments similar to what Volvo CE offers, Volvo CE can capitalize on this and build a relationship with the customer to offer this service. It should be noted that this service is customer’s operational process oriented and not necessarily connected to Volvo equipments on site.

This service innovation can be classified as radical new service development as such service has not been in Volvo CE’s portfolio. As a result, several challenges can be expected while offering this service. One of these challenges is the fact that the customer might not consider Volvo CE as competent in offering this service since Volvo CE did not have the reputation in offering Energy Efficiency Improvement service. One remedy to alienate this risk is to involve the customer in the service development process. In this thesis project, the customer is involved in the exploring phase, i.e. in search of business opportunity and when customer’s major business challenges were studied. However, better results could have been attained if the customer was involved in the brainstorming sessions and the screening workshops (specifically when ideas were being screened against customer desirability criteria).

Since this service offer is about improvement, it is necessary to have a good performance measurement system. This study found out that the customer’s do not have a robust enough energy performance measurement systems and indicators. Energy consumption per ton of crushed rock material can be a starting point to measure performance. However, there should be some bar against which the current performance can be compared. Moreover, no measures regarding carbon emissions were identified. This suggests on the need to improve current energy performance measures.

To realize the service offer at the practical level, it was important to develop tools and method to use. Since the suggested method to offer this service is in two stages, assessment and improvement, tools to use in assessment and improvement need to be in place. With in this thesis project the five lean principles define value, identify value stream, create flow, pull system and continuous improvement were tested is they can be used as a tool during the assessment stage. The study of the customer operational process and site using these five lean principles showed positive results in displaying energy wastes. However, this site study was carried out on only one customer site and more study at different sites might help creating a generic flow chart of applying these principles to all sites. Table 5.1 summarizes the research questions and the results found in this study.
<table>
<thead>
<tr>
<th>Research questions</th>
<th>Results found</th>
<th>Practical implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>What service concept provides a business opportunity for Volvo Construction Equipment and a solution to the customer, in the quarries and aggregates business segment?</td>
<td>Energy Efficiency Improvement service</td>
<td>Volvo CE can expand its soft product portfolio to this field of service offer</td>
</tr>
</tbody>
</table>
| What are the key performance indicators currently in use by the customers to measure their energy efficiency? | Litre Diesel/ton crushed material  
Electricity/ton crushed material  
No KPIs to carbon emission  
No set target points (bench marks) | Better energy performance measurement systems required                          |
| What tools and methods can be used while delivering this Energy Efficiency Improvement service? | The five Lean principles can be used as tools                                  | Lean quarry and aggregate operation from an energy perspective                         |

Table 5.1 results summary

In order to build a strong business case around the Energy Efficiency Consultancy service, further study in areas not covered in this study is necessary. One of these areas is competitive studies of firms offering similar service offer in the quarry and aggregate or mining business area. This will help to create differentiating factor to the new service offer by Volvo CE and achieve a promising market share.

This study was totally based on the Swedish market and to limited customers in Sweden. This implies that it might be beneficiary to carry on similar studies in markets other that Sweden and confirm the Energy Efficiency Improvement service has customer desirability in markets other than Sweden as well.

The other potential research direction is the study of best practices in quarry and aggregate operations. This will help in collecting best practice knowledge from different market conditions which Volvo CE needs to acquire to be able to adopt the service offer to different market conditions.
6. References

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Books


Volvo Internal materials
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7. Appendices
7.1 Interview protocols

Interview 1A

This interview questionnaire is intended to help answer research question 1, “What service offerings provide a business opportunity for Volvo Construction Equipment. They are forwarded towards Volvo Construction Equipment customers in the quarry and aggregate business segment.

The interview questions are designed in a way to help explore what opportunities underlie to increase customer satisfaction through creating the prerequisites for the new service.

Organization name: Case company A
Business area: Crushed rock and gravel
Location: Gothenburg
Interviewee: Site manager
Date: 24-02-2011
Interviewer: Anteneh Berhane Gebremeskel

Introductory question:
1. Can you give a short introduction about the company?
   - Company A together with Skanska is a company providing crushed rock material to customers in the construction business area such as Skanska, NCC and private customers as well. The crushing site has been active since 1969. Currently, it has a licence to extract up to 6 million tons of rock material. It has a production capacity of about 500 000 tons per year. The crushed rock material it provides is of enough quality to be used in production of concrete. The crushing activity is on 4 days in a week and 1 day is assigned to maintenance of equipments. However, customers are welcome 5 days a week.

Main questions:

2. What does the operational business process look like?
   - It starts with the production plan for the year. Then, trees and earth material on the surface is removed to expose the rock layer. This is a very expensive process which might take up to 20 percent of the operational cost. It is dependent on the location of the site as different sites have different level of trees and earth material covering the rock surface.

Once the rock surface is exposed, it will be drilled with a drilling machine in order to put in explosives (dynamite) for the blasting process. Depending on the production demand, blasting is done between 6 to 10 times a year. The depth to which the rock is drilled is an important factor to the average size of the blasted rock. The smaller the size of the blasted rock, the easier for the loading machines to feed the crushers and also for the crushers to crush which intern means significant on the amount of energy consumed by each equipment. But in contrast, to make smaller sizes of blasted rock, a stronger explosion in required which would mean higher vibrations to the surrounding earth, higher noise, and a wider radius of scattering blasted rock which eventually takes a lot of time and energy to collect. So it takes some kind of optimization here.

After the blasting, the rock is excavated and loaded or fed in to the primary crusher which crushes down the blasted rock in to a smaller fraction size. All the crushers are mobile and which makes it possible to move the to the rock source instead of too much movement of rock to the crushers. And that saves a lot of energy consumption and man hour. The primary crusher uses a jaw crushing mechanism.
After the primary crusher, the crushed rock is fed to the secondary crusher using cone crushing mechanism. Then the output from the primary crusher passes to a screen in order to separate the crushed rock into different grain sizes. The grain sizes which could not pass the screen are fed back to the cone crusher by a conveyor mechanism.

After separation, the loading machines manage to pile up the inventory. Since the product is of low value, inventory holding cost is not a big issue. Then the customer arrives with its own truck and the loaders from the company assist them loading. The truck will be weighed on its way out for invoicing.

3. What does the value chain integration look like?
   ● The company handles the production planning, surface removing, crushing, and loading. Transportation carried out by the customer itself. Also, the drilling and blasting is outsourced to atlas Copco.

4. What does the fleet configuration look like (drillers, crushers, loading equipments, hauling equipments, etc.)?
   ● One drilling machine, one excavator, four wheel loaders, and one crusher operate at the site and are owned by the company itself.

5. How do you match the production demand/ Capacity and the fleet configuration and size?
   ● A yearly demand is forecasted on the basis of previous year depend and a production plan is made accordingly. Moreover, this production plan is revised in shorter terms to best match specific customer demands.

6. What are the core activities in your business segment?
   ● Planning the production to have adequate supply of products to the customers, planning site layout (for easy movement and future construction), assure the crushing activity conforms with environmental regulations (sound, dust, vibration, chemical spills, eco and safety certified drivers, use of electricity as a preferred source of power) and the crushing.

7. What kind of services does your organization buy or get from other service providing organizations?
   ● Operational: Sandvic, SWECON, atlas Copco provide maintenance services which are beyond the company’s capacity.
   ● Consultancy: Hydro/ Geological consultancy, measurements for vibration, laboratory services

8. Are there any inefficiencies arising from getting disintegrated service offerings from a number of service providers?
   ● (Not answered)

9. If you can rate the operational business challenges in your organization, which ones would come to the top of the list?
   ● Currently, the blasting process is the most challenging. The reason is it produces a significant amount of big sized rocks which can not be fed to the primary crusher. As a result, these rocks need to be further broken down to smaller fractions by the use of hydraulic hammer mounted on an excavator taking so much man-hour and fuel.
   ● The rock material is of low value so lowering cost of production per ton is of big interest.
   ● Environmental regulations are of big attention.

Closing questions:
10. Can you think of any service offering your organization needs which it is not getting now? And how important would that be for your organization?
   - *(Not answered)*
11. Which area in your operational business process do you think needs improvement at this moment? And in the future?
   - *The blasting process needs improvement as there is a higher waste of man hour and diesel there.*

**Interview 1B**

This interview questionnaire is intended to help answer research question 1, “What service offerings provide a business opportunity for Volvo Construction Equipment. They are forwarded towards Volvo Construction Equipment **customers in the quarry and aggregate** business segment.

The interview questions are designed in a way to help explore what opportunities underlie to increase customer performance and satisfaction through creating the prerequisites for the new services.

Organization name: Case company B
Business area: gravel and sand
Location: Göteborg
Interviewee: managing director
Date: 02-03-2011
Interviewer: Anteneh Berhane Gebremeskel

**Introductory questions:**

1. Can you give a short introduction about the company (when it is established, products, production capacity, which customers you provide, no of employees, working hours, establishment process, closing etc.)?
   - *Our company is a company providing gravel and sand to customers in the construction business area. It has been operating since 1989 and has its licence to extract rock material renewed four times since then. It has a production capacity of 300 000 tons per year from its three pits located around Gothenburg. Currently, the company has a licence to extract 2.5 million tons of gravel and rock material which would take about 8 to 10 years to extract with the current production capacity.*

**Main questions:**

2. What does the operational business process look like (starting from order to delivery)?
   - *The operational process is as follows: removing surface materials, blasting the rock, feeding primary crusher, primary crushing, feeding secondary crusher, secondary crushing, screening to different sizes, loading inventory, loading to haul, and measuring load.*

3. What does the value chain integration look like (which activities in the operational business process are owned by the organization and which outsourced)?
   - *The company is owned by a transport company, Skanska (a construction company) and some employees in Transport Company. The crushing activity is outsourced to another company in an agreement where the company pays about 75kr per ton of crushed material. The company manages the production working closely with the crushing contractor. Marketing and transportation of end product is managed through the transport company. And administrative tasks are handled by Skanska.*
4. What does the fleet configuration look like (drillers, crushers, loading equipments, hauling equipments, etc.)?
   - 2 drilling machines, 2 diesel powered crushers, 3 wheel loaders and 2 excavators operate on the site.

5. How do you match the production demand/Capacity and the fleet configuration and size?
   - A yearly demand is forecasted on the basis of previous year depend and a production plan is made accordingly. Moreover, this production plan is revised in shorter terms to best match specific customer demands.

6. What are the core activities in your business segment?
   - Planning the production to have adequate supply of products to the customers, planning site layout(for easy movement and future construction), transportation and delivery, assure the crushing activity conforms with environmental regulations (sound, dust, vibration, chemical spills, eco and safety certified drivers, use of electricity as a preferred source of power)

7. What kind of services does your organization buy or get from other service providing organizations?
   - Operational ; Maintenance and service contracts are handled by the crushing contracting company
   - Consultancy and measurement; Hydro/ Geological consultancy, laboratory testing of rock material, vibration measurement, site mapping, etc

8. Are there any inefficiencies arising from getting disintegrated service offerings from a number of service providers?
   - Not significant

9. If you can rate the operational business challenges in your organization, which ones would come to the top of the list?
   - The rock material we are providing is a low value product. And as a result, lowering cost of production and transportation is a major issue. As for lowering the cost of production, delivering to customers who are closely located is one option followed.
   - The other concern is environmental issues. The quarry site is located close to two living areas, water body used as a source of drinking water, active traffic to an airport which needs not be disturbed, electric transmission lines. All together results in a higher environmental concern.

Closing questions:

10. Can you think of any service offering your organization needs which it is not getting now? And how important would that be for your organization?
    - (Not answered)

11. Which area in your operational business process do you think needs improvement at this moment? And in the future?
    - We have a plan to increase production in the future

**Interview 1C**

This interview questionnaire is intended to help answer research question 1, “What service offerings provide a business opportunity for Volvo Construction Equipment. They are forwarded towards Volvo Construction Equipment customers in the quarry and aggregate business segment.

The interview questions are designed in a way to help explore what opportunities underlie to increase customer performance and satisfaction through creating the prerequisites for the new services.

Organization name: Case company C
Introductory questions:
1. Can you give a short introduction about the company?

- We are a quarry and aggregate business segment of NCC Roads AB. Gravel, Sand, crushed materials, and washed stone products are among the main products Ballast supplies its customers. We currently operate in Sweden, Finland, Denmark and Norway with a total production capacity of 24 million tons per year. The company has about 21 sites around Stockholm area. The customers for us include all the major construction companies such as NCC, Skanska, PEAB, etc and also individuals. A total of 120 employees work for our company in the sites located around Stockholm area. The company has a standard 40 working hours in a week.

Main questions:

2. What does the operational business process look like?

- The process starts with identifying a suitable site and studying the kind of rock material available. The transportation facility around that place is then analyzed. After this, the land owner is contacted and land permit or contract processed. Once the land is acquired, the site is established and the operation starts. When the land permit or contract is finished, then it is made sure the used land looks like a certain predefined condition. It might take up to 4 years to get a permit for a land.

- The operational process is as follows: removing surface materials, blasting the rock, feeding primary crusher, primary crushing, feeding secondary crusher, secondary crushing, screening to different sizes, loading inventory, loading to haul, and measuring load.

3. What does the value chain integration look like (which activities in the operational business process are owned by the organization and which outsourced)?

- The value chain integration is different from site to site. As far as the land is concerned, some of them are owned by NCC, some by the community and some contracted from individuals.
- Crushing equipments are a mix of owned by NCC and some contracted with a ratio of 70: 30 respectively.
- Transportation of raw materials and crushed products are totally subcontracted to a hauler company called Danderyd- Kedjan LBC.
- Loading and drilling equipments are also a mix of self owned and contracted. In some there is no need to own a drilling and blasting equipments as the company buys an already blasted rock material and crushes it further to the required sizes.

4. What does the fleet configuration look like (drillers, crushers, loading equipments, hauling equipments, etc.)?

- Not answered

5. How do you match the production demand/ Capacity and the fleet configuration and size?

- The demand is forecasted using previous years demand. There is as such a big need of using a site simulation tool for many of the sites as there is only few number of earth
moving equipments being used. However, Lennart thinks there is a possibility to use a site simulation on the upcoming site (2012) port construction as it involves a lot of earthmoving equipments working together.

6. What are the core activities in your business segment?
   ● **The core activity is crushing only.**

7. What kind of services does your organization buy or get from other service providing organizations?
   
   ● **Operational e.g. Maintenance and service contracts, etc.**
   
   ● **Consultancy: Hydro/Geological consultancy, measurements**

8. Do you see any potential in integrating contact, purchase and coordination for different service offerings you need from external service providers? If so, what kind of potential?
   
   ● This is dependent on different parameters. One is location: in Stockholm, it is easy to get what ever almost easily. So there is no worry. However in remote areas, as there might not be easy access to all of the required services, there might be a potential benefit in integrating different services and offer a one point contact service.
   
   ● On the other hand, there is a cost issue. The price paid for the integrated service provider should not be higher than what was being paid for the services in the current set up.

9. If you can rate the operational business challenges in your organization, which one would come to the top of the list?
   
   ● Lowering the cost of the final product is the biggest challenge. We continuously strive to achieve this using different method as buying cheaper raw material, lowering transportation costs etc.

Closing questions:

10. Can you think of any service offering your organization needs which it is not getting now? And how important would that be for your organization?
   
   ●

11. Which area in your operational business process do you think needs improvement at this moment? And in the future?
   
   ● **Transportation efficiency. We get consultancy from the contracted hauler company.**
Interview 2 A & B
This interview questionnaire is intended to help answer research question 2. “What are the key performance indicators currently in use by the customers to measure their energy efficiency?” They are forwarded towards Volvo Construction Equipment customers in the quarry and aggregate business segment.

Organization name: Case Company A and B
Business area: Quarry and aggregate

1. What kind of energy do you use in your operation?
2. How significant is the cost of energy compared to the operational cost?
3. How do you measure energy efficiency? And what performance indicators do you use?
4. Do you have any bench-mark for energy consumption per unit production?
5. Do you measure environmental impacts of your energy consumption behaviour?
## 7.2 Idea screening protocol

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Note: H represents one positive point unless specified

1. Teaching services
2. Incremental operational improvement
3. Production control consultancy service
4. Cost tracking consultancy service
5. Site layout design
6. Inventory management service
7. Production planning service
8. Business model development service
9. Investment consultancy service
10. Energy efficiency consultancy service
11. Logistics planning consultancy service