TAMPERE UNIVERSITY OF TECHNOLOGY

KARI HUTTUNEN

MANAGEMENT ACCOUNTING IN NEW PRODUCT INTRODUCTION PROCESS

Master of Science Thesis

Prof. Petri Suomala has been appointed as the examiner at the Council Meeting of the Faculty of Business and Built Environment on March 6, 2013.

ABSTRACT

TAMPERE UNIVERSITY OF TECHNOLOGY
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New product development process is one of the key processes of every organization simply due the fact that the majority of product costs gets fixed during the development phase. Competitive global wind market puts pressure to the whole value chain in order to develop products that lower the cost of energy. This thesis is a case study made for a wind gear unit manufacturer Moventas Gears Oy. One of the major targets of this thesis is to recognize what are the most critical phases of the development process of a wind turbine gear unit.

This master’s thesis addresses the relationship between management accounting and new product development process in order to develop new products with a desirable cost levels. The main goal of this master’s thesis is to discuss how to improve the level of cost consciousness within the development engineers and to implement management accounting methods to the existing product introduction process. The current new product introduction process (NPI-process) is managed mainly through schedule discipline whereas product costs are not monitored during the development process. The current NPI-process follows a stage-gate model and its main purpose is to enhance the product serviceability, component manufacturability and integrate employees to the development process in order to ease the manufacturing and assembly processes.

In the literature section of this thesis the principles of management accounting and project management are studied. Furthermore, to get a broader view of the challenges related to management accounting and new product development projects a benchmarking study was conducted. The study pointed out excellent lessons learned by other companies.

This thesis is aimed at enhancing the overall cost consciousness within the development process and organization by providing ideas on how to monitor the product cost structure during the design process. As a result of this thesis the NPI-process is updated with a framework where management accounting techniques are implemented to the project workflow. Tools of the implementation are performance measuring and cost accounting calculations in the NPI-process. Data is drawn from an on-going project and from past experiences in order to evaluate the future.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Konetekniikan koulutusohjelma

HUTTUNEN, KARI: Laskentatoimi tuotekehitysprosessissa
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Uuden tuotteen kehittäminen on yrityksen kannalta epävarmaa toimintaa ja tuotteen todellista menekkiä ei voida varmuudella sanoa sen elinkaaren alkuvaiheessa. Lisäksi yritykset joutuvat yleensä rahoittamaan itse tuotekehitysprojektit, koska uuden tuotteen kehittämisen kulut syntyvät etupainotteisesti ja tulot jälkipainotteisesti. Tuotekehitys on yksi yrityksien tärkeimmistä toiminnoista jonka aikana lukitaan suurin osa uuden tuotteen kustannuksista. Sen jälkeen kun tuote on suunniteltu, on muilla toiminnoilla tuotekehityksen jälkeen vain hyvin rajalliset mahdollisuudet vaikuttaa tuotteen kustannustasoon. Tästä syystä yritykset joutuvat usein tilanteeseen jossa teknisesti valmistuote joudutaan suunnittelemaan uudestaan, jotta tuotteen kustannustaso saadaan halutulle tasolle.

Tuulivoima on vielä suhteellisen uusi tapa tuottaa sähköä ja 2000-luvun nousukauden jälkeen markkinat ovat rauhoittuneet merkittävästi. Energiamuotona tuuli on edelleen hyvin voimakkaasti riippuvainen erilaisista tukitoiminnoista minkä takia huonoina aikoina tuulivoimateollisuus kärsii muita teollisuuden muotoja enemmän. Tuulivoimalla tuotetun energian hinta on tällä hetkellä liian korkea toimiakseen omavaraisesti ja tästä syystä koko arvoketjun tulisi tehdä töitä yhdessä, jotta tuulivoimasta saataisiin kilpailukykyinen vaihtoehto verrattaessa muihin energiamuotoihin. Tästä syystä omavaraisuusrajan saavuttaminen lähitulevaisuudessa on merkittävää tuulivoiman menestymisen kannalta.

Tämä diplomityö laadittiin Moventas Gears Oy:n tarpeeseen saada liitettyä kustannustietoisuus osaksi tuotekehitysprosessia. Käytössä oleva stage-gate -mallinen tuotekehitysprosessi viedään nykyisin läpi pääsääntöisesti aikataulutavoitteella ja prosessin aikana päätökset pohjautuvat pääosin tuotteen teknisiin seikkoihin. Tämän työn tavoitteena on tuoda kustannustenhallinta ja niiden seuranta olennaiseksi osaksi olemassa olevaa tuotekehitysprosessia. Suunnittelijoiden ja tuotekehitysinsinöörien tulisi voida tehdä tuotekehitysprojektin aikana päätöksiä tuotteeseen liittyen myös kustannusmielessä.

Työ sisältää kirjallisuustutkimuksen sekä pienimuotoisen benchmarking osion. Benchmark -tutkimuksen tärkein tavoite oli selvittää miten muut tuotekehitysorganisaatiot hyödyntävät kustannustietoisuutta tuotekehitysprosessissa ja mitä laskentatoimen työkaluja he käyttävät sen aikana. Lisäksi tätä työtä varten on tutkittu 10 toteutuneen tuuliturbiinivaihteen kustannusrakenne, jonka avulla oli mahdollista havainnollistaa mitkä tuuliturbiinivaihteen osat muodostavat suurimman osan tuotteen kustannuksista ja missä vaiheessa tuotekehitysprosessia ne lukitaan.

Uusi ehdotettu toimintatapa tukee kustannusten läpinäkyvyyttä läpi organisaation ja korostaa kustannuslaskennan tärkeyttä ennen kuin tuotteen kustannukset ovat sidottuja. Työn tuloksena esitetään lisäyksiä nykyiseen tuotekehitysprosessiin, jotka tukevat kustannustietoista tuotekehitysprosessia. Ehdotettu toimintatapa korostaa myös tuotekehitysprosessin suorituskyvyn mittaamista ja diplomityö toimii lähtökohtana tuotteen elinkaaren aikaiselle hallinnalle.

PREFACE

The topic of this thesis was provided by Moventas Gears Oy. The target of the thesis was to enhance the level of cost consciousness of the people working in the product development organization and to create a systematic framework for monitoring costs of product development projects. The Examiner of this thesis was Petri Suomala from the Tampere University of Technology. The supervisors from Moventas Gears Oy were Toni Krankkala and Teemu Kukkola.

I would like to give my thanks to Toni and Teemu for giving me a challenging and interesting topic. I would also like to thank Professor Suomala for examining this thesis. Naturally, I want to express my gratitude for the benchmarking companies that gave their time and participated to this project. Furthermore, I would also like to say thanks for all the friends and colleagues at Moventas for supporting my studies. Special thanks go to a very good friend JP who has helped me greatly with the grammar and the written language of this thesis. I am happy to be surrounded by so many dear friends.

Above all, I acknowledge my appreciation to my family and my dear girlfriend Minna for supporting and encouraging me through my studies – thank you all for being in my life.

Jyväskylä, October 20th, 2013

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ABBREVIATIONS AND NOTATION

0-Series	So called 0-series is the last phase to adjust manufacturing machines and production to be ready for serial production. Some design changes can be made to ease transition to full size serial production.
BOM	Bill of Material is a list of all parts and components needed to build a product.
C-Part	C-parts such as fasteners, seals and covers are relative cheap to manufacture and they are produced with high production volumes. C-Parts have a short lead time and they require little or no design.
NPI-process	New Product Introduction process includes the production development process and productization process of the product.
NPD	New Product Development is a process of bringing a new product to market.
OEM	Original Equipment Manufacturer
PLH	Planet-Helical gear unit is a typical gear concept in under 2MW size class.
PPLH	Planet-Planet-Helical gear unit is a typical gear concept in under 3MW size class.
COGS	Cost of Goods Sold describes a costs committed to manufacturing the product. COGS include material costs, direct labor and overhead costs.
POH	Production Overhead covers indirect expenses associate with processes that are used to produce goods or services. May include costs such as rent, blue collar salaries, electricity and facility expenses.
MAKE	MAKE consulting is an independent company which offer renewable energy market intelligence for companies.

EWEA	European Wind Energy Association communicates and studies the wind industry in cooperation industry and research institutions.
GWEC	Global Wind Energy Council is the international trade association for the wind power industry.
Onshore wind turbine	Wind turbine that is located in the land
Offshore wind turbine	Wind turbine that is located in the sea or coastline.
Grid Parity	Grid parity level is considered as a level where an energy source can function without subsidies or government supports.
VA	Value Analysis concentrates to study the relationship between cost and value.
VE	Value engineering is a systematic process, where the specified purpose of the product is used as a guideline and cost of the product is studied by using required quality standards and specifications.
MOVE environment	The MOVE environment integrates calculating software that is used in gear calculations and 3D-modelling software. It is a company internal tool for designers to generate fast multiple different gear calculations and evaluate those simultaneously.
LCC	Life cycle costing is an economic method to analysis all costs related to manufacturing, operating and maintaining a project over a determined period of time.
DFC	Design for Cost is a tool for analyzing and evaluating product’s life cycle cost.
DFX	Design for X addresses issues such as development, production, utilization and disposal phases that occur in product life cycle.
PM	The idea of the Performance Measurement is to communicate what is the most important focus for company, get real time performance feedback and learn from the past history.

WG	Wind Gears is Moventas business sector that manufacturers gear units into the wind turbines.
IG	Industrial Gears is Moventas business sector that manufacturers gear units for different industrial sectors such as mineral and paper business areas.
O&M	Operating and Maintenance
BCWP	Budgeted Costs of Work Performed
BCWS	Budgeted Costs of Work Scheduled
ACWP	Actual Costs of Work Performed
BAC	Budgeted at Completion
CV	Cost Variance
CPI	Cost Performance Index
CVI	Cost Variance Index
SV	Schedule Variance
SPI	Schedule Performance Index
SVI	Schedule Variance Index

1. INTRODUCTION

It is a known fact that product costs are a consequence of design solutions and features. In today's highly cost competitive environment it is crucial for companies to manage product costs if they want to survive. New products have to be designed in such a way that they generate enough profits for the company while they also deliver the demanded functionality and quality for customers. If a company fails to be cost competitive compared to its competitors, the firms' profit margin will be squeezed and its entire existence becomes threatened. Global market economy has created an intense, highly competitive environment in which companies must be able to develop products with low-costs and with high quality in order to fulfill the functionality requirements and customer demands.

Research and development, in short R&D, organizations have the key role when new products are introduced. Future products should bring the highest value to the customers with the lowest possible costs. New product development projects faced by the R&D organizations are often rather complex in terms of the demand and uncertain in terms of the outcomes (Jorgensen & Messner 2009). The fundamental idea of manufacturing products that are profitable for a company should be the driving force behind making cost conscious designs.

The wind energy industry grew rapidly in the early years of the 21st century and dropped suddenly in 2009. Today the global wind market is at a phase where the biggest boom is over and the market has rationalized shifting the focus towards efficiency. Cost of energy (COE) is a crucial factor when the wind industry is competing against other green technologies such as solar- and hydropower. To achieve this, the cost of wind energy kilowatt still needs to be reduced by 20 – 25 percent. This challenging market situation has put product costs to the focus and raised a question of how to design products more cost efficiently? Development organizations are accountable for the major part of product costs in new product design. According to Cooper and Slagmulder 1997 p. 73; Asiedu and Gu 1998; Uusi-Rauva and Paranko 1998 this can be almost 80 – 90 percent. Thus, it becomes highly important for design engineers to know the causal effects of the different design alternatives. Consequently, this thesis studies where the product costs originate from and furthermore gives suggestions on how to monitor costs during the development process.

This thesis is a case study and its main purpose is to implement cost accounting system into the New Product Introduction process (later "NPI-process"). The current NPI-process follows a stage-gate model (Cooper 2001) and the new development projects should be evaluated by using cost information in the decision making situations during the gate meetings. The product cost structure and all of its design features are frozen during the NPI-process and production or purchasing has only little impact in reducing the cost for the final product. The need of cost follow-up and cost reduction initiatives during the new product introduction is essential when trying to achieve product leadership and good product profitability.

Theory and the data collection of this thesis are based on a literature review and empirical data collection. To connect project management and management accounting in new product development the following question were used as a guideline throughout this thesis. How management accounting techniques can support and produce relevant information for the NPI-process decision-making situations? What kind of cost information does a design engineer need during the design process and what is the right cost accounting method for that purpose? Furthermore, where should all the cost information be collected? The information should be easy to collect and update when needed. In early phases of the design process preliminary design features should also be translatable into occurring costs. Lastly, this thesis is aimed at enhancing the cost consciousness and awareness of the whole R&D and project organization.

By providing a sufficient level of accurate cost information for company’s internal purposes, it is possible to make better decisions from the cost perspective. Key point for improving profitability is the cost competitiveness and consequently it is highly important to implement cost monitoring into the current NPI-process. Design engineers should know the cost effects when they are comparing different alternatives and furthermore, they should be able to make tradeoffs between quality, functionality and costs during the design process. However, product costing is an important part of a costing system and this study does not aim for allocating machine hours using specific costing systems like job-costing or activity-based costing (ABC). This kind of information is already inside the company so the question in this thesis is only to answer how to use it.

This master’s thesis will introduce the reader to the following topics. First and second chapter will give a short outlook to the wind energy market and to its prospects. Third and fourth chapter describe the management accounting and project management theories. The chapters will give guidelines for designing cost-effectively and discuss the relevance of cost information during development process and how project management is related to monitoring costs. The case company Moventas Gears Oy and its current practices in new product introduction process are introduced in chapter five. In the sixth chapter the research methods and material of this thesis are discussed. Seventh and eighth chapter are the applied section of this thesis and the chapters will give suggestions on how to implement management accounting into the NPI-process. Lastly they also present the results of the implementation of management accounting. Chapter nine is for conclusions.

2. WIND ENERGY MARKET

Wind energy as a business is only 30 years old, thus it is a newcomer inside the energy market mix. The wind energy market has increased to six-fold during the past ten years and today the suppliers find themselves in a highly uncertain and complex macro-economic situation. During the past 20 – 30 years the wind energy has gained a certain level of maturity. However, from the industry point of view the market has not industrialized yet and only few components of the wind turbine are standardized creating significant cost effects. During past few years' the global wind energy market has suffered from overcapacity and the cost of produced energy has consequently become everyone's focus. In order to achieve more competitive ways for generating energy compared to other conventional methods, cost reduction targets are rolled out to the entire value chain.

Meanwhile, the global energy demand is rapidly increasing and fight against climate change requires instant actions to be made. Wind energy provides a good alternative for generating pure, free and green energy. Within the coming year's crude oil and carbon prices will most likely keep on increasing making the volatile and unpredictable fossil fuel prizes a risk factor for the cost of power generation. Under these circumstances the wind industry provides more steady solutions for power generation. However, there are still many challenges to be faced.

According to MAKE report (2012, p. 9) there are three main challenges in the global wind energy market and its supply chain. Firstly, global economic growth is stagnant consequently driving the mature Western power generation markets into a slow growth. Secondly, a bloated supply chain is leading to poor profit margins. Thirdly, wind industry's addiction to support mechanisms and incentive systems. In the future, aspects like these may be a reason for some structural changes in the global wind energy supply chain. The entire wind industry will suffer if strong global players leave the market due to poor profitability or strong multinational industrials stay out of the market for the same reason. (MAKE: Global Wind Turbine Supply Chain Report 2012).

Wind energy is a form of electricity generation that relies highly on subsidies. Today government incentives and support mechanisms create the backbone for the growth of wind power. However, during global macroeconomic concerns, like the economic downturn, European debt crisis and lowered growth in India and China have put these mechanisms under fire. This is evident especially in Southern European countries such as Portugal, Italy and Spain. (MAKE: Global Wind Turbine Supply Chain Report 2012, pp. 9-12).

The evolution of the installed wind power capacity during years 1996 – 2012 can be seen from Figure 1. The growth of wind market has slowed remarkably when compared to early 21st century. Nevertheless, global cumulative wind installations end up with a total of 282 430 MW in 2012.

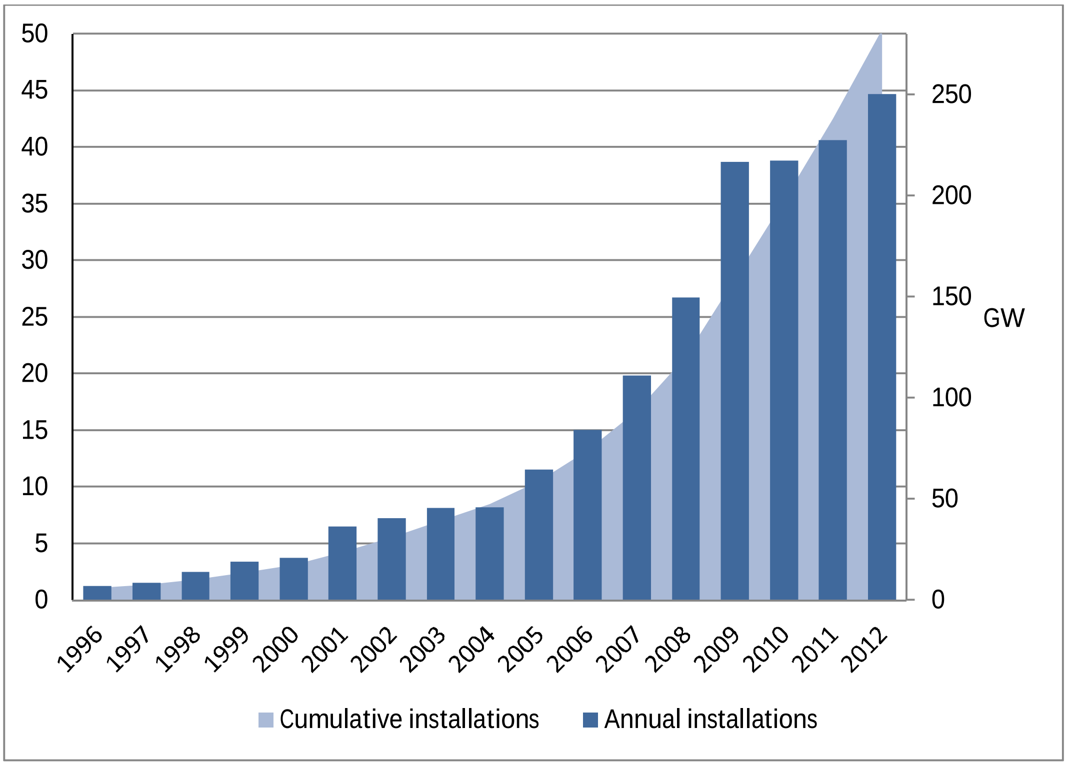

Figure 1. *Global annual and cumulative installed wind capacity 1996-2012 (adapted from GWEC http://www.gwec.net/wp-content/uploads/2012/06/Global-Annual-Installed-Wind-Capacity-1996-2012.jpg; http://www.gwec.net/wp-content/uploads/2012/06/Global-Cumulative-Installed-Wind-Capacity-1996-20122.jpg Reference 13.6.2013)*

MAKE consulting argues (2012) that the turbine OEM market has been divided between Western and Asian players. Today there can be found 15 top players in the turbine OEM markets and these players are presented in Figure 2. These Top15 OEMs had 85.3 percent of the market share in 2011. The other OEMs outside Top15 have increased their share of the market by three percent compared to 2010. (MAKE: Global Wind Turbine Supply Chain Report 2012, p. 18).

Figure 2. *Top15 OEMs in wind turbine market. (Adapted from MAKE: Global Wind Turbine Supply Chain Report - July 2012, p. 18).*

Insourcing gear units is relatively uncommon among turbine OEMs. Today, there are only two Chinese companies Sinovel and United Power and two Western OEMs, Siemens and Gamesa that insource gearboxes. This is mainly because of the technical complexity of the gear units and the current availability of experienced suppliers. (MAKE: Global Wind Power Market Outlook 2012, pp. 22-23).

2010 was a substantial milestone for global wind industry as it was the first year when more wind capacity was installed in the emerging markets than in traditional OECD countries. Some countries that were not even on the map of the global wind market six years ago have now increased their installed capacity remarkably. The emerging markets and developing countries have risen the percentage of investments dramatically during the years from 2004 to 2011 respectfully from 19 percent to 46 percent becoming a high potential market for the entire wind industry. (GWEC: Global Wind Report 2011, p. 7).

When going down in the value chain, overcapacity is largely the reason for poor profitability in the supply chain. According to MAKE consulting report (2012, p. 9) material cost reduction is one of the main issues in Americas, Europe, China and India. It can be said that the global supply chain of wind energy has changed its focus from capacity to capability. (MAKE: Global Wind Turbine Supply Chain Report 2012).

The biggest competitors for wind energy within renewables are solar and hydro that create a minor substitute threat for wind. Low natural gas price is the biggest threat to wind power especially in the United States. Price of natural gas is forecasted to remain under 6 USD/MMBTU for the next four years. This can be considered as a tide breaker where wind becomes competitive in current gas prices and technology (Krohn et al. 2009). Achieving grid parity level in the mid-term is important for success of the wind power. Wind energy cannot rely on subsidies in the future as it still does today. Grid parity level is considered as a level where an energy source can function without subsidies or government supports. Wind power is still 20 – 25 percent off that mark being the main reason why cost reduction projects are so familiar term for the people working inside the wind industry.

Wind market is highly capital-intensive according to EWEA (The European wind energy association) report of the economics of wind energy. EWEA states that about 75 % of the total cost of wind energy using a wind turbine is upfront costs like the cost of the turbine, grid-connection, electrical equipment and foundation. Cost structure of a typical 2 MW wind turbine installed in Europe clearly shows that just the cost of the turbine is over 75 % of total costs. (Krohn et al. 2009, pp. 9-10).

Wind power plants differ from conventional thermal power plants because most of the costs of operating and owning the plant are known in advance with great certainty. One of the biggest benefits of wind power is that the fuel source is free reducing the exposure to economies of fuel price volatility. Price volatility due to the unpredictable rises in the price of CO_2 and fossil fuels being a major handicap for traditional power production methods in the future. This benefit is so considerable, that even if wind energy is more expensive per kWh than other power generation forms it could be easy to justify. There are seven key characteristics which will determine the basic cost of wind energy: the upfront investment costs that mainly come from the turbines, the installation cost of turbine, the cost of capital (the discount rate), operation and maintenance costs, project development and planning costs, lifetime cost of turbine and production of electricity. (Krohn.S et al. 2009, pp. 25-29).

Krohn.S et al. (2009) remind that when comparing the cost of different technologies the different discount rates should be used for various technologies, mainly because risk levels are different between available alternatives. This view is missing from many studies done in the field of power generation. For example, if carbon price risk would be included to the cost analysis of generating electricity, wind energy would appear cost competitive when compared to gas, coal and nuclear. (Krohn et al. 2009, p. 22).

The price of wind energy depends highly on where the wind energy is produced and delivered to thus there is no single price for wind-generated electricity. The price has to cover the costs in order to make the delivery and the risks that wind turbine owners have. Wind power is sold on a long-term basis with duration of 15 – 25 years. Krohn et al. (2009) have pointed out, that as a relatively new technology, wind energy meets two challenges. One, market rules and technical regulations of existing markets are made based for conventional power generation technologies. Two, stability and certainty of government regulations are economically more important for capital-intensive technologies such as wind power than for conventional fuel-intensive technologies. In Denmark during 2004-2007 the cost of power to the consumers would have been 4 –12 percent higher if wind power had been not used in the power production. (Krohn et al. 2009, pp. 14-19).

Generally speaking wind turbines are priced according their swept rotor surface area (kWh/m²) where all the energy comes from. However, the generator size has only a minor role in wind turbine pricing even though generator tends to be proportional to the rotor swept area. Technical design lifetime of wind turbines is 20 years and all leading international wind turbine manufacturers have type-certified their turbines to withstand local wind climate classes for the mentioned lifetime of 20 years with appropriate safety factors. Wind turbines though are known to survive even longer times especially in low-turbulence areas. Offshore the wind conditions are less turbulent and thereby offshore turbines are certified for 25 – 30 years. (Krohn et al. 2009, p. 38).

Wind market in Europe has been divided geographically between the stronger northern Europe over the southern neighbors. Inside the wind industry there are two alternative solutions available, onshore and offshore turbines. Offshore has gained some market share from the onshore turbines. However, turbines built offshore are 2 – 3 times more expensive than the ones placed onshore. Nonetheless, offshore turbines will gain more market share in the future and according to MAKE council (2012) the offshore wind sector is today one of the strongest growing market sections in Europe (MAKE: Global Wind Turbine Trends 2012, p.9). Krohn et al. (2009) argue that the higher wind speeds and the lower visual impact of the larger turbines will favor offshore wind sites. The energy production indicator in offshore installation can reach up to 4 000 full load hours per year, while onshore it is typically around 2 000-2 500 full load hours per year. (Krohn et al. 2009, p. 11).

When the wind market is evolving and the competition between companies increases, the firms have an increasing pressure to maintain their competitive advantage. This requires controlling product costs, shortening the development lead times and improving the product quality. Product costs are one of the main factors influencing competitiveness directly. However, well-designed gear units can also lower the COE of wind turbines. Aspects such as lower weight, higher torque density and efficiency of the gearbox reduce investments costs of wind turbines and good serviceability leads to lower O&M costs.

When the 2MW segment supply chain is studied many players can be found from the marketplace, especially Chinese manufacturers. When moving towards 5MW or 7MW market segments, the number of player is substantially lowered. Typically these large wind turbines such as 7MW are offshore turbines used in sea conditions. Global electricity demand creates major possibilities to wind energy as well. MAKE consulting has projected in 2012 that global electricity generation will grow over 20 percent in the years from 2012 – 2020. During the boom years 2004 – 2009 wind capacity increased remarkably, over 200 percent (see Figure 1). Asia pacific and especially China, has carried the markets for the last two years. In 2011 China reached over 50 percent market share. European Union has set a target that in 2020 20 percent of the energy is produced using renewable energy. The target may be unrealistic because the economic downturn has led to poor electricity demand. If the demand stays weaker than expected the target will slip away. MAKE (2012) pointed out that especially the growth of offshore has not fulfilled expectations in European markets and without extensive development of offshore wind the EU will not be able to meet its carbon emission targets (MAKE: Global Wind Power Asset Ownership 2012, p. 4).

Wind market in Finland is behind the schedule and utility companies are struggling with environmental applications. To achieve a target of 2500MW set by the Finnish government before the year 2020 will require large investments to both onshore and offshore sector. In 2012 only 288MW of new wind capacity was installed, 229MW was in construction phase and 80MW was in application process. Coast of the Baltic Sea offers good potential for offshore wind turbines where at least 5 – 6 offshore wind parks would easily fit. (Lukkari 2013, p. 5).

Figure 3 is illustrates how the global wind market shares have been divided. MAKE consulting expects that current core markets will be responsible for installing the majority of the new capacity during the next five years. (MAKE: Global Wind Power Market Outlook 2012, p. 23). As it can be seen from the figure, five countries (China, USA, Germany, Spain and India) clearly dominate the current wind market and combined have a 74 % market share.

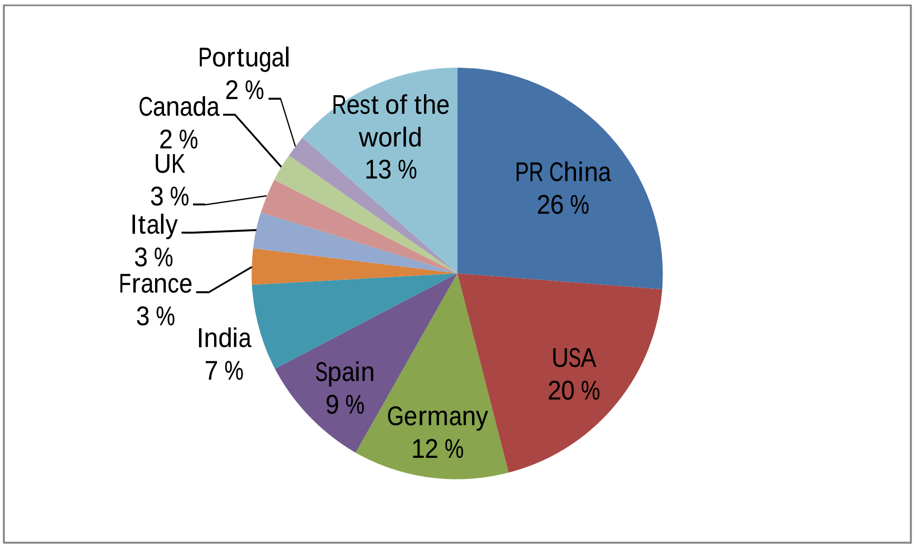

Figure 3. *Wind market shares divided top countries in Dec.2011 (adapted from GWEC: Global Wind Report 2011, p. 12; MAKE: Global Wind Power Market Outlook 2012, p. 11)*

Figure 4 is presents the world´s top five markets (PR China, USA, India, Germany and UK) in terms of annual installed capacity. They have three-quarters of the total new installed capacity in 2011 and moreover, top ten markets dominate 88 % of the global annual installations.

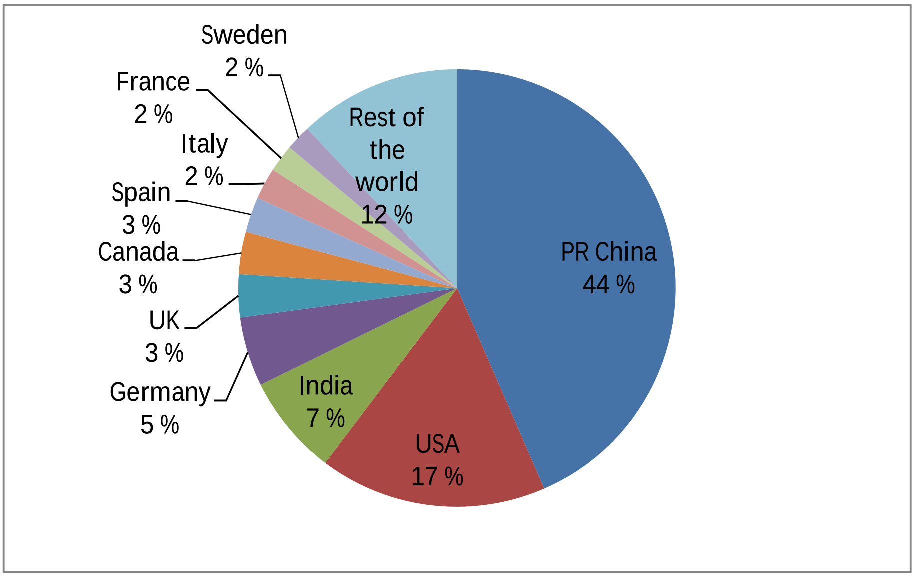

Figure 4. *Installed wind capacity in Jan-Dec 2011 (Adapted from GWEC: Global Wind Report 2011, p. 12)*

The growth of markets in Americas is shifting from the U.S. to Latin America and Canada. Macroeconomic factors and political uncertainty influence negatively especially to the North American wind market. The wind industry suffered when the congress failed to extend the Production Tax Credit support system on time. Furthermore, a heavy competition with natural gas has lowered the demand for wind power. The new project pipeline in Canada is strong and market forecast for the next five years is over 11GW of new installations. In 2011 the Brazilian market of 500MW represented nearly half of the installed new wind capacity in Latin America. However, wind power development in Latin America is projected to remain mainly with onshore turbines. (MAKE: Global Wind Power Outlook 2012, p. 7 & 25-28, 39).

In Europe the economic downturn affected negatively on the wind market especially in Southern Europe where Spain and France pulled down the European markets. In Spain the market feed-in-tariff expired at the end of 2012 being one of the reasons for the drop of Spanish market in 2013. Overall the European market ended up to over 10GW of installed new capacity in 2011. Germany is still the largest country in the European wind market when measured in both new installed capacity and cumulative capacity. German government´s decision to phase out of all nuclear power by 2020 will definitely give possibilities to alternative ways of generating electricity. Market growth in the region is though highly coupled to the success of offshore sector and almost 17GW of offshore wind capacity is already approved in Northern Europe, Belgium and Denmark. Despite recent setbacks with emerging markets, Eastern Europe has attractive wind resources and sites to support growth on that region. (MAKE: Global Wind Power Outlook 2012, pp. 50, 66 and 75).

In Africa the development of wind industry has been slow and negatively impacted by political instability, limited financing and construction-related complications. Nevertheless Africa can provide major potential for renewable energy development. Only 52MW of installed new wind capacity in 2011 brings the region´s cumulative capacity to little over 1GW. (MAKE: Global Wind Power Outlook 2012, pp. 113-114).

Energy demand in Asia Pacific is projected to increase by 3 % annually up to 2030 creating an enormous possibility for wind industry. It is also forecasted that by 2016 119GW of new wind energy will be installed to China and India alone. Although more than 100GW of the total is expected to be installed to China. Current Five-Year plan in China supports renewable energy and China will continue to be the world´s largest single market by installing and grid-connecting more than 17GW in 2011. In India challenges with conventional power generation give an opportunity for renewables. Australia will also boost the wind market in the Asian Pacific region where over 3GW of new capacity is forecasted to be installed by year 2016. Korea is developing a major offshore industry however the timetable is still open. (MAKE: Global Wind Power Outlook 2012, pp. 92-95).

2013 will be a difficult year for the wind industry where companies will struggle to secure funding and the whole world seemingly holds its breath in wait of the next turn in global economy. MAKE (2012) argues that when looking beyond 2013, market signs represent remarkable growth giving an opportunity to expand portfolios. China will lead market growth with their closed markets giving the local companies a better market position. There is no doubt that this will increase competition in all other markets also. (MAKE: Global Wind Power Asset Ownership 2012, p. 4).

Market councils like MAKE and GWEC are expecting for the wind industry to recover and start to grow within the next five years, it is not going to be easy. Especially lower in the supply chain manufacturers with chronic oversupply will be under remarkable cost pressure. GWEC (2011, p. 18) argues that most of the market growth in the future will come from outside the traditional markets like North America and Europe and players in the wind industry need to shift towards emerging markets such as India, Brazil, Korea, Eastern Europe and South Africa (GWEC: Global Wind Report 2011).

Current stagnant market situation gives time and an opportunity for companies to develop products to the level, where manufacturing a certain product for wind energy value chain, can offer the best value for its customers at an acceptable price. So, when the next market rise or even boom will come, baselines and processes should be ready in order to develop and produce fast competitive and cost-effective products. According to MAKE council, the emerging markets will be responsible for an increasing percentage of wind power demand and opportunity. The growth in European market is highly depended on the strength of the offshore segment. (MAKE: Global Wind Power Asset Ownership 2012, pp. 18-20).

Based on this short market overview wind power still seems an attractive form of generating electricity and from the cost assessment point of view wind energy can be classified as a low-risk technology. MAKE: Global Wind Power Market Outlook (2012, p. 18) argues that the economic growth and demand for new electricity generation is one of the best indicators when forecasting the increase of wind power capacity. However, current Eurozone crisis still affects negatively on new investments' especially in southern Europe. The distinction between uncertainty and unpredictability is an essential consideration when the cost of energy is estimated.

Wind power as a form of generating electricity has its pros and cons. Most pros derive from the environmental factors and low O&M cost´s. Cost of producing electricity using a wind power plant after the initial investment is paid off faster than any other fuel-based technology and thereby lowers the price of electricity. Future fuel prices are unpredictable and uncertain and this is one of the biggest advantages of the wind power. By adjusting fuel-price risk when making cost comparison between different technologies is uncommon and this affects poorly on wind power.

All in all, regardless of the challenging market situation and moderate growth expectations, the fight against climate change favors wind energy. The big question is how to bring wind energy on par with oil and gas requiring a joined effort throughout the product value chain. Companies that cannot compete in the mainstream product range will have to focus more on niche areas such as low wind regions, offshore and high altitude in their innovation. This will further drive the market towards lower overall costs. As the demand for electricity is at a steady increase globally, it offers wing energy a solid foundation to build on. The market green image of the wind energy especially in the western countries will help to justify the higher spot price of wind electricity until the par price with oil, gas and coal has been achieved.

3. MANAGEMENT ACCOUNTING THEORY

Management accounting measures and reports financial information inside a company and also supports decision-making situations (see for example Horngren et al. 2005, p. 5; Suomala et al. 2011, p. 10). Figure 5 illustrates the importance of management accounting in a company where management accounting has an important role as a strategic partner in the value chain. This master's thesis investigates how management accounting can be implemented to the R&D and design functions, and what challenges occur when accounting methods are brought among development engineers.

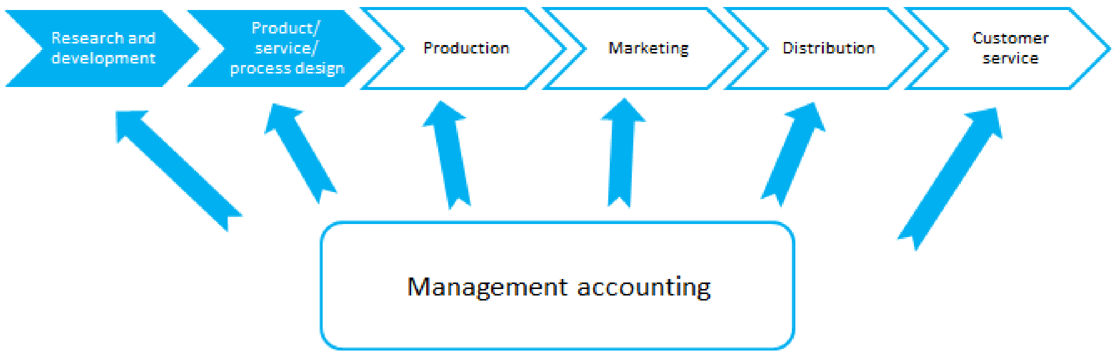

Figure 5. *Management accounting in the value chain of business functions. (Adapted from Horngren et al. 2005, p. 15).*

Management accounting methods can be used to support decision-making situations starting from early phases of the product life cycle to the very end of it when the product is disposed and recycled. By using management accounting it is possible to:

- Predict the future together with different scenario analysis
- Study current status in financial terms
- Study history in order to learn from the past.

Cost information can be used for multiple different purposes, for example: planning, monitoring, evaluation and rewarding purposes. This chapter will introduce the reader with the basic theories based on literature review and studies of academics.

3.1. Management and cost accounting

According to Horngren et al. (2005, p. 35) cost is defined as a resource sacrificed to achieve a specific objective. This means that costs are usually generated when goods and services are acquired, it is the monetary amount paid and it is not always the same thing as acquired costs. Pellinen (2003, pp. 49-53) argues that there are four main problems in the field of cost accounting: the problem of scope, allocation, valuation and measurement. Understanding these problems is essential for decision-making situations and analyzing financial reports. For decision maker it is important to understand that there is not a single definition for costs. Saying “Different costs for different purposes” indicates that first, costs are developed and used for some specific purpose and second, how the cost is used will determine the way it should be computed (Atkinson et al. 2004, p. 31).

A cost object is needed when costs are computed. For example, product or organizational unit can be used as a cost object. Typically, costs are divided into direct costs and indirect costs. A direct cost is defined as a cost of activity or resource that is acquired or used by a single cost object. This can be steel used to machine a wheel, the steel used creates a direct material cost for wheel. An indirect cost on the other hand is the cost of a resource that an organization acquires to be used by more than one cost object. For example, the cost of a drill is an indirect when it is used to manufacture different kind of products. However, cost classification can vary when the cost object changes. Classification presented provides only a guideline to study different kind of costs. (Atkinson et al. 2004, p. 32).

Organization generates costs when they manufacture volume of products during a specific time period and those costs are called product costs. Product costs include direct and indirect costs like; material, labor, equipment, machinery and buildings. Direct costs are possible to allocate directly on a selected cost object as presented in Figure 6. Cost object can be for example a product or a customer. Indirect costs must be allocated by using different cost pools such as marketing, designing, electricity and rent.

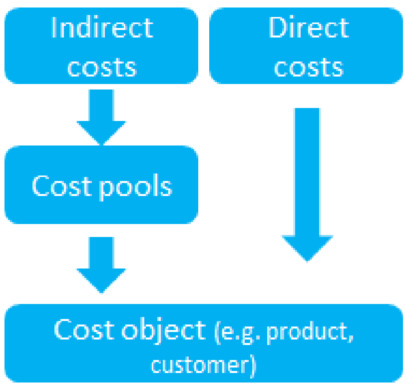

Figure 6. *Basic principle of cost accounting.*

Atkinson et al. (2004) point out, that manufacturing costs can be classified into two categories manufacturing costs and non-manufacturing costs (see Figure 7). Manufacturing costs are divided into two sub-categories based on their traceability. When it is possible to trace the manufacturing costs to a single cost object the costs are called direct and when manufacturing costs are related to more than one cost objects the costs are called indirect manufacturing costs. Costs that did not originated from the manufacturing of the product are called non-manufacturing costs. Marketing costs consist of advertising and promotion expenses. R&D costs are related to designing and introducing new products to the market. Selling costs include salaries of sales personnel, commissions and other sales office expenses. Distribution costs are related to delivering the manufactured products to the customers e.g. freight and the salaries of shipping and delivery personnel. General and administrative costs are such as the CEO’s salary, legal and accounting office costs. After-sales cost originated from dealing with customers after the delivery of the product e.g. warranty issues and costs of maintaining customer support. (See for example Atkinson et al. 2004).

Product manufacturing costs	Period non-manufacturing costs
1. Direct manufacturing costs	1. Marketing costs
2. Indirect manufacturing costs	2. Research and development costs
	3. Selling costs
	4. Distribution costs
	5. General and administrative costs
	6. After-sales costs

Figure 7. *Summary of cost classifications (Adapted from Atkinson et al. 2004, p. 37)*

Uusi-Rauva and Paranko (1998, p. 2) argue that cost accounting helps in finding answers to questions like: which products and services are the most profitable? Which customers are the most satisfied? What are the activities in our value chain that operate the most efficiently? For a company it is crucial to known if some products or customers are unprofitable. It is not to say that there cannot be unprofitable products or customers because sometimes there may be other reasons to maintain such customership or portfolio. Could be that the customership provides valuable marketing exposure or the product can be a reference for entering a new marketplace. When a company recognizes what products and customers are profitable and which customers are satisfied and what is the most efficient way to use the value chain, the managing part becomes much easier.

According to Atkinson et al. (2004, p. 38) cost information can be used inside the company for several different purposes that are divided into planning and evaluation purposes. Decision makers use the cost information when they make decisions and control the processes they manage. When decisions are made the cost calculations can be tailored according to the specific case under evaluation. That tailoring can be called as a management accounting. (Atkinson et al. 2004).

Management accounting offers many different costing models to study and choose from. One of them being ABC (Activity-Based Costing), that was developed for more accurate assignment of indirect costs (see for example Thorne and Gurd 1999; Kaplan and Atkinson 1998, p. 97; Horngren et al. 2005, p. 345). ABC can be considered as an accurate costing method but also expensive to implement. One of the biggest advantages of ABC is that it reveals cause-and-effect relationships that are important for development engineers. However, designers need the cost information rolled out to a part or feature level and this may easily result to a complex costing system. According to Kaplan and Atkinson (1998, p. 151) companies that have a cost structure where direct labor and overhead costs form the major part of total costs, benefit the most from ABC systems. However, benefits come from aspects, such as analyzing profitability, improving processes and making outsourcing decisions.

When a company is defining all activities and the amount of activities that are required for manufacturing a new product, Suomala suggests (2004) to combine known unit costs of different activities based on activity-based costing and difference between consumption level of used activities of the new and existing products. By combining the information together it is possible to give a cost estimate for the future product.

> *"The costs of new products can be analyzed as combinations of activities that are carried out in the various processes of a firm. Activities consumed by the products are thus seen as the parameters that affect the cost of the product."(Suomala 2004, p. 108).*

Kaplan (2012) points out that the ABC method is typically used when a company studies its profitability level and investigates which products and which customers bring the most profit to the firm. The discussion of dropping an unprofitable customer or rejection of an unprofitable development project is not usually an easy decision. Kaplan and Cooper (1998) argue that companies normally have only few profitable customers and few unprofitable customers. Moreover, 20 % of the most profitable products can generate almost 300 % of the profits and remaining 80 % are break-even or loss items. This cumulative profitability phenomenon is typically presented as "a whale curve" (see for example Kaplan and Cooper 1998, p. 162; Porter 1997, p. 35).

From the company point of view, it is important to make these kind of analysis and recognize which are the customers and products that are profitable from the ones that are not. It is not necessarily recommended to drop the customer or product out of the portfolio immediately after the analysis. Instead, recognizing the reasons behind unprofitable customers or products is more important. For example, by guiding customers to use certain batch sizes in orders, may lead to a raise in profitability levels. If a certain customer or product is not needed for reference purposes and it is unprofitable it makes sense to end the customership.

Moventas uses activity-based costing as their cost accounting system and the company has long roots in activity-based costing. Moventas uses around 70 activities in the existing ABC system and the cost object is typically a product. The ABC method in Moventas can provide sufficient cost accuracy for cost accounting purposes. However, question is, is it flexible enough to serve the needs of the product development organization? Development engineers need real time cost information of current products and different scenario analysis between design alternatives.

3.2. Cost management

Cost management can be defined as following: “Cost management is the performance by executives and others in the cost implications of their short-run and long-run planning and control functions.” (Horngren 1991, p. 92). Furthermore, Cooper and Slagmulder (1997, p. 38) point out that managing costs can be divided to three mainstreams:

- To manage cost of the new products
- To manage cost of the current existing products
- To create an entrepreneurial spirit among work force.

At Moventas cost management is applied mainly on existing products. Nowadays there are several cost reduction projects where the cost structure of the gear unit is analyzed. Cost reduction projects are usually challenging tasks and they often require some redesign work giving more pressure for supply chain. Cost reduction projects are usually a consequence of poor cost management during the original NPI-project. However, sometimes it is justified and more important to develop the products within tight time schedule than make several iteration rounds to mature the design to a low cost level.

When companies want to minimize the total cost of the product it is vital to recognize cost elements related to that particular product and put focus on the right places. Figure 8 presents the main features that contribute to the product cost. A person who analyzes product costs at the early stage of the development project must have a good knowledge of all the elements needed for manufacturing the product. Moreover, that person must be able to understand where the design features originate from and how those features are manufactured. (Geometric 2010, pp. 7 – 8).

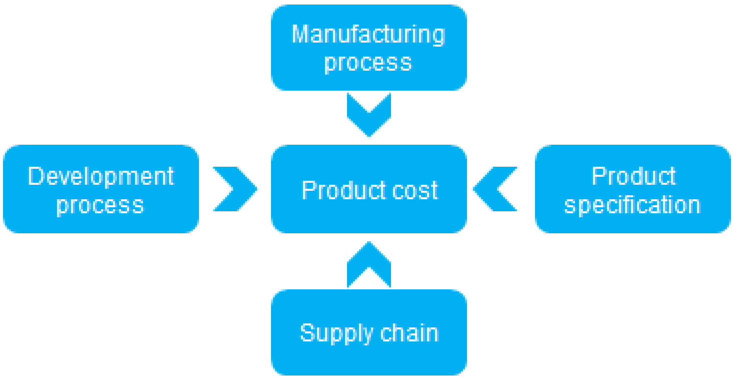

Figure 8. *Characteristics for cost optimization. (Adapted from Geometric 2010)*

Optimizing the *product specification* can be done for example by reducing material usage, making trade-offs between costs and functions, modularizing products and by using standard components whenever possible. *Supply chain* can be optimized by choosing suppliers based on used raw materials. When supplier can use their standard materials and machinery, it can reduce component costs. Furthermore, costing analysis can provide vital information when seeking out right suppliers for the right components. Optimization of the supply chain is also a good exercise on managing transportation costs and on the use of inventory management techniques, such as flow analysis, just-in-time production and what-if analysis. There are several parameters in the *development process* that influence the cost of the product. Optimization of the development process can lead to a reduced lead times in development projects and also reduce the number of iteration cycles during projects. Inside the development process different kind of solutions can be recognized, that will increase productivity and decrease repetitive tasks reducing the product development cost. *Manufacturing process* can be optimized by improving material utilization, reducing manufacturing operations, using flexible machinery and increasing manufacturing throughput. (Geometric 2010, pp. 8 – 10).

According to Uusi-Rauva.E and Paranko.J (1998, p. 3) the most fundamental questions when cost reduction programs are addressed are: (see also Ostranga and Probst 1992)

- How much our current product costs?
- Why does it cost so much?
- What can be done to reduce the cost level of the product?

Companies are required to do tradeoffs between costs, manufacturing, quality, design and functionality in order to achieve a desirable cost level. For this reason cost management is not just a management and R&D topic. The cost discipline begins from the design table and continues through purchasing, manufacturing and logistics departments involving everyone in the company and spreading across the entire supplier and customer value chain.

However, cost management is vital in the early stages of the product life cycle, in short PLC. Interest towards costs should not be restricted only to the development and design stages. When products are evolving as a function of time different aspects need consideration in the later stages of its life cycle. Suomala (2004) underlines the meaning of life cycle management and life cycle costing (LCC, see for example Ansari et al. 1997; Dell'Isola 1997) when product life cycle is studied. According to Kumaran et al. (2001) by using LCC method it is possible to collect all costs throughout the product life cycle. These costs are composed from cost of design, development, production, use and disposal of the product. Furthermore, Suomala (2004) points out that uncertainty also has to be considered in the LCC. The literature around life cycle of the product or technology is usually divided to design, introduction, growth and maturity stages. In addition, stages like disposal and recycling should be considered. (See for example Suomala 2004; Prasad 1997).

Asiedu and Gu (1998, p. 884 – 885) remind that R&D organization should keep the PLC and all different characteristics such as reliability, serviceability, costs and effectiveness in mind when new products are introduced. Furthermore, Suomala (2004, p. 123) suggests that by analyzing the product life cycle it is possible to recognize important and otherwise less important tasks of product development. From a company point of view it is important that focus of usually limited resources is in the right place.

Duration of the development phase when compared to the product life cycle addresses how much focus the company should put on the early stages. Suomala (2004, p. 131) argues that efficiency of the NPD (new product development) is important only when the development phase is relatively long compared to the life cycle. When the development phase is relatively short the efficiency of the NPD is not so relevant. Furthermore, Sandström (2001, p. 52) points out that when most of the engineering design includes adaptive and variant design with relative long life cycle of the product design information from previous projects, can be considered as valuable.

3.3. Cost information in development projects

Development engineers and project managers are in the key role when costs of new products are defined. Especially, development engineers should be aware of the cause-and-effect relationships of their decisions. Sandström (2001) argues that in the field of engineering a cost object is much more sophisticated and complex than just a customer or a product. The amount of cost objects is typically high in the design of products and that increases also the amount of cost drivers. Thus assigning cost from recourses to cost objects via activities is easily a complex task. Naturally, the more detailed the cost object is, such as a component of a subassembly or material type, the more accurately the designer is able to estimate the costs. This on the other hand will increase the complexity of the costing system. That's why internal ABC system is considered to be too difficult during development projects. (Sandström 2001, pp. 83 – 86).

Nixon (1998) underlines the importance of collaboration between the R&D organization, manufacturing, supply chain, the customer and the financial controller. This cross-functional team is responsible for executing the development project and of the balance between different cost requirements. These trade-offs between different design alternatives highlight the role of the financial controller when evaluating cost consequences.

Cost accounting information can be used in multiple different situations inside the business. Neilimo and Uusi-Rauva (1997, pp. 93 – 94) have listed the following situations:

- product pricing and/or quotation
- monitoring production costs
- monitoring profitability levels of products and customers (price – total costs)
- to support product portfolio decisions
- make or buy decisions
- investment decisions
- provide cost information for R&D
- enhance organization’s cost awareness
- budgeting and supporting financial planning
- benchmarking and continuous improvement.

Furthermore, Sandström (2001 pp. 22 – 23) suggests that cost information to engineers can be classified into four different groups.

- Formulating the cost information needed using different alternatives with the help of experts or experienced engineers.
- Estimating the costs of new products by using costs of previous similar products.
- Analyzing direct costs (material, labor) using drawing of the new product.
- Analyzing total costs of the new product with a drawing and process plan.

The first suits when a new design concept is being developed and it requires a cross-functional team to discuss the different design alternatives. Also, choosing the best alternative requires normally several iteration rounds. The second alternative suits better for quotation purposes. Third and fourth groups will provide cost information for engineers requiring design features to be available in order to transfer cost features.

One of the main problems with accurate and quantitative cost estimation models is that the cost information evaluated is dependent of many variables. Sandström (2001, p. 24) points out that for example a company’s own production can manufacture a similar part using different machinery or by using the same machine with different settings and machining parameters resulting in variation of manufacturing costs. Figure 9 lists three different models to formulate cost information for the needs of development engineers.

ABC-system	Process cost model	Feature costing model
1. Identifying activities	1. Model the activity process of the organization	1. Define features of the product
2. Create activity centers	2. Recognize all relevant process and product cost drivers	2. Determine activity process of each feature
3. Selecting recourse drivers	3. Simulate operations of each process scenario	3. Define cost of activities
4. Reporting cost of each activities or activity centers	4. Define how long process are used	4. Determine characteristics of the product that affect to process
5. Selecting activity drivers		5. Define how much selected characteristics cause the process to vary
6. Cost reporting of selected cost objects		6. Associate characteristics and features to product
		7. Adjust the activity cost based on the product´s characteristics and features

Figure 9. *Alternative models to formulate cost information for engineers. (Adatped from Sandtröm 2001, p. 92; Greenwood & Reeve 1994, pp. 8 – 11; Brimson 1998, pp. 9 – 11).*

Previous projects may provide valuable information if the information is available. In the case company of this thesis the information from finished projects is not collected and evaluated systematically. Historically, even the project managers have not been able to find themself the actual COGS (Cost of Goods Sold) of finished products. This shows that group controllers and the financing department have mainly driven cost management. The consequence has been that the R&D organization has been isolated into designing products according to given timetables.

The conceptual design stage, when designers choose preliminary materials and design the components for a future product, is the time and place to provide cost information to support their decisions. Also, the information of manufacturing processes should be available for the engineers at this stage. If feature based costing is to be used the cost information concerning different design features requires a data base or at least cost tables according to the cost drivers of products. (Sandström 2001, pp. 78 – 79).

To minimize costs of a product Pahl & Peitz present (1992, pp. 510 – 511) a few following ground rules:

- Keep it simple (small number of parts)
- Target to design smallest as possible to achieve smaller material costs
- Favor effective manufacturing methods using largest possible batch size to cut down costs
- Designers should allow as rough tolerances as possible.

Design features represent the detailed technical and quality properties of the product. Figure 10 illustrates the product feature hierarchy. In the end it is the component features that determine how expensive that certain component or product will be. When feature-based costing method is used the concept of the feature needs to be defined carefully. Cost data from the manufacturing process can be estimated by using simple standard processing times or by analyzing features using appropriate models built for the purpose. (Sandström 2001, pp. 86 – 87). Modeling standard process times may be challenging as people normally use safety factors in estimating the time needed within the process.

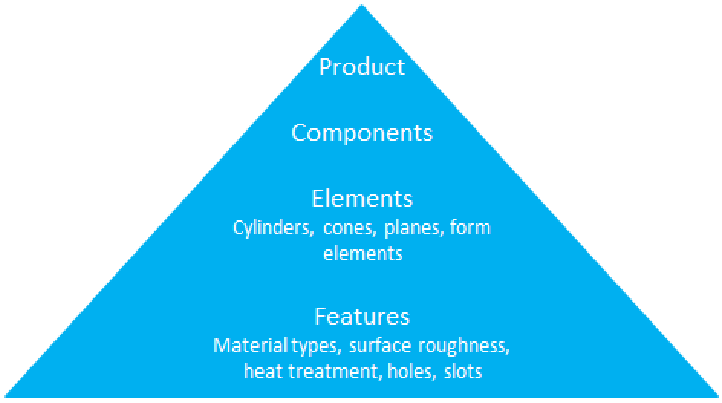

Figure 10. *Product´s features hierarchy from top down (Adapated from Sandström 2001, p. 86)*

Sandström (2001, p. 104) suggests that the easiest way to build up a costing model contains the following steps. First, make a list of features to be considered for making the cost estimation of the new product. Second, determine the list for every process, activity and resource. Third, make a rule for accounting costs (what and how). Fourth, convert the list to a form of a spreadsheet file, document activities and input data. Fifth, test the model.

Sandtröm (2001, p. 108) listed three main factors guiding the choice of the cost accounting method for engineers. The most important factors related are:

- Design related
  - innovation level of the design (original, adaptive or variant)
  - phase of the design process (fuzzy-front-end / at the end)
  - cost consciousness level of designers
- Product related
  - product life cycle
  - complexity of the product
  - volume of the product
- Manufacturing related
  - own manufacturing or out sourced
  - complexity of the manufacturing process
  - production type (mass, batch, single)

Sandtröm's (2001) study showed that the externally focused ABC system was the most suitable for the early phases of an adaptive design process where design engineers were not cost conscious. Internally focused ABC method became easily too complex in the same situation. Moreover, externally focused ABC can offer useful cost information only when the products and the manufacturing processes are simple. Based on this, it can be said that the complexity of the product and the manufacturing process are the most relevant issues to be considered when creating a cost system for the needs of development and design engineers. (Sandström 2001, pp. 108 – 109).

3.3.1. Target costing vs. cost targets

Target costing is used to manage future profits of the company and it is one of the ways of making sure that new products have sufficient gross profit margins when they are launched to the market (see for example Tanaka 1993; Cooper and Slagmulder 1997; IMA 1998). The process starts when a product is conceptualized and ends when the product is released for mass production. Cooper and Slagmulder (1997) argue that target costing has a critical role in developing new products because at the end of the design phase majority of all costs are already committed. During the product design stage, product layout, number of components and material types are defined. Robert Kee and Michele Matherly (2006, p. 269) pointed out that 80 – 85 percent of a product life cycle costs are fixed during the development phase (see also Asiedu and Gu 1998; Uusi-Rauva and Paranko 1998). Therefore reducing product costs is limited after the production has started.

When a new development project is launched it is important that only realistic cost-reduction objectives are set. Otherwise the targets do not motivate the designers since they know that they can never reach them. Communication and target setting are one of the most important aspects when target costing methods are used. Cooper and Slagmulder (1997) give three conditions that need to be considered. First, the target cost must be clear to all employees involved in the development project. Second, the cost-objective must be achievable but nonetheless challenging. Third, the specification of the product must be clearly understood. (Cooper & Slagmulder 1997, p. 77).

According Cooper and Slagmulder (1997) the idea of target costing can be summarized to one important rule – "target cost of a product can never be exceeded." If the target cost is exceeded too easily, the whole idea loses its meaning. The aim of target costing is to achieve complete cost consciousness and design costs out of the product. This means that the design of a new product ends only when the cost of the future product is minimized. For this reason target costing is not a suitable method for development projects with tight schedule. If the project timetable is prioritized before costs, target costing slips away easily and target costing changes to cost targets. For this reason when target costing is adapted, it requires commitment from the whole company and also support from the company management team.

When the price is market driven, functionality and quality customer driven the manufacturers are forced to balance around this survival tripod by Cooper & Slagmulder (1997). Therefore, manufacturers cannot make decisions purely from the cost perspective. Furthermore, using target costing during new product introduction process requires making continuous trade-offs between costs, functionality and quality of the product (see for example Cooper and Slagmulder 1997; Zengin and Ada 2009, p. 2).

Cooper and Slagmulder (1997) presented a survival triplet where both the internal and external forms can be found. Internal are product costs, functionality and quality. External being the selling price, perceived functionality and perceived quality. These internal and external forms create the balancing environment that all manufacturing companies face when they are producing products.

Target costing is a process starting from the analysis of market conditions, Figure 11. The aim of the analysis is to set target selling price for the product before it has been introduced. Target profit margin is normally determined through historical margins of similar products. However, sometimes market situation and competitor actions may be reasons to modify the historical profit margin. Thus, when price, quality and functionality targets have been determined, the allowable cost of the product can be estimated by subtracting the target profit margin from the target price. (Cooper & Slagmulder 1997, pp. 11 – 12). Furthermore, Horngren et al. (2005, p. 380) point out that the target price is the estimated price for a product or service that a potential customer is willing to pay. The target price is based on an understanding of potential customers' perceived value and competitors' responses.

Cooper & Slagmulder (1997, pp. 87 – 88) argue that the main focus of the market-driven costing is to take into consideration the customers and their requirements. This market information is used to put pressure on both the product development engineers and to the entire supply chain. Life cycle costing (see for example Suomala 2004; Xiaochuan et al. 2004; Ansari et al. 1997; Dell'Isola 1997) is normally used when the target is to create a product that has an adequate profit margin throughout its life cycle.

Setting the target selling price depends highly on three different elements: value perceived by the customer, customer's competitive offerings and firm´s strategic objectives. Customer's perceived value is the key element in the price-setting process (see for example Suomala et al. 2011). Another aspect that effects on pricing from the customer side is the loyalty and level of commitment. From the strategic point of view, the most important aspects are long-term profits, market share and corporate image. For example, sometimes for a company it is important to gain market share even without profits. After the desired market share is achieved the product pricing can be altered.

Cooper & Slagmulder (1997) point out that the process of market-driven costing does not take into consideration the company´s capabilities for cost-reduction. However, majority of the product costs are fixed during design stage the production development engineers and supply chain can influence on the cost level of the product. Cost reduction challenge is defined to be between the allowable cost and its target cost. This cost reduction objective should be on a level where it is achievable but only if the project group is using their creativity and challenges the old ways of doing. Target costing method requires cost discipline and continuous monitoring of the progress during the design project. When the product-level target cost has been determined, the development engineers and production engineers have to design the product in such a way that it is possible to manufacture with the target cost. One technique for achieving this target is called value engineering (see for example Brown 1992).

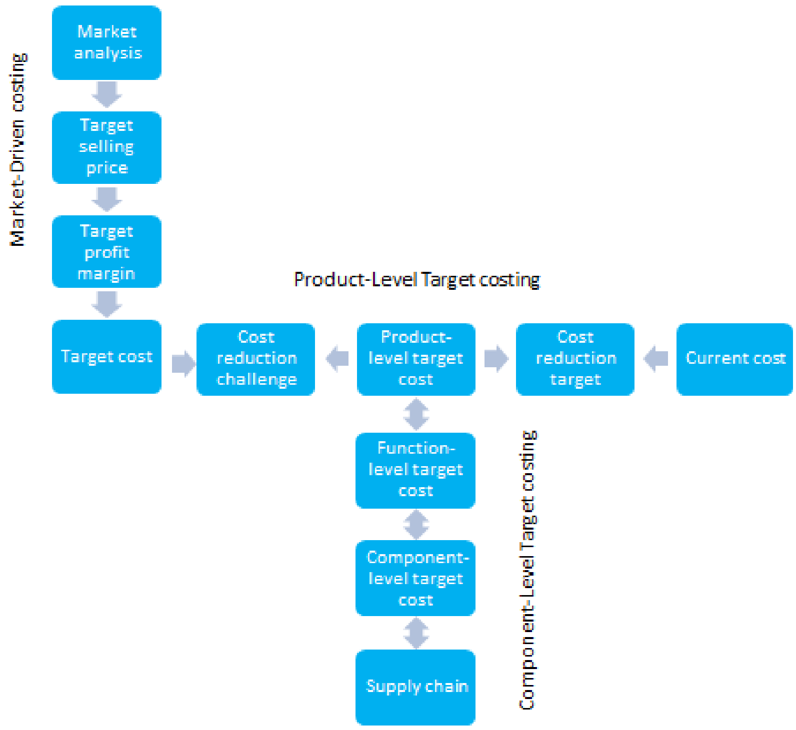

Figure 11. *The process of target costing (Adapted from Cooper & Slagmulder 1997, p. 11).*

Component-level target costing can be considered as detail based cost accounting. The product cost reduction target is allocated via subassemblies to component level. Usually target costs of the components are the selling prices of subsequent suppliers. Multifunctional product management team includes people from different parts of the organization such as R&D, production, logistic and purchasing. The purpose of this cross-functional team is to determine make-or-buy decisions. When the manufactured component has been outsourced the design features must be reviewed with the supplier in order to make sure that the component fits to their production flow. (Cooper & Slagmulder 1997, p. 14).

There are multiple different factors that influence the target costing. According to Cooper and Slagmulder (1997) the intensity of competition and the nature of the customer influences especially market-drive costing. These two characteristics help to collect information during the market analysis process. By analyzing the degree of customer sophistication, how customer requirements are changing and what is the level of knowledge concerning future products it can be recognized what are the benefits for the company derived from market-driven costing. At the product level, side factors such as product strategy and product characteristics influence heavily on target costing. Especially, the characteristics of the product have a strong influence. For example, the complexity of the product determines how difficult it is to manage the design process of the product. In component level supplier-base strategy has a strong influence on target costing process. Factors such as the nature of the supplier relation and company’s power over its suppliers influence heavily to the outcomes of target costing process. (Cooper and Slagmulder 1997). During cost reduction projects it is urgent to hear the supply chain and their ideas. In practice, component suppliers usually have suggestions for improvements after they have manufactured first production batches. Furthermore, the suppliers experience in manufacturing components should be considered when improvement ideas are heard.

Questions like what features are possible to include in the product at this price in order to be competitive are important when products are managed. Target costing method (Cooper & Slgamulder (1997) offers a way to manage costs of the future products. However, often the R&D organization that develops the products directly to the customers with their specification is under tight timetable and there is no room, or at least little time, for iteration rounds. For this reason target costing can easily change into cost targets for pre-selected components.

3.3.2. Value analysis and Value Engineering

Value engineering (VE) is used to manage trade-offs between costs and functionality. One important aspect of the VE is that it is used mainly for specifying the level of cost reduction, not to minimize the cost of new products. The essence of VE can be introduced by using five questions. (Cooper and Slagmulder 1997, pp.80 - 81).

1. What is it?
2. What does it do?
3. What does it cost?
4. What else will do the job?
5. What does that cost?

Value engineering is a systematic process, where the specified purpose of the product is used as a guideline and cost of the product is studied by using required quality standards and specifications (see for example Cooper and Slagmulder 1997; Brown 1992). The main purpose is to find those components that bring the true value for the customer. Secondly, to increase the true value of components and decreases features that do not bring value to the customer. According to Cooper and Slagmulder (1997, p. 13) the process begins by analyzing products and by recognizing what are the necessary functions and essential characteristics of the product. Necessary functions being the ones that the product has to fulfill. Essential characteristics are requirements like reliability, quality and maintainability.

There is a difference between value analysis (VA) and value engineer (VE). Sandström (2001, pp. 37 – 38) points out that VA concentrates on studying the relationship between cost and value whereas VE has a broader scope evaluating product design while it is still in the design phase. Analyzing the cost of components is important for companies that assemble products because they normally buy components and subassemblies in large volumes. By analyzing component costs the company can recognize parts that are costly and which of the used components will soon be out of production or outdated. Component analysis also puts focus on the cost relationships between components. When for example, two components are integrated into one, is the result actually cheaper and better than the original solution? Real life example can be a situation where oil distribution channels are integrated inside the casted components. As a consequence the number of oil pipes and assembly time is reduced. However, the integrated oil distribution channels increase costs of the casted parts.

3.3.3. Design for cost

Design for cost (DFC) is a branch of the Design for X (DFX) family. DFC is a tool for analyzing and evaluating product life cycle costs (LCC). This analysis is highly important since customers are also interested of the operational and maintenance costs of the product. The purchase price is only one characteristic when the product life cycle cost is evaluated. Xiaochuan et al. (2004) have found three gaps in the available costing information for engineers. First, product design engineers are traditionally isolated from the cost information in accounting database. Second, the lack of cost feedback from internal and external reference groups when they propose new parts and design features. Third, the inability of engineers to integrate the existing data of the various functions to support design decisions during the design phase. This is mainly because the data available is heterogeneous and versatile.

Xiaochuan et al. (2004) argue that by using DFC methodology during product introduction process the whole life cycle of the product will be analyzed. These life cycle costs include for example the cost of manufacturing, sales cost, operational costs, maintenance costs and recycling costs. Usually designers and development engineers tend to pay attention to the schedule, product reliability and performance but not to the costs. When design for cost is used as a design method, cost must be an equivalent parameter among others (Xiaochuan et al. 2004, p. 1).

When implementing the DFC system into the development process the following questions need to be answered (Xiaochuan et al. 2004, p. 2).

- How to model the LCC at the different stages of the design process?
- How to use uncertain information and design features to estimate LCC?
- The concept of LCC is rather complex, what cost features are used when LCC is estimated?
- How design features are transformed into cost features?
- How to choose reasonable costing method for estimating LCC?

Activity-based costing can be used when life-cycle costs are estimated. According to (see for example Cooper and Kaplan 1988; Sandström 2001; Lukka and Granlund 2002; Xiaochuan et al. 2004) ABC method can be applied to research and development environment. Activity-based costing provides more accuracy to cost calculations because by using ABC the indirect and overhead costs are allocated to products based on the use of cost drivers such as batch numbers, batch size, based directly on a set of resources.

For Moventas development process the DFC method can offer benefits, especially when Moventas MOVE environment is used during the early design phases. The MOVE environment is a tool for design engineers to generate fast multiple different gear calculations and evaluate those simultaneously. MOVE environment integrates calculation softwares that are used in gear calculations to 3D-modelling software. By generating different alternatives designers can update the 3D-models easily and see immediately the consequences in their computer screens.

By using MOVE the engineers can evaluate early on what are the most promising options from the technical point of view to continue. If these design features could be transformed into cost features, the designers would be able to see the subsequent costs as well. Integrating cost information inside the MOVE system requires feature-based thinking and methods for data handling. For example, simple €/kg prices for different materials can be used to provide fast cost information for designers. Also, standard components that have yearly contract prices such as bearings, fasteners and some c-parts could be price-labeled inside the MOVE environment. Updating the cost data should be done on yearly basis or in a case that something exceptional happens during the contract period.

When MOVE design features are transferred into cost features the design engineers can iterate the planet stages of the gear unit. For example, the amount of planet wheels can be optimized also from the cost perspective. When the amount of planet wheels is increased, also the amount of planet wheel bearings and planet wheel journals is increased. This will increase the overall number of components and subsequently overall costs as well unless the size of the components is not decreased simultaneously.

For optimizing the planetary stage price information of alternative planet wheel bearings and cost estimates of geared components (€/kg) as well as journals (€/kg) are needed.

3.4. Performance measurement of development project

Performance measurement (PM) is an inseparable part of project management. In order to gain improvement, progress and growth in performance it needs to be measured (see for example Suomala 2004). Generally speaking complex and uncertain R&D projects can be classified to the category “difficult to measure” (see for example Pillai et al. 2002). Even though if something is difficult to measure it does not mean that it should not be measured at all. The idea of performance measurement is to communicate what is the most important focus for the company. Additionally it is to get real time performance feedback and learn from the history. Kaplan and Norton introduced the famous real-time measuring tool Balanced Scorecard in 1992. Since then the Balance Scorecard has spread globally to several organizations. In 1996 Kaplan and Norton underlined that the Balance Scorecard is a very useful tool when the company strategy needs to be translated into actions. They presented four management processes that integrate the long-term and short-term goals together. These four processes are called customer, financial, internal business and learning & growth. (Kaplan and Norton 1996).

According to Ijiri (1975) performance measurement is a mechanism to illustrate achieved results during a period of time in respect to the goals of an organization specified by the metrics. Therefore, performance measures have to be designed in such way that all the metrics are simple to understand, they should reflect business processes and they should also be tied to specific targets (see for example Neely et al. 1995; McMann and Nanni 1994).

According to Schuman et al. (1995) research and development organizations primary outputs are products, technology and information. Measuring can also have other aspects than monitoring and improving the business processes. By measuring the activity of the development organization the management of the company can determine the true value of R&D. Brown and Svenson (1998) have pointed out that R&D is expected to show its value for the organization, not only developing products and processes.

Choosing the right metrics for measuring R&D performance is not the easiest decision to make. The amount as well as the focus of the metrics has to be carefully considered. Cooper and Kleinschmidt (1995) suggest that a single meatric for monitoring multidimensional NPD performance is not enough. Suomala (2004) summarizes the following key points of PM systems.

- Measurements systems and metrics should be constructed from top down.
- Measurement should provide lessons learned from past mistakes and ease learning.
- Metrics should focus on achievements, results and outcomes.
- Cause-effect relationship should be identified.
- Internal coherence of measurement is important.
- Measurement should be at the same time simple and comprehensive.

In addition, Brown and Svenson (1998) argue that the measurement system should be as simple as possible. Werner and Souder (1997) stress that the most effective metrics for research and development environment should include both quantitative-subjective and quantitative-objective elements. These integrated metrics are needed for capturing the true nature of the R&D process. According to Suomala (2004, p. 73) performance measurement is the way to ensure the success of NPD projects and its usefulness for the organization. By using carefully chosen specific metrics the performance level achieved by new product development can be influenced. Furthermore, Nixon (1998) suggests that it is possible to apply management accounting techniques to improve performance measurement of research and development.

Measuring R&D performance level, for example during recession years is a hard task. At least it is obvious that the same metrics do not work in both good and bad times. People who work inside the development organization have usually their hands full of tasks even when there is nothing coming out from the factory. There always seems to be an upgrade project, cost reduction project or customer quotation waiting for the engineers. Question like: *"How to measure the performance level during the difficult times when R&D organizations don't have any ongoing development projects?"* seems reasonable to ask. Also, more fundamental question *"how the performance of the R&D is defined?"* needs to be solved before PM system is employed.

When evaluating the overall performance both commercial and technical aspects need to be taken into consideration (Cordero 1990). Literature gives multiple financial and non-financial suggestions for measuring development activities. (See for example Griffin and Page 1996; Suomala 2004; Brown and Svenson 1998; Werner and Souder 1997; Hertenstein and Platt 2000; Goffin 1998, p. 49)

- customer satisfaction
- customer acceptance
- meeting profit goals
- internal rate of return
- competitive advantage
- market share targets
- profit margin goals

- the net present cash flows of the PLC compared to development cost
- number of patents or patent applications
- number of design modifications
- number of product developed
- time-to-market
- failure rate

Suomala (2004) points out that performance measuring should be a dynamic phenomenon and therefore same metrics do not work all the time when the environment and the requirements are changing. Schuman et al. (1995) have also argued that different objectives lead to different types of metrics. Proper measuring seems to require both financial and non-financial metrics (see for example Sandström 2001) and measurement of multidimensional NPD leads easily to adapt the idea of the Balance Scorecard (see for example Suomala 2004, p. 93). Suomala (2004) also suggest that performance measurement should also be done from the life cycle perspective.

Nixon (1998, pp. 340 – 341) stresses three important financial metrics that need to be considered; the total development cost, direct costs of the new product or service and operating costs. The total costs include all direct and indirect costs that can be allocated to the development project. Direct costs are those costs that can be associated with the manufacturing of the new product. Operating costs are classified as costs that the customer incurs while using the product.

Performance measurement system is a tool for monitoring and improving NPD activities. However, it offers also a way to build an incentive system. Kim and Oh (2002) have found that reward or economic compensation systems work nicely inside the research and development in motivating the employee. They have also shown that there is a strong correlation between job satisfaction of the R&D personnel and their satisfaction with the implemented PM system (Kim and Oh 2002).

According to literature review it seems clear that there is no single approach to measuring performance of the NPD. Furthermore, Brown and Svenson (1998) argue that focus of the measuring should be more on external metrics rather than internal, because external measures are considered as more valid and important. Authors also stress that outputs should be measured instead of behavior. In addition, Brown and Svenson (1998) stress that the role and the understanding of the stakeholders is crucial when an effective PM system is developed.

It is very common in the field of product development that the metrics are somehow related to cost and time. According Suomala (2004) several companies have an overemphasis on single products or projects and suffer from shortsightedness in performance measuring. Study of Driva et al. (2000, pp. 151 – 152) reveals that the most common performance measures are:

1. total cost of the project
2. on-time delivery of the development project
3. actual project cost compared to budgeted cost
4. actual versus target time for the project completion
5. lead time to market

In addition, over 50 percent of the companies made some kind of profitability analysis (Driva et al. 2000 pp. 151 – 152). Suomala (2004) points out that these widely used metrics are related to product performance and actually do not take into account the output and effects of product development.

3.5. Summary of literature

This chapter presented the basic principles behind the management accounting theories. As it can be seen above, management accounting and new product development processes should go hand in hand in order to produce cost effective products with sufficient profit margins. Tradeoffs between product quality, functionality and costs are required when new products are being introduced. Nonetheless, tradeoffs can only be made if the correct information is available for use.

Estimating the cost of a future product is usually a great challenge in NPD and management accounting in development process is based on certain uncertainties. For this reason different kinds of scenario analysis are usually required. Two different approaches can be suggested when the costs of new products are estimated. First alternative is to use products that already exist – own or competitor products. The second alternative is to use parametric models where costs are associated with different parameters.

Target costing gives a good idea how to focus on right places and improve products as well as profitability. Nonetheless, it requires participation from all functions within an organization and requires complete cost consciousness. In addition, Everaert and Bruggeman (2002, pp. 1349 – 1350) point out that target costing has a positive effect only when the employee are not pressured with schedule and can work relaxed. In practice though, working relaxed with a loose schedule is not usually the case in product development organizations and the idea of target costing easily changes into cost targets.

Although, management accounting has been available for utilization by product development organizations, practice shows that many industrial companies fail to use the potential of management accounting in developing successful and cost effective products (see for example Suomala 2004). Product life cycle costing and performance measuring methods are not usually considered during NPD. The metrics used to measure performance levels are not used to steer the boat and communicate company targets to personnel. On the contrast, they are only used to fill reports. To summarize, the measurement system should be able to answer what is important for the company and what is not (Suomala 2004).

Several studies support the argument that the NPD process is in the spotlight when the costs of new products are fixed. For this reason, product costing and cost information should be as transparent as possible throughout the organization. When the people working inside the company understand how they can influence the product cost level, it is possible to make improvements from the cost point of view. The fundamental mission of management accounting is to provide this urgent cost information throughout the product life cycle and ease the decision making. Furthermore, Suomala (2004) points out that the length of the life cycle is an important parameter in life cycle management. It is not uncommon that products may seem unprofitable after the initial introduction and become profitable at later stage of the life cycle.

By using management accounting techniques it is possible to enhance general cost awareness in order to make better decisions. Cost consciousness is something that can be learned by doing. This means that when a company has a cost estimate before the decision, that decision being followed by certain consequences, the ex-post calculation reveals the reality. Thus, the whole company can learn by doing.

4. PRINCIPLES OF PROJECT MANAGEMENT

A project can be defined as a set of activities aimed at accomplishing a specific target, for example building a house. Project group consists of people who have the project responsibility and people who have different specialties within the project. A project has always a clear starting point, where a target is set and an end point where the project is closed and the project group is dismantled. (See for example Melton 2007; Dieter 2000; Anttonen 2003).

During the life cycle of a project, the project goes through “value-adding” stages. Every stage has its own start point and a deadline with specific objectives to achieve (Melton 2007; Anttonen 2003). It can be said that there are multiple projects inside the main project that are required to be executed in order to accomplish the main target. This chapter will introduce the basic principles of project management and how project costs can be managed. At the end of this chapter there is a simple example of how earned value can be calculated.

4.1. Project management

Project management is all about ensuring that the project objectives are met. Project objectives are for example staying within the scope at predefined timetable and with acceptable costs. The scope defines what is to be done. Time, by when it has to be done and cost objective tells in what costs and resources it has to be done with. Project failures are such as costs exceed the budget, project is not finalized in the required time or the customer is not satisfied with the outcome of the project scope. (Artto et al. 2011; Anttonen 2003).

Melton (2007) divides project management into “Hard” and “Soft” sides. “Hard” project values address: the scope definition, project schedule and costs, risks, tangible objectives, business benefits and project control. “Soft” values are related mostly on project organization and communication. This includes topics such as, how people work together, how project team morale can be improved, influencing customers, ownerships and politics.

During the project life-cycle all tasks are not equal in their significance level within the project. Essential for the project manager is to understand this and recognize those tasks that are important for the success of the project from those that are not. According to 80/20 principle 20 % of causes leads to 80 % of effects. (Anttonen 2003).

Project management is most of the time management of changes that occur during the project execution. The change can originate from the customer, own manufacturing, new information concerning the market situation or from end users and other project stakeholders. For these reasons the general principles of change management need to be applied on project management as well. Typically the early phases of the project execution will determine the project success. If the crucial work associated with the early steps of the project is not done properly, the project will most likely fail. Reasons why projects usually fail can be summarized in following (Melton 2007; Webb 2003, p. 28; Cooper 2001; Whittaker 1999):

- The project objectives are unrealistic or poorly perceived.
- Poor project planning (insufficient planning, risk analysis and a weak business case.
- Moving too quickly.
- No answer to “why this project is launched?”
- Up-front homework is not done.
- A lack of market orientation.
- The project sponsor frustrates the project.
- The project organization is lacking of expertise and capability (project team is not best possible for the work).
- Lack of project management support.
- No focus, too many projects, lack of resource and commitment.

Failure to understand the customer needs and the market situations are one of the main reasons why projects fail. Even if a product is introduced on schedule and within the project budget, the customer may still be dissatisfied if the outcome is wrong. This underlines the importance of the first steps of the project and how crucial up-front homework really is. Furthermore, without setting clearly communicated targets for the project organization the outcome of the project is often non-profitable. Whittaker pointed out on his studies that 60 percent of the failed projects were short projects, where planning takes under one year to execute. This indicates that short projects are easily underestimated. (Whittaker 1999).

4.2. Project cost management

Fuzzy front end or early phase of the development process is the most critical stage of a project. Changes become more and more expensive to execute when the design matures throughout the project duration. At worst case the changes may affect to already closed orders in the supply chain. (Artto et al. 2011, p. 121).

Artto et al. (2011) point out that proper project cost management contains the following elements cost evaluation, resource planning, project budgeting and monitoring task completion. Cost management is not limited only to executing one project within the project budget. Cost management should be considered from a broader point of view including the project budgeting, cost estimation, pricing, budgeting revenues, planning cash flows and finance planning, reporting revenues and costs, and ensuring profitability. Received profits from the project and the costs after the execution have to be taken into consideration when the project profitability is studied from the product life cycle perspective. (Artto et al. 2011, pp.119 – 120).

Cost management influences other areas of project management as well. Areas such as project scheduling and project cost and resource planning usually require a lot of balancing as well. Artto et al. (2011, p. 120) argue that all project actions should be considered as economic activities that influence costs and revenues. To study project costs and revenues all the actions related to the project have to be converted into monetary values that can be compared between one another.

Figure 12 illustrates the importance of cost management during early stages of the project. Majority of the costs are fixed based on decisions made early on in the design phase. Later on these costs are realized when the product is manufactured, assembled and tested. Possibility to influence the project and product cost level decreases dramatically after product design is fixed. Furthermore, during the early stages of the project the number of decisions is low. However, the decisions made are highly important and the associated risk level is high compared to the decision made during the project execution. The number of the decisions made usually increases through the project life cycle and the significance of a single decision decreases. (Artto et al. 2011, pp.120 – 121).

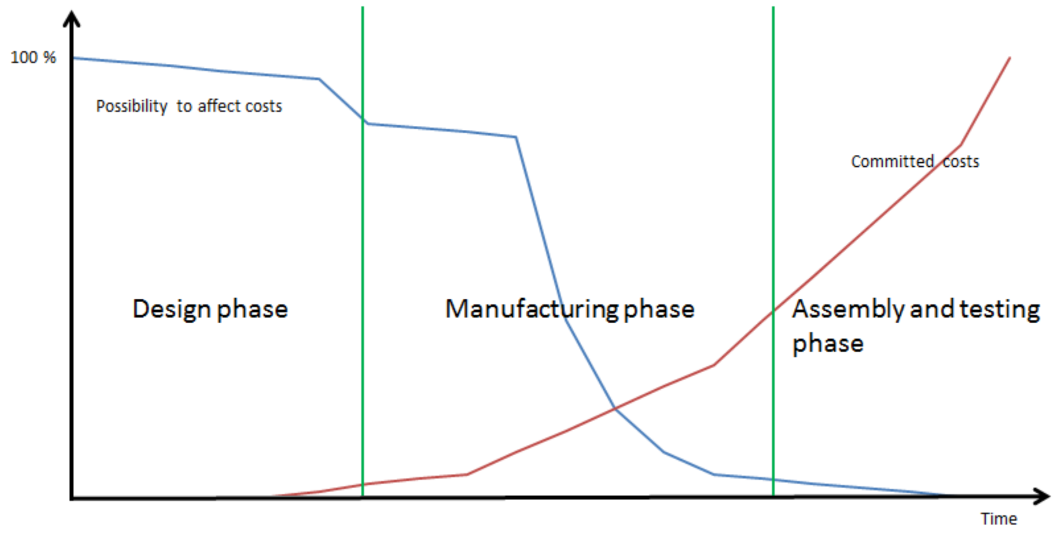

Figure 12. *Commited costs and possibility to affect cost curves during project life cycle. (Adapted from Artto et al. 2011, p.121)*

According Artto et al. (2011, pp. 125 – 129) cost estimates are needed throughout the project and the estimates have to be updated during the project execution. Naturally the project total cost estimate becomes more accurate as the project progresses. The reason for making cost estimations is to find out whether it is profitable or not for the company to engage on a project. First cost estimate is required when the project proposal is written. Information used for the estimate can be found by studying previous similar projects or from supplier price quotes. Based on the cost estimate the cost objective for the project can be set. Cost objective can be also called as the project budget.

All costs related to the execution of a particular project should be allocated for that project. These costs can be divided to direct and indirect costs. For example, the direct salary of the design engineers from labor hours and material costs should be allocated as project costs. Indirect costs can for example be the equipment needed, training sessions, office space, accessories etc. Revenue of the project should also cover other costs than the indirect and direct cost allocated to the project. Cost of sales and marketing, cost of developing processes and products, training costs and the indirect costs of general management should also be considered when profitability of the project is assessed. Assigning these kinds of costs to single projects can though be difficult. Activity-based costing method provides one possibility to allocate indirect overhead costs to projects based on the actual occurrence of costs related to a specific activity. (Artto et al. 2011 pp. 132 – 133).

Artto et al. (2011, pp. 135 – 136) point out that monitoring actual and committed costs of given projects are important parts of cost-control principles. The actual costs consist of unfinished work that has already generated and incurred costs. Typically the actual cost information can be found from the accounting system of the company. In order to get the full picture of the project situation also the degree of completion of each activity and the cost allocated to the activities must be known (Artto et al. 2011, pp. 135 – 136). Monitoring costs during the project will provide a more anticipative perspective for project follow-up.

Project communication is about transferring information between project stakeholders and parties. Principle of a good communication is a clear continuous communication. Communication between parties can be informal or formal, written or oral, spontaneous or planned, and emotional or factual. Regardless of how the information is shared, information management is in a close connection with project management. Managing information refers to creation, storage, and distribution of information, documentation and knowledge related to the project. Successful communication can be described in following – the recipient of the information understands the content of the message and the sender knows that the recipient has understood it. (See for example Artto et al. 2011, p.181; Nicholas 2004).

Project control and reporting forms a central toolkit for managing projects and enforces the dialogue between project stakeholders and parties. Project controlling requires consistent reporting. Reporting is usually formal follow-up that is periodic in nature and is tied to the project stages, deviations, or time. When deviations or faults are detected in early phases, it is easier to influence them. (See for example Artto et al. 2011, pp. 192 – 194; Rissanen 2004).

Artto et al. (2011, pp. 199 – 202) present an earned-value calculation method. The method is used to study the progress of the entire project and its elements. The earned-value calculation combines schedule and cost monitoring and the results achieved to date. An estimate of the work completeness level is required for the use of the calculation method. Artto et al. (2011, p. 138) point out that estimating the degree of completion of an activity can be difficult and for that reason pre-determined labels should be used to help the estimation. Labels such as not started (0 %), started (25 %), almost ready (75 %) and ready (100 %) will help the project organization to estimate the degree of completion.

First step is to calculate the value of the executed work and to define a basic input for the calculation. Budgeted costs of work scheduled (BCWS), actual costs of work performed (ACWP), budgeted costs of work performed (BCWP) (i.e. earned value EV). BCWP is calculated percentage of completeness (%) * BAC (budget at completion). Estimating the percentage of completeness can be hard. However, the estimation can be done by comparing the amount of work done to the still unfinished work.

In the next step cost variance (CV) and cost index are calculated.

- Cost variance (CV) = BCWP – ACWP
- Cost performance index (CPI) = BCWP/ACWP
- Cost variance index (CVI) = 100 % * CV/BCWP

In the third step all figures that describe the schedule variance (SV) and schedule index are calculated.

- Schedule performance index (SPI) = BCWP/BCWS
- Schedule variance index (SVI) = 100 % * SV/BCWS.
- Schedule variance = BCWP – BCWS

If the CPI or SPI value is 1.0 the project performance is according to plan and if CPI value > 1.0 the performance level has been better than planned. If cost variance index is positive the performance level is better than planned and result achieved has been less expensive than planned.

As the final step, the entire project completion is forecasted. To ease the forecasting certain assumptions are required concerning how the remaining part of the project will progress. One scenario is that project ends according to the original project budget. Meaning that the absolute cost variance value will remain at a same level until the project is finalized and the cost variance will not change during rest of the project. Other estimation could be that cost efficiency continues at the same level until project is finalized. This estimation is based on the assumption that cost efficiency achieved remains at the same level. (Artto et al. 2011, p. 202).

Figure 13 depicts a simple example of transferring information from task level to upper level. The level of completeness for both manufacturing and design are the same 50 percent. Dividing tasks and calculating each of them separately reveals which of them works more efficiently. It is important for the project manager to recognize when some tasks are behind the target and what are the reasons behind it. Also, more fundamental question should be asked. What can be done to make sure it won't happen again?

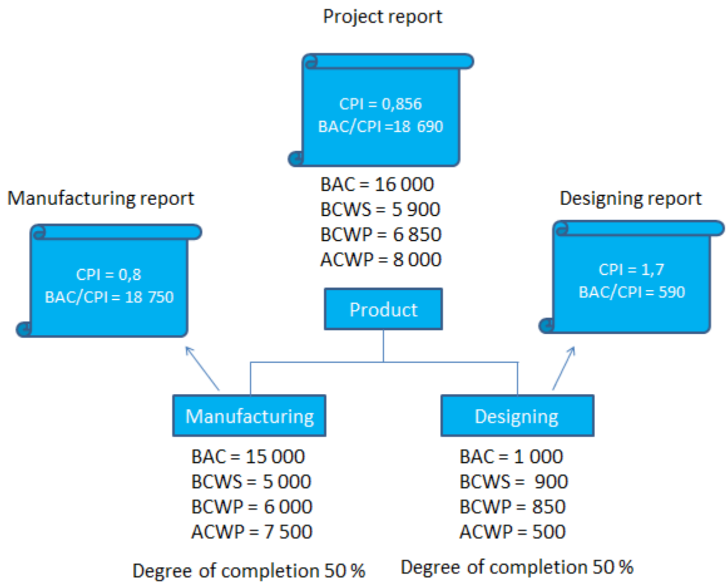

Figure 13. *Example of simple way to cumulate information from lower level to upper level. (Adapted from to Artto et al. 2011 p. 204).*

According to Artto et al. (2011, p. 208) the success of a project can be evaluated through two perspectives: efficiency and effectiveness. The project can be described to have been successful when it has been executed according to the plan in relation to the time, scope and cost objectives. Efficiency can be determined by using numerical measures where the schedule and the budget are verified. If several stakeholders are involved in the project the evaluation of the project success may differ. Evaluating the success of the project is an important phase and the project should never be terminated before the final review is done. Artto et al. (2011, p. 210) point out that evaluating the success of an executed project may benefit the company in general by lessons learned being passed on from one project to another.

5. MOVENTAS GEARS OY

Moventas Gears Oy is a one of the leading wind and industrial gear manufacturers in the world. Production units are located in central Finland – Jyväskylä, Wuppertal Germany and Suzhou China. Currently Moventas employs around 940 employees in 14 different countries. Two manufacturing facilities are located in Jyväskylä employing the majority of Moventas personnel around 590 employees. This makes Jyväskylä the biggest production location.

The company has a long history in gear manufacturing. In 1938 Moventas manufactured its first gearwheel at the Rautpohja factory in Finland. The economic downturn in 2009 affected negatively on the company and a few years later in 2011 Moventas group filed bankruptcy. However, the group subsidiaries Moventas Wind Oy and Moventas Santasalo Oy continued the business and entered a corporate restructuring program. In November 2011 an industrial engineering group Clyde Blowers announced its acquisition of both subsidiaries. The two subsidiaries were merged together and Moventas Gears Oy was founded on 31.8.2012.

5.1. Market areas and customers

Primary market areas of Moventas in the wind gear business are Southern Europe and Americas. Wind turbine manufacturers such as Vestas, Areva, Gamesa, GE energy and Suzlon Group are the key clients of Moventas. Last years have been difficult for the whole wind energy sector. There is no doubt that 2013 will continue to be a difficult year for all turbine manufactures as well and companies will continue to cut expenses by outsourcing and with further layoffs. This is a clear signal that the biggest wind industry boom is in the history and the wind industry is finding a place to stabilize.

As mentioned in chapter two the market situation is very challenging and reducing the cost of energy is one of the main topics of every turbine manufacturer. All manufacturers are driving further cost reduction programs and this has a major influence on Moventas as well. The focus of entire value chain is developing their current product portfolio in order to be more cost effective.

Today the biggest challenge is to close deals. Without new sales the company turnover will not grow and the goal of increasing EBITDA to positive level will be challenging. Moreover, Moventas needs only 2 – 4 good customers to make profit. Since almost all agreements in the business are so called frame agreements, couple of long term frame agreements could create enough turnover to make a profit.

5.2. Competitors

Moventas wind sector offers its products for the wind energy market and does not have any direct competitors in Finland. From Moventas Wind point of view the biggest competitors are other wind gear manufacturers and other wind turbine technologies such as direct drive where the gearbox is not needed. Other renewable energy sources can be considered as competitors as well. Majority of the cost pressure comes from the low cost countries like China, where many gear manufacturers in the 2MW turbine class can be found. In Europe there are also several big companies in the wind sector. Excluding the Chinese players four biggest competitors are from Germany. German company Winergy part of Siemens Corporation is one of the biggest companies in Europe. ZF is the second largest manufacturer of wind gear units. The third biggest is Bosch Rexroth and fourth is Eickhoff.

All the European based manufacturers are facing similar challenges as Moventas. Moventas is however remarkably smaller player than the German companies and this can be an advantage when competing against the big companies. Small companies can often be more flexible and able to adapt to new situations faster than large organizations.

5.3. Products overview

A typical wind turbine contains about 8 000 different components. The main sub-components that form a 5 MW turbine and the percentage of total turbine cost are listed in following. Figure 14 depicts the cost share of each main component. (Krohn et al. 2009, p. 37).

1. Tower – usually manufactured from rolled steel and has a height range of 40 meters to more than 100 meters.
2. Rotor blades – consist normally from three blades with a maximum length of up to 60 m. Blades are manufactured in specially designed moulds using the material combination of class fiber and epoxy resin.
3. Gearbox – used to increase the rotational speed of the main shaft to the adequate level required by the generator.
4. Power converter – needed to convert direct current from generator to altering current required by the power grid.
5. Transformers – used to increase the voltage of generated electricity to meet the electricity grid requirements.
6. Generator – transforms mechanical energy into electrical energy.
7. Main frame – supports the turbine power train which is mainly made from cast iron.
8. Pitch system – used to adjust the blade angle(s) to maximize turbine power production in the prevailing wind conditions.

9. Main shaft – located between the gearbox and the rotor hub transferring the torque and rotation acquired from the wind to the gear unit.
10. Casted rotor hub – holds the blades as they turn.
11. Nacelle cover – encapsulates the wind turbine power train and is made from glass fibre for reduced weight.
12. Brake system – stops the turbine to halt when required.
13. Yaw system – rotates the entire nacelle to the prevailing wind direction.
14. Main bearing(s) – (number of main bearings may vary between one and two) support the main shaft and take reaction forces from the rotor blades.
15. Bolts – hold all the main components in place and designed for extreme loads.
16. Cables – the link between turbine and wind farm electricity sub-station.

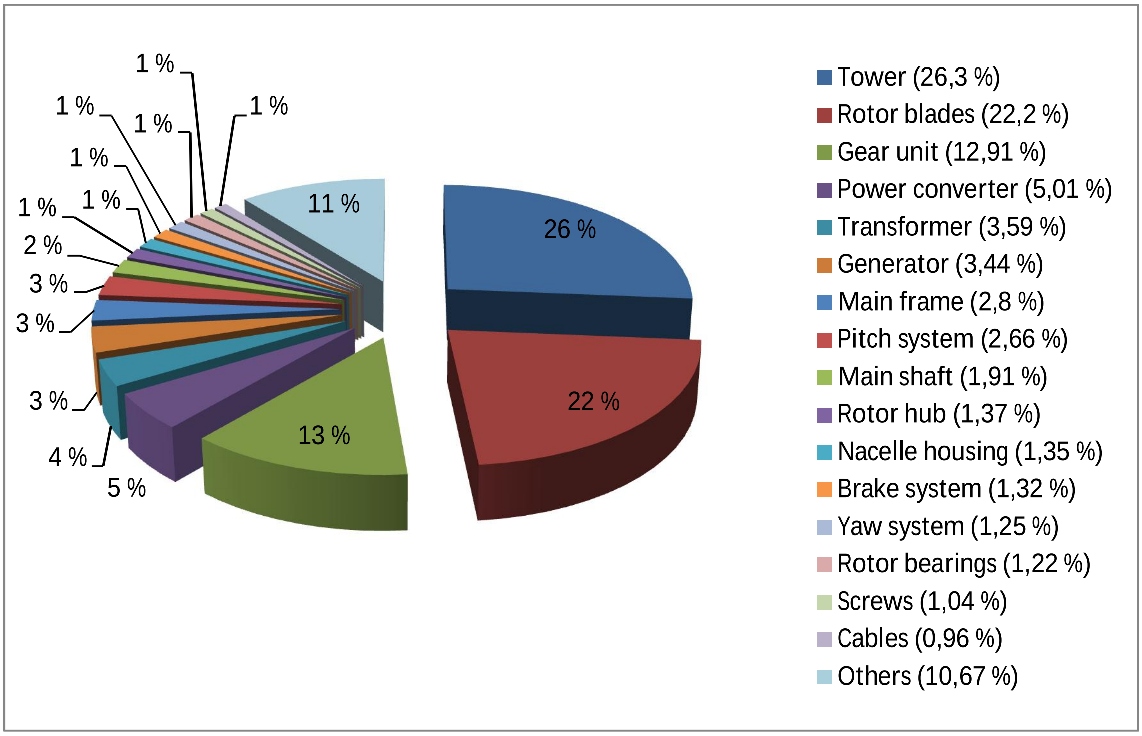

Figure 14. *Main components of 5 MW wind turbine and their share of total turbine cost. (Adapted from Krohn et al. 2009, p. 37).*

Gear unit is one of the strategic key components of the wind turbine as it can be seen from the figure above. Gearbox reliability and serviceability are one of the key factors when gear units are designed. With a lightweight gearbox design combined with high torque density it is possible to achieve lighter overall powertrain weight. This has an impact on the initial cost of the wind turbine. Furthermore, when serviceability aspects are taken into consideration during the design phase it is possible to reduce service and maintenance times affecting the lost production factor of the wind turbine.

Today Moventas has a strong product portfolio with 26 different types of wind turbine gearboxes. Varying from 1 – 3MW in range with an installation base of over 12 000 units. Wind sector gear units are mostly of the PLH (planet-helical) or PPLH (planet-

planet-helical) type and the wind gears can be classified into three categories: multimegawatt-, megawatt-, and kilowatt-classes. Today the mainstream products are in the MW-class. However, the size of the wind turbines is growing all the time leading to MMW-class. Figure 15 illustrates the product classes and cumulative deliveries of Moventas products.

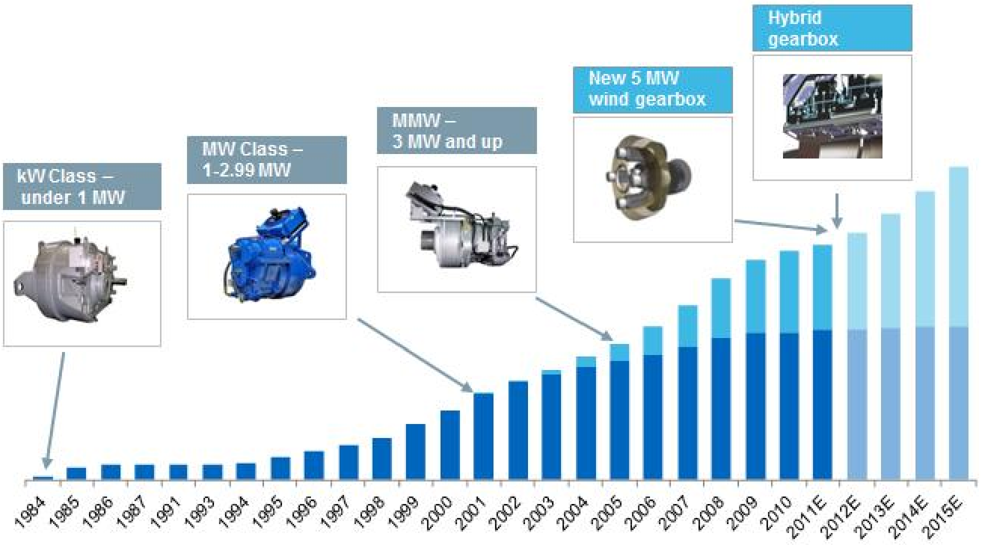

Figure 15. *Moventas cumulative delivers and product classes.*

Wind turbine gearbox components can be classified as following: casted housings and planet carrier, geared wheels and shafts, bearings, machined and laser-cut C-parts, lubrication components and fasteners. Typical bill of material consists normally of 150 – 250 items depending on the size of the gear unit. Ability to manufacture case carbonized ring wheels is one of the core competences of Moventas business. Typical gear unit contains eight to nine geared components that are all carefully designed using latest standards and software. Geared components are: ring wheel, typically three to four planet wheels, sun pinion, hollow shaft assembly, intermediate shaft assembly and high speed shaft.

5.4. Business overview

Today, Moventas business is also suffering from a lack of orders like other gear manufacturers as mentioned earlier. Wind business grew remarkably up till 2008 when the global finance crisis began (see Figure 16). After 2008 Moventas net sales dropped almost 50 percent during one year and since 2009 the plummet has been more moderate. Furthermore, the wind sector seems to suffer more from the stagnant market situation than the industrial sector. This is mainly because the industrial sector is broader business area and the number of customers is much larger than in the wind sector. Lastly, the wind market relies heavily on grid feed tariffs and government tax credits making it more sensitive to global fluctuations.

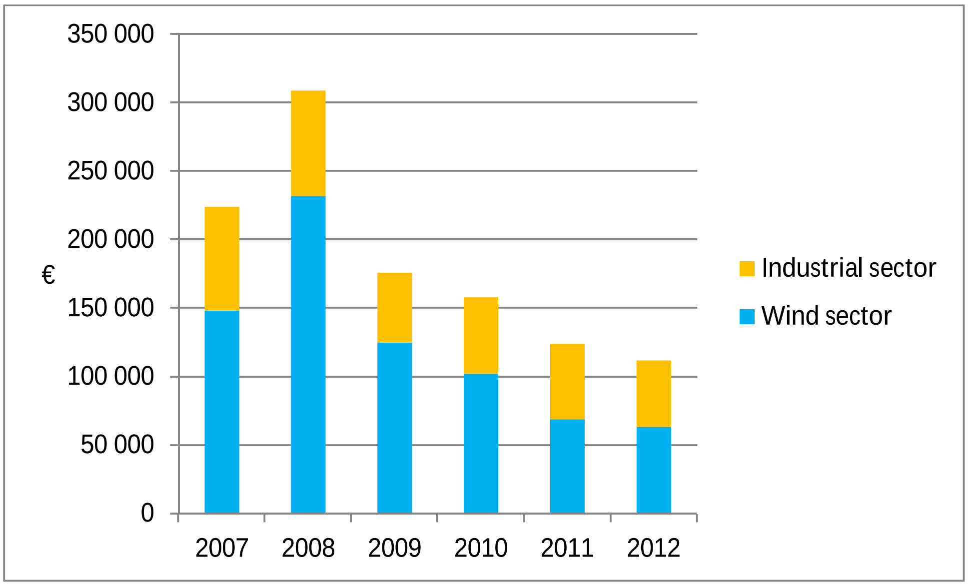

Figure 16. *Moventas Finland net sales in years 2007 – 2012.*

Even though the current Moventas project pipeline is relatively thin, the market indicates that Moventas has a good opportunity to grow together with new customers and offshore projects. Moventas has an expectation to grow with a CAGR (Compound Annual Growth Rate) of 7 % from 2013-2020. To achieve this target Moventas needs to turn its focus on new areas such as emerging markets and offshore wind turbines.

In order to get better picture of the current status of Moventas R&D a short SWOT analysis was done. SWOT analysis is an overall method of evaluating company`s external and internal marketing environment. External environment is divided into opportunities and threats and internal environment is divided into company´s own strengths and weaknesses. Opportunities give the company a high probability of profitability success. Threats on the other hand are classified as aspects that could seriously hurt the company if realized. Strengths and weakness are internal aspects and the company can evaluate them based on the current situation by using for example a performance checklist. Topics like marketing, manufacturing, finance and organization are evaluated in the checklist. (Kotler & Keller 2009, p. 89 – 93).

Figure 17 lists strengths, weaknesses, opportunities and threats of Moventas R&D. This study aims to reduce the weaknesses related to costs topics. However, this study is not aimed at reducing directly the cost level of the products. Instead the goal is by increasing engineers the cost consciousness of engineers to affect the cost level of development projects in the future and give tools to work with ongoing cost reduction projects.

Strengths	Weaknesses
• Capability to develop new products • Global service support • Personalized attention to the customer	• Cost level of the gear units • Pricing • Lead times • Lack of development projects • Responsibilities during projects are unclear • Overall cost conscious level
Opportunities	**Threats**
• Emerging markets such as Brazil, India, Korea • Success of FusionDrive can open new markets • Customers cost reduction programs	• Customers cost reduction programs will increase cost pressure in the future • High competition level on mainstream size class

Figure 17. *SWOT analysis of Moventas R&D.*

Moventas has a very good capability in developing new products. Development organization can adapt quickly to new situations by tailoring products in order to offer best possible products to the customer. Unfortunately, the best possible product is not always the cheapest and when the designers are not supported by cost information they make decisions mainly from the technical point of view. It is clear that manufacturing products with over-quality increases the overall cost level of the gearboxes.

The ongoing cost reduction programs of the customers will definitely increase the product cost pressure in the future. But the programs can also be a great opportunity to show customers that Moventas is open-minded and willing to improve its products from the cost perspective. Entering the emerging markets may open new opportunities and increase the global footprint of Moventas with new products.

Current global market status and poor level of the R&D cost consciousness underlines the need for enhancing overall cost awareness inside the research and development organization. By implementing cost monitoring and management accounting techniques to the current development process, the capability to develop cost efficient products will increase. When designers can make trade-offs between the product functionality, costs and quality they have a direct possibility to effect on the product cost structure.

5.5. Current New Production Introduction process

New product introduction (NPI) in Moventas is mainly done based on the customer demand and specification. Therefore, the outcome from the NPI-process is a new gear unit variant customized for the customer needs. Actual level of the demand is usually characterized by high uncertainty. Especially the last couple years have shown that actual demand for new gear units is something else what company has believed at the beginning of NPI-projects. The current NPI-process is suitable for all customer design, reverse engineering, product transfer and facelift projects where for example the bearings, housings and/or gearings are updated.

According to Yrjönen (2010) two types of NPI-projects can be identified. First is fundamentally new design with new engineering solutions and technology. Second type is so called customization projects, where existing products are modified according to the needs of the particular customer. Typical NPI-project lead times from the project kick-off meeting to the shipment of the gear unit to the customer are 12 months varying in both contents and size of the project. Customer specification is the document that creates the baseline for the entire design process. The length and content of the specification may vary from hundreds of pages to zero pages.

Scope of an NPI-project is defined in the project start gate at management level and formalized to a written 0-serie survey report. The NPI-process is triggered only via management level decision. The ultimate goal of prototyping is to ensure the product performance and reliability before releasing it to serial production (see for example Ulrich & Eppinger 2003).

5.5.1. Research and development organization

The R&D organization at Moventas wind division is divided to five teams that are: layout, FEM (finite element method), technical drawing, verification and technology team. Technology manager leads both the technology team and the verification team. Product design manager supervises the layout, FEM and technical drawing teams. Both managers share information and resources flexibly between the wind division and global R&D. The composition of the current R&D organization is illustrated in Figure 18. Project managers that are responsible for the project execution are from a different organizational part called WG product management team. Product managers who take the responsibility of the products after the NPI-process belong to the same product management team as the project managers do. Project managers are the key persons managing projects from the signing of a contract to the customer approval of the product. Moreover, the project managers manage engineering resources during the execution of projects. They also take care of project scheduling and are in direct contact with the customers. Internal and external reference groups support the R&D organization during the development projects.

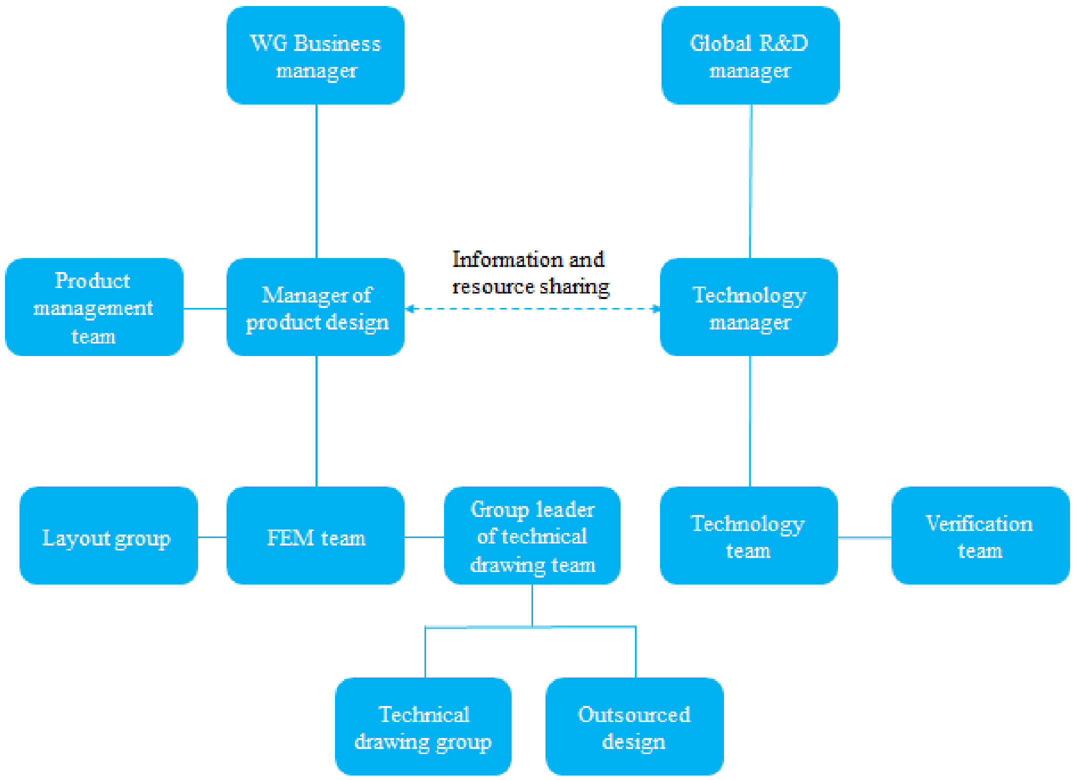

Figure 18. *Moventas development and design organization.*

Layout engineers take the role of lead designers in the project and they are responsible for designing the physical layout of the gear unit. Layout design requires the calculation of all geared components and the selection of bearings that fulfill all customer requirements and standards from both technical and loads perspectives. Normally, one lead designer is assigned to a project and his input is crucial in the early stages of the project. The drafted layout will provide a guideline for all subsequent designs choices and stages to follow. During the layout design certain aspects, such as manufacturability and serviceability, are taken into consideration. Furthermore, the lead designer participates in all gate reviews and works in a close co-operation with the project manager and the customer throughout the NPI-process.

Engineers in the FEM team are responsible for the structural analysis of the gear unit by using finite element (FE). One of the most important tasks of the FEM team is to optimize prismatic parts. Prismatic parts in the gear unit are considered to be the main structural components under load during the operation of the wind turbine. These components are for example the planet carrier that connects the gearbox to the wind turbine, torque support that prevents the gearbox from rotating and the housing structure(s) that provide(s) support against reaction forces originating from the internal components of the gear unit. Optimizing these prismatic parts requires an iterative approach where the weight of the component is minimized making at the same time sure that all mechanical safety factors are fulfilled.

Technical drawing team finalizes all technical drawings based on the respective 3D-models. They are responsible for generating the manufacturing and assembly drawings in close co-operation with the internal and external production units. The technical drawing group is also responsible for making the operation and maintenance manual of the specific gear unit. Lubrication system design is also one of the responsibilities of the team. Instrumentation design consists of engineering the condition management system (CMS) for remote monitoring of the gear unit performance.

Lastly, the verification group is responsible for making sure that the gear unit fulfills all agreed customer standards and specifications. The verification process consists of component and product level testing of the assembled gear unit. The technology team is a relatively new group within the R&D organization and the global R&D manager supervises the team. The group is responsible for studying new technologies, technological possibilities and supporting the project organization with their technical experience.

5.5.2. Project organization

After the Moventas management team has approved a new development project, a kick-off meeting is held. At the meeting, the new project is presented to the project organization and the NPI-process contents are agreed. The project manager has the responsibility for the budget and the schedule of the project. During the execution of the project the project manager also has to make sure that all tasks are completed on time. The size of the project organization core group is typically around five people. The number of people actively participating on the project execution varies highly. During the early stages the number of people involved can be as low as two or three and while the assembly and manufacturing drawings are generated the number of R&D people involved can be over ten. The composition of the high level project team in an NPI-project can be seen from Figure 19.

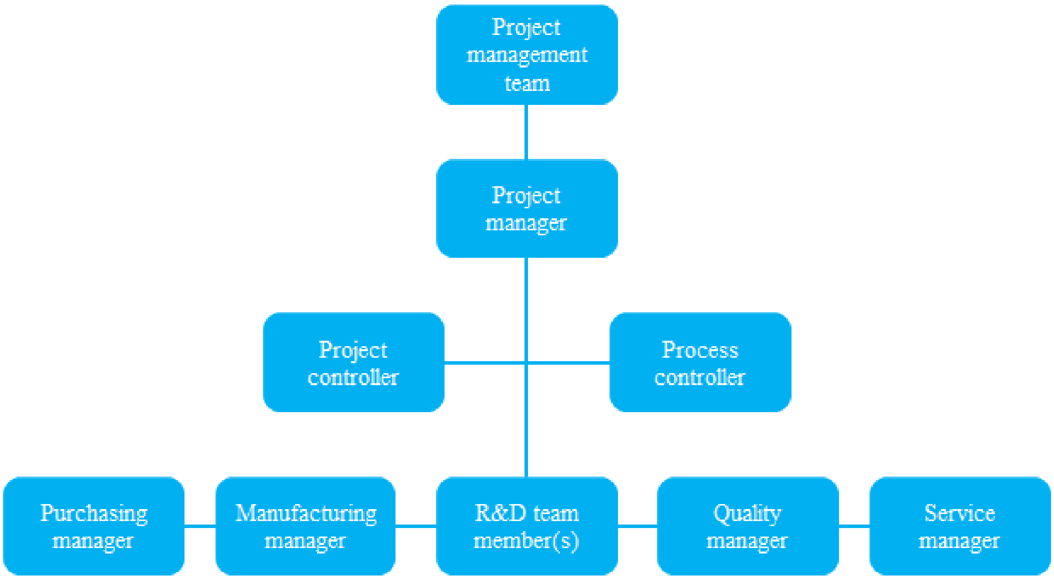

Figure 19. *NPI-project team at company level. (Adapted from Yrjönen 2010)*

The project core group provides guidance to the internal and external reference groups. Internal reference group has participants from production, purchasing, quality and logistics. External reference group refers to component suppliers and raw material suppliers like foundries. The project manager is in charge of the project execution and also from managing the whole project organization.

The R&D managers and team manager from the line organization assign the personnel to the project organization of a particular NPI-project. Normally there is one project manager and a lead designer for every project. From the other groups more than one member can be assigned to work in the project depending on the workload. Sometimes external reference groups or engineering consultants are used in the design phase. Especially the design of 3D-models and/or technical drawings can be outsourced.

Manufacturing manager coordinates the tasks from the project organization to the manufacturing organization. The manufacturing organization contains component production, assembly, logistic and test run. Manufacturing responsible is to make sure that all organizational groups within manufacturing are participating to the development process and provide feedback to the project organization. (Yrjönen 2010, p. 87).

Purchasing manager coordinates the activities of the sourcing organization and makes sure all the required information concerning the purchase of individual components is available and reports to the project manager if any problems rise. Sourcing manager oversees that the sourcing organization provides the required information for the project organization. Furthermore, sourcing has the responsibility of providing all the needed components for the project at the right time. Purchasing manager works in close cooperation with the project manager and controller. (Yrjönen 2010, p. 87).

Quality manager has a specialist role in the project in communicating all the quality risks related to the project. Quality organization provides the risk analysis for the project manager and is also responsible for arranging and supervising all prototype and 0-series inspections. (Yrjönen 2010, p. 87).

Service manager is in charge of all maintenance and after sales related aspects such as the serviceability of the gear unit and should also communicate all well-known failure types of previous gear units back to the project level. Person is also to provide feedback based on field experience, competitive gear technologies & products to the project team. As serviceability aspects need to be taken into account at the early design phases, it makes the service manager an important member of the early project organization. (Yrjönen 2010, p. 88).

5.5.3. Current Moventas Stage-gate model

Moventas uses a stage-gate process that is based on the model presented by Cooper (2001) in the new product introduction. Model is based on the assumption that a project consists of distinguishable stages that are followed by gates. These gates are checkpoints where a Go or No-Go decisions are made. Go means that the project may progress to the next stage. If a project receives a No-Go status there can be two outcomes either the project is terminated or the project tasks were undone. In order to receive the Go-status all undone tasks are required to be completed prior to a new gate meeting. The gate dates are derived directly from the project schedule. Project manager has the role of a chairman during the gate review-meetings.

There are six gates in the NPI-process after the kick-off meeting as depicted in Figure 20. These phases of the process are: kick-off, preplanning and layout design, design of geared parts, housing design, design of technical drawings, prototype survey, 0-serie survey and project ending. After each gate a portion of the design is frozen and actions related to the gate meeting are executed. For example, orders for the cast components are released after passing the housing design gate. Main purpose of the gate-process is to enhance the serviceability of the product, component manufacturability and to integrate employees from around the organization to the NPI-process easing the assembly (Yrjönen 2010, p. 39). The model integrates all organizational functions as illustrated in Figure 19 to the development project and moreover integrates the productization process and the product development process together. Gate meetings in general are not the place for design and manufacturing discussions. Having a design discussion in a gate review often results in an unclear meeting outcome. If the pre-defined tasks are not done, the gate is a No-Go and a new meeting date should be scheduled. The product bill of material (BOM) gets updated when moving from one gate to another.

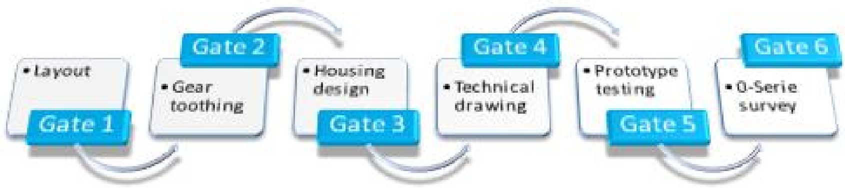

Figure 20. *Moventas stage-gate model after kick-off meeting (Adapted from Yrjönen 2010, p. 81)*

Start gate called "gate zero" is the trigger for an NPI-project. It is the decision of the senior management based on financial data and risk analysis provided by the early project team. When the NPI-project is triggered the initializing step is to start the work and a kick-off meeting is needed. At this phase, the project gets an assigned manager who drafts the project schedule along with a definition of R&D resource needs. These are both rough estimations based on the project manager's experience and previous NPI-projects. During the kick-off meeting the project plan and the team are introduced as well as project targets, schedule and risks. Customer order is often behind the launch of an NPI-project. However, this is not the case in every time. Sometimes the company can take a risk and start a project without customer commitment. (Yrjönen 2010, p. 88).

The first actual stage after the kick-off in the stage-gate model is to design the physical layout of the gear unit. At this point the layout engineer drafts the basic architecture of the gear unit, calculates geared components and chooses the bearings. If the project is based on an earlier quotation preliminary calculation and layout can be found from the material submitted to the customer at the early phases of the PLC. Designing the layout is critical from the cost perspective as frozen layout fixes the majority of costs. This is also discussed later in this thesis. After the first gate, the layout drawing and bearing BOM should be available and documented. (Yrjönen 2010, p. 89).

The second gate meeting requires that all manufacturing drawings for geared components have been finalized and are available for review. Drawings should be available one to two weeks before the meeting. Production engineers should review the drawings and provide feedback to the designers. If the designed components require new tooling, the manufacturing engineers need to know it early on in order to release the tool orders. If the second gate is passed then the billet orders for the geared components, required test run components, toothing tools and other long delivery time components can be released. (Yrjönen 2010, p. 89).

During third stage the large castings are designed in close co-operation with internal and external stakeholder groups. Design of the large castings gives the product its visual dimension and requires the designer to also consider the manufacturability aspects. Optimization of the casted components together with FEM-group is also done before gate three. After the gate three meeting cast models of the prismatic components are released for purchasing. (Yrjönen 2010, p. 89).

The fourth gate is the final gate before manufacturing of the prototypes commences. The gate can be held after all component drawings of manufactured parts and assembly drawings are available for review. Assembly methods should have been discussed together with production engineers. By this stage the engineering BOM of the gear unit should also be finalized and released. As an outcome of the fourth gate the C-parts are released for purchasing and permission to start machining the remaining components is given. (Yrjönen 2010, p. 89)

During the fifth stage prototype gear units are assembled, tested and verified. Production units and the assembly line have the possibility to give feedback and improvement suggestions to the design engineers. The engineering BOM is usually updated and classification material is created for the certification authorities. Decision of the gate five is Go when all needed documents for 0-series are available and approved by the project management team. (Yrjönen 2010, p. 89)

According to Yrjönen (2010, p. 90) the final stage is 0-series survey where the capability of the production process is tested. Batch size of the 0-series depends highly of the importance and scope of the project. Gate six can be held after all gear units of the 0-series have been manufactured and tested. The final gate meeting releases the product for serial production and product responsibility is transferred from the project to the product manager who is in charge of the product life cycle management (LCM) of the allocated wind gear product portfolio.

The NPI-process ends when the final report has been written and stored to the database. The report consists of lessons learned and of the project team’s thoughts during the project execution. After this the project team can be dismantled. (Yrjönen 2010, p. 90)

5.5.4. Communication and documentation during NPI-process

Moventas uses Teamcenter and Microsoft Office Sharepoint Server softwares for storing documentation during the design process. All employees have both softwares installed to their computers and everyone has for example access to manufacturing drawings through it. Production engineers and/or purchasers can access pdf-versions of the required drawings using Teamcenter without the R&D organization. Product lifecycle management (PLM) is done by using the Teamcenter database. All approved documents such as drawings and the bill of materials are stored to the PLM-system. Main purpose of the PLM is to make finalized documentation available for all participating in the project at Moventas. Sharepoint workspace is used for storing all unfinished documents and project minutes of meeting that are related on certain project. Access to confidential documents can be limited by adjusting the security levels. The project manager is able to grant access for editing or viewing documents within a particular project.

Communication during the NPI-process is mostly informal and required documents may be missing from gate-meetings because of unclear deadlines and responsibilities. Information sharing within the design organization is relative easy since almost all R&D employees are located in the same area. Only the technical drawing team is located outside the R&D area. Main reason for this is the limited space of R&D facilities and the fact that the drawing team needs to work in close cooperation with the production.

The main challenge of the current process is the supervision of task completion before gate reviews. The number of tasks and documents connected to a certain project is relatively high. There should always be an assigned person for every task. Failing to have assigned responsible results often in an undone task. Furthermore, people assigned with a responsibility of a certain task should be informed of it. Project manager is the key person in all communication related to a certain project. Many studies stress the role of good communication and effective cross-functional cooperation in order to develop a successful new product (see for example Elias et al. 2002).

5.5.5. R&D costs

Moventas Gears Oy research and development costs are approximately 1-2 percent of the company’s yearly turnover. Costs of the new NPI-projects are estimated roughly during the early stage of the process in the project proposal document. By the time of the project kick-off meeting every NPI-project should have its own work number, to which all further project costs should be allocated. If the project number is not available when the project starts it may cause some distortions in the reporting of project hours.

Development engineers and managers register their working hours on a monthly basis. However, registering work hours even on monthly basis seems to be difficult for the R&D organization and most of the employees do not register their working hours regularly. This causes uncertainty in the evaluation of working hours related to a project. When improving the cost awareness of the product development process and during the product lifecycle, it is vital to recognize where the costs originate. Typical cost factors in an NPI-project are listed in below:

- Sales and marketing costs (up-front homework, quotations)
- Designing costs (registered working hours, software licenses)
- Material costs (billets, components, castings)
- Manufacturing costs (production and assembly)
- Production overhead costs
- Quality costs (measuring, verification and documentation)
- Cost of scraps and rework
- Booked extra billets and castings for prototypes
- Travelling expenses (customer visits, supply chain visits)
- Cost of productization (acquired working tools, racks)

- Classification cost (fee of the authorization company, material tests, material placement)
- Cost of testing the product (test benches, working hours, electricity used, oil used)
- Post-delivery costs (warranty costs, design changes after NPI-process)
- Customer support

Allocating costs correctly between projects or products requires work number(s) that are used for reporting of the costs. Accuracy of cost evaluation suffers greatly if this is not the case. With the recognized cost factors it is possible to calculate the total costs of the developed product. The list may not be perfect and some factors may be missing but it provides a starting point for enhancing the general knowledge related to product lifecycle costing.

For the time being work hours used for customer quotations are not registered. The amount of work varies significantly between quotations. If the company has a similar already existing product in the portfolio, the work is much easier compared to a development of a totally new product or concept. Moreover, the work done in the quotation process can be added to costs of the development project afterwards if the customer accepts the quotation.

5.6. Conclusions

A gearbox, used to increase the rotational speed of the main shaft, is one of the strategic key components of the wind turbine. Furthermore, it has a significant impact on the initial cost of the wind turbine. Although Moventas is nowadays suffering from lack of orders, several European based manufacturers are facing similar challenges as well. Regardless of the challenges, Moventas has still a good capability in developing new products and ability to adapt quickly to new situations by tailoring products to the customers.

Moventas has a clearly defined stage-gate model that is used in the NPI-process. However, some responsibilities are unclear and commitment of internal reference groups outside the research and development organization during the design process is questionable. One major problem being that the production engineers don´t have enough time to review the manufacturing drawings prior to the gate meetings thus vital comments are usually missing from the gate meeting. A suggestion would be to have technical reviews before the actual gate meetings. The idea of the technical meeting would be to bring together the design and production engineers into a discussion of the preliminary drawings. Although, the design and production engineer should use technical meeting to share information, the design engineer should also use knowhow of the production in early design phases as well. This kind of technical review should be at least couple weeks before the gates 2, 3 and 4. Before gate four, the technical meeting should focus on assembly drawings and methods not going through all C-part drawings. Technical reviews would force stakeholders to work together. After the review there would be:

- Time to make design changes
- A Technical consensus of the contents of the drawing and how its presented
- Better level of preparation to the gate review

It is important that the manufacturing organization provides comments and feedback to the R&D from the manufacturability point of view. Moreover, when providing feedback on technical details they should also provide cost information and give cost estimations related to own production (POH and labor). This cost estimation should then be cross-referenced with pre-stated cost targets. If the estimation reveals that cost target(s) are exceeded the design team still has time to influence the component cost levels before the release of the product. This is especially important in stage 2 where all geared components are designed. Importance is highlighted by the fact that the mentioned components form a substantial part of the overall cost of the final product and the components are mostly insourced. In addition, standard solutions can be utilized in design phase as well. When the design engineer knows the costs of different standard features, it is possible to make decisions from both technical and cost point of view.

Serviceability aspects are considered to be important. The current process defines a significant role for the service department in the NPI-process. However, the participation of the service organization has not been active and the knowledge of the service organization is still not highly utilized in new product development. Also, the sourcing department should take part more actively to the design process and help the design engineers in getting cost information. Without the vital cost information the development engineers cannot make tradeoffs between costs and design features. Vice versa the designer should also give different design alternatives for souring department for price comparisons throughout the supply chain and loop the information back to the R&D. For example, when a design engineer makes a list of alternative bearings configurations for a purchaser, the sourcing should be able to provide cost estimations for each item. According to the current NPI-process model every single component should have bid price before it is released. However, this rarely happens and the discussion during gate-meetings is related mostly on technical aspects and to the project schedule.

One of the most obvious problems of the current NPI-process is that the costs of the new product are not monitored properly. Project manager makes a rough budget for the project during the early phases. The project budget is not used for anything during the NPI-process. Costs of the product are not typically discussed during the gate meetings. Even the design engineers who work in the project do not always know what the budget is creating a significant problem for the designers. How can they design cost-effective products, if they don’t have any targets or references? The head designer and design engineers are the key persons when the component costs are fixed. They should know all the cause-and-effect relations of their decisions.

Project schedule is the only parameter monitored regularly and projects don’t seem to have further targets or goals than the delivery of prototypes to the customer on time. Furthermore, evaluation of the project without well stated targets is not even possible. Another fundamental problem originates from communication. Even though the NPI-process is viewed in the system, not all personnel recognize it. Especially the recognition of the process end point and transfer to serial production seems to be difficult. For this reason, projects are not necessary finalized correctly and the work number for project stays open for extended times. From the cost monitoring point of view the ex-post calculating study should be done after 0-series survey and it should be attached to the project final report.

Main performance indicators for the NPI-process are project costs, schedule keeping and torque density. When the current status is that all cost factors are not allocated properly for certain project using work numbers the project cost monitoring has great uncertainty. Torque density measures strictly the product performance level not the performance level of the NPI-process. At the same time measuring the schedule keeping seems to be the most important indicator for measuring project flow. At least that is the only parameter being monitored regularly throughout the project duration. As mentioned the above measures are related to product performance and actually do not take into concern the output and effects of the product development (Suomala 2004).

In Moventas R&D there seems to be constant challenge to develop products without a hurry. When focus is unclear and there are too many projects on the table, design resources are overbooked and people are jumping between several projects. If projects are not clearly prioritized at the management level and well communicated to R&D organization, the lack of resource will continue to be a constant problem. When projects are clearly prioritized and resources allocated accordingly for chosen projects, the design engineers can commit to the selected projects without jumping between different projects.

This thesis concentrates on improving the new product introduction process by implementing cost awareness to the current stage-gate model. Even though project costs are one of the performance indicators of the process, the costs are not allocated and monitored properly. This is the main reason for cost reduction projects after the initial NPI-process. Moreover, when the designers do not get any cost information to support their design choices, the decisions are made only on from the technical point of view. This lack of cost information leads to a poor cost-efficiency levels of the products. The costs should be a transparent parameter throughout the entire process and the costs of the product should be an integral part of the gate meetings.

6. RESEARCH METHOD AND MATERIAL

This thesis is a case study made for the need of an industrial company. Theoretical content and the data collection are done based on literature review and empirical data collection. The cost data used through this study has been collected from ex-post calculations. In total 10 case products were studied and analyzed from the cost perspective. Collected data is from the Moventas IT-system used by controllers and project managers for viewing COGS-reports (cost of goods sold). For viewing the current state of project management, cost accounting and product costing several company employees were interviewed.

Table 1 depicts the workflow of this research. In the first phase, it was studied how to connect NPD project management and management accounting. This phase contained researching of the literature sources and analysis of cost data from the case company IT-system. Goal of the literature review was to study basic principles of management accounting, cost accounting and project management for the purposes of this thesis.

Table 1. *Workflow of the research.*

Phase	Connecting NPD project management and management accounting	The identification of current activities in case company	Management accounting in NPD process presented with framework
Evidence /data	Literature review: management accounting, cost accounting and project management	Literature: management accounting in NPD	Literature and previous phases
	Empirical evidence from 10 case projects	Bechmarking: three case companies	
		Empirical evidece from sample case: New Concept A	
Methods	Case study	Survey, case study	Synthesis, conclusion

In the second phase, current status of activities in the case company was investigated. Empirical data is from a sample project (New Concept A), a new technology project worked during the preparation of this thesis. The sample project was also a pilot project in the company where management accounting was actively used. Literature research in the second phase gave more background to what management accounting actually means when implemented to the new product development process. Furthermore, benchmarking study was executed during the second phase in order to gather practical information from other companies. Last phase, views the framework together with the results and conclusion of this thesis.

6.1. Ex-post calculation study

For the synthesis of this thesis top ten COGS-reports from different product types were analyzed. Reports were pulled from kilowatt class products to multi-megawatt size. These reports clearly illustrate the cost structure of Moventas manufactured wind turbine gear units. Due to the sensitive nature of the information all COGS-reports are classified as confidential material and excluded from this thesis.

The investigation was initiated by choosing a variety of different types of gear units to get an overview as wide as possible. It was required that the chosen gear units were manufactured between 2009 – 2013 so that changes to the reporting system would not skew the data. In the first phase of the ex-post calculation study, the product cost structures were dived in to seven main categories. These categories are: material, labor, warranty provision, purchase freights, production overhead, material overhead and scrap & rework. Furthermore, differences between the product cost structures of all chosen gear unit types were analyzed.

In the second phase, the cost of material(s) was chosen for further study. The cost of material(s) was chosen because they clearly dominate the overall product cost structure and secondly because they can directly be influenced by the R&D organization and design engineers. Total of seven component categories were recognized inside from the product material costs. These categories are: bearings, geared components, large castings, C-parts, seals and fastenings, other standard components and cooling, lubrication and heating components. After the categorization it was easy to identify where the design engineers should put their focus in cost sense. The amount of components that influences the majority of the total product costs was identified only to be less than 30.

Figure 21 depicts the structure of the product costs and gross profit. All costs are work id registered and they can be traced back to a certain gear unit. Ex-post calculation is based on registered costs.

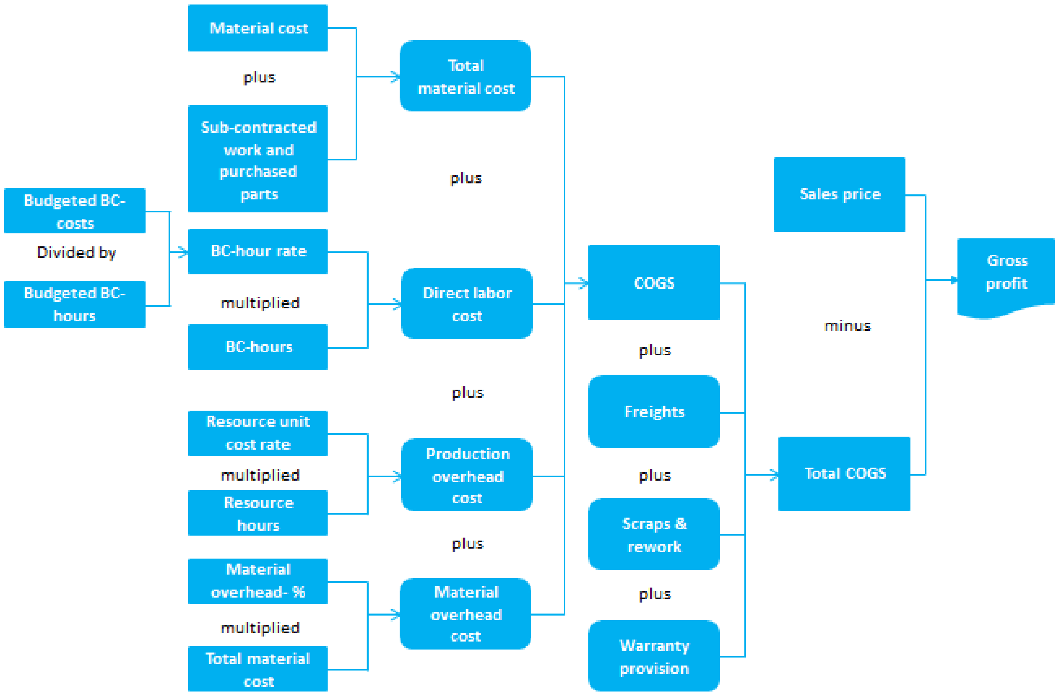

Figure 21. *Calculating of Gross Profit.*

Total material cost includes the cost of raw materials, sub-contracted work and purchased parts. For example pre-machining of geared parts is considered as sub-contracted work. All bearings, seals, C-parts and fasteners are outsourced. The basic principle followed is that the cost of all catalog items and outsourced items is under the total material cost.

Direct labor is registered to a specific work id. All blue collar workers register their hours to work numbers and the total cost is calculated by multiplying total hours with a standard hourly rate. Hour rate to calculate blue collar-hour rate is calculated by dividing budgeted blue collar-costs from budgeted blue collar-hours as illustrated in Figure 21. Production overhead (POH) is calculated by using predefined cost rates for resource units and by multiplying that with resource hours. Process development engineers calculate standard cycle times for all components and these cycle times are used for calculating POH. Material overhead contains the cost of quality assurance, internal logistics, rent of inspection machinery, logistic centers and purchasing activities. They are calculated by using a fixed percentage of total material costs.

These four categories (total material costs, direct labor, production overhead, and material overhead) generate the product COGS. Total COGS is calculated by adding warranty provisions, cost of scrap material/work & rework and freight costs to COGS. Product gross profit is calculated sales prices minus total GOGS. Gross profit should cover all the costs of sales and general administration (SGA). Once all the costs of manufacturing and distributing the product are covered the remaining part is profit for the company. A generic cost structure of a gear unit is presented in Appendix 1.

Figure 22 depicts the basic principle of production costing system. Direct labor and production overhead are allocated for the products by using pre-determined cost rates for the resources. Resources represent the machinery used for manufacturing the product. The routing or manufacturing process of each item is defined and it varies between different items. Cost accounting of resources is mainly based on hours, however at case carburizing (resource 2) kilograms are used to calculate the costs.

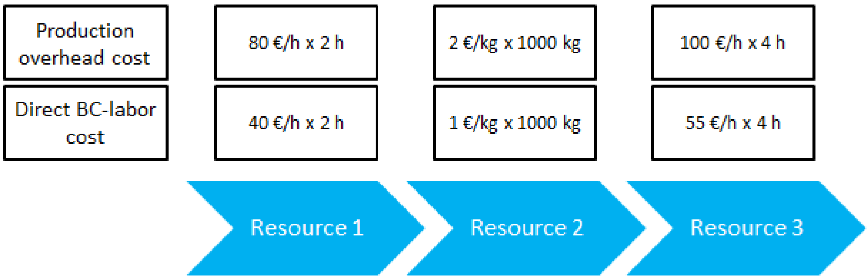

Figure 22. *Product costing system (adapted from Pänkäläinen 2008, p. 23)*

In the third and last phase of the ex-post calculation study the actual costs were imported to the current stage-gate process. By doing so it was possible to analyze the financial importance of each gate meeting. As presented in chapter 5.3, every gate has a different purpose. Figure 23 illustrates how material costs are committed during a project that follows the stage-gate model. After the gate 4 all drawings are released and costs are fixed although they not even manufactured yet. If the design engineer makes any changes after the gate 4 more costs will be generated and for this reason the costs can be consider as committed after each gate even though the manufacturing has not even begun.

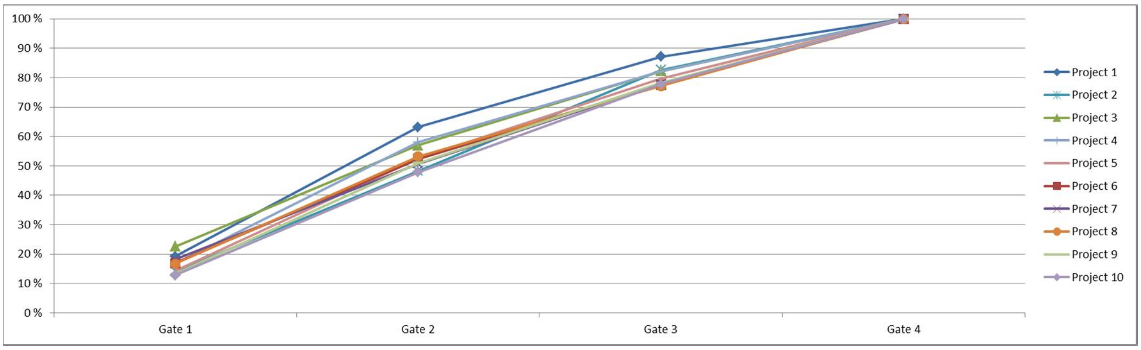

Figure 23. *Accumulating committed costs in Stage -gate model.*

As it can be seen from Figure 23 gates 1 and 2 fix almost 60 percent of the product total costs. This underlines the importance of layout design phase were the basic architecture of the gear unit is fixed. Layout designers are the key persons to make trade-offs between functionality, costs and quality. Moreover, it is essential from early on for the layout engineer to get feedback and support from manufacturing, sourcing and from the project controller.

Research and development organization has limited possibilities to influence the curve shape. However, the engineers can challenge traditional ways of design a gear units. For example, by choosing less expensive components/materials and think outside the box. Every milestone includes certain tasks to be executed and moving from one gate to another fixes the product costs up to that particular point. Possibility to influence the total costs decreases after each gate. After the second gate, development engineers can affect only to approximately 40 percent of the total product cost.

6.2. Sample case

New platform A was a project where the target was to design a new gear concept for 2MW wind turbine. The project was classified as an NTI-project (new technology introduction) and its target was to reduce 20 % of the total weight and costs compared to current reference 2MW product. 2MW platform is the current mainstream product in the market and voice of the customer supported the decision to put effort on this wind turbine size class.

The NTI-process contains three phases where each phase is followed by a gate meeting. Results of each phase are evaluated and reviewed prior and during the gate meeting. First gate meeting is to analyze the voice of the customer. During the first gate meeting project targets were set and responsibilities were allocated. Project group contained seven people from the R&D organization and also sourcing department was used actively throughout the project. The project piloted the use of a financial controller, as a part of the project core group. The main task of the controller was to provide cost information for the design engineers.

The project was initiated by analyzing the cost structure of a reference product in order to recognize the main components to which the engineers should focus their efforts on. After recognizing the cost structure and the most critical components of the gear unit a brainstorm session was held. Idea of the brainstorm session was to think outside the box and present new design ideas for consideration. First brainstorming round was very informal and no criticism was allowed. During the second round all unsuitable ideas were screened out and most promising ideas were further analyzed.

Cost information of this project was mainly related to bearings, casted components and geared components. Lead designer of the project drafted three alternate layouts that were evaluated from both technical and cost perspective. Project ended to an introduction of two different layout concepts combined with cost estimates. The project was terminated to the end of conceptual phase because there was no customer commitment behind the development project. After the conceptual design phase the decisions become much more detailed when the technical solutions and detailed structure of the product are determined.

Major problem of the project was an intense schedule which caused difficulties for the design engineer and for sourcing. When the time span is limited there is little time to do sufficient amount of iteration rounds (project duration was under four months) and the achieved cost level had to be frozen very quickly. Furthermore, tight project schedule did not allow enough time for sourcing to apply pressure further down the supply chain. From the cost analyzing point of view the most crucial problem was that there was no actual design features that could have been translated into costs. Also, gathering reliable cost information was challenging when the purchasing department was not used to giving proper cost estimations with a short notice.

Despite the fact that New Platform A did not reach the targets the project can still be considered as a success. The project produced many new ideas that can be applied in other projects and it increased the cost awareness of design engineers. Final project meeting concluded that analyzing product costs was a welcome activity and the support that the financial controller provided was highly appreciated.

When the cost consciousness level of the development engineers is compared before and after the New Platform A project, the result shows that even with tight schedule the engineers made decisions based on both cost and functionality. The project ended with estimated 10-percentage reduction on product costs and weight reduction of 15 percent.

6.3. Benchmarking

Benchmarking is an improvement process used to observe and study superior performance activities from other companies and apply them to own operations – it´s not just copying processes from the benchmarking company. By using benchmarking, companies try to adapt suitable processes from the benchmarking company. Benchmarking is a used tool when corporations are practicing continuous improvement in their daily work. In order to get the best results out of benchmarking the chosen business area and process need to be defined carefully. Benchmarking can be executed both internally and externally. (Damelio 1995). Since the goal of this thesis is to improve the performance of new production introduction process the operational benchmarking which is a sub-category benchmarking process is used in the scope of this thesis. (See for example Watson 2007)

6.3.1. Company A

Company A is a part of large global corporation that employs approximately 49 000 personnel worldwide with the company sales of 996 billion EUR in 2012. The corporation is a global leader in its business area and it operates approximately in 130 countries. The product development model is based on five milestones and new projects follow three basic strategies: business, customer segment and technology strategy. The new development projects are launched after a market feasibility study. In 2012 company used 5.1 percent to research and development activities from its revenue. The nature of the product development can be defined as applied research where new products are developed for markets without customer commitment.

The size of the R&D project group differs greatly depending on the nature of the development project. The amount of employees actively involved in the project varies from few persons to tens of people. If the R&D project is based on similar product manufactured before the number of personnel is notably lower than compared to developing new product platforms. The lead time of new products is at least two years and when an existing product is being updated the lead time is from one to two years. The product life cycle is relatively long, approximately 10 – 15 years, and spare parts will continue the life cycle by 10 more years.

The role of cost management is not defined in the product development process and finance controller is not assigned to individual development projects. Financing resources are borrowed when needed from the finance department. During the development process the project manager is responsible for cost management. However, the project manager does not typically have enough time to monitor cost levels of the future products. The product manager is the person giving targets for the development project and challenges the project from the business point of view. Nevertheless, cost management is not a defined function in the R&D process and the company uses several management accounting techniques during the development process. Used techniques are project budgeting, preliminary calculations, cost monitoring, ex-post calculation, cost targets, calculating cost and price estimations.

Company would like to put more focus on financial control during the development process. However, limited resources do not allow assigning a controller for certain R&D projects. In the ideal situations the company would put more focus on target costing and business calculations where different scenarios would be calculated before new products are finalized. Biggest challenge for company is to calculate cost targets for new products. Cost targets are typically used when the new product belongs to an existing product family. Standard costs and purchasing prices for existing components are available for the design engineers. In addition, engineers can study cost structures of manufactured products and use that information during the design phase.

The pricing method is based on market and customer segments. Furthermore, customer can choose the product features and effect on the product price level. If the company has been manufacturing a similar kind of product previously, that product is used as a reference when the new product is being priced. When the product is fundamentally new rough estimations like €/kg prices are used. Company A underlines the meaning of product pricing and gross margin. The product costs should not be the most important driver when the product life cycle is relatively long. For this reason the focus of the R&D should be more in the life cycle costing and life cycle management.

6.3.2. Company B

Company B employs approximately 2 300 employees worldwide and is a part of a large corporation. The corporate revenue in 2012 was 9,962 million dollar. Their product development model contains six gates. The different phases are definition, feasibility, development, validation, implementation and evaluation. Customer demand and competitor activities are usually the trigger for new development projects. Project core groups are normally composed of selected people from all company functions such as R&D, product management, production, marketing, quality, sourcing, after sales and service. Depending on the project, the number of R&D personnel participating on the development process is between 10 – 50 persons. When a new product is been developed the project lead time is approximately three years. Life cycle of the products is relatively long approximately 10 – 20 years. In the future, the life cycle is expected to increase.

Cost management is considered as highly important function inside the company. The R&D activities and project manager are responsible for the cost level of future projects. Manufactured products are based on module structures, and before the design phase has begun the cost structure of the future product has been studied. I other words, the design phase will not be triggered before cost information of the future product is available. Product modules are based on similar products and one product consists approximately of 250 different modules where every module has its own cost target. After the first prototype approval the product cost structure is monitored and updated if needed. In practice the cost structure is updated in every 1 – 3 months. Moreover, project budgets and costs are monitored on monthly basis.

Cost information for every item is available for all personnel and all cost information is inside the product management systems. Engineers increase their cost consciousness by working in close co-operation with the supply chain and sourcing. In serial products the cost information updates automatically to ERP system. Furthermore, estimated cost fields are used in early phases to support decision making. The idea of estimated cost fields is that the designer and buyer fill their estimations when the new item is launched for the first time. Estimates and targets for each item are based on communication between engineers and design managers. If product cost estimation seems to lead in to an expensive product compared to market target price, the product structure is open and discussed.

The main focus of the cost management is to monitor material costs. One of the biggest challenges is monitoring the value of ordered and invoiced materials and services in real time. Allocating labor costs is much more complex because of the nature of the production. However, labor is allocated to product level. Cost management during the design phase is done by creating 2 – 3 different cost models and by comparing costs of the new products to existing similar products. If needed, the costs gaps are then analyzed in more detail. Company would like to use method of target costing much more. However, the availability of finance resources is limited and most of the time it is used for monitoring costs. The main responsibility for cost structure is therefore in the engineering and sourcing departments.

The role of the management accounting is to provide tools for real time monitoring and product cost optimization. For this reason the company uses several different management accounting techniques during the development project. Techniques are budgeting, pre-calculating, cost management, ex-post calculation, pre-stated cost targets, cost estimations, product price estimation, product life cycle costing including service costs and value engineering. Furthermore, the company uses two softwares Apriori and Perfect ProCalc for the product cost optimization. In order to challenge the design engineers, the company has arranged design to value sessions. Company view that, these sessions have helped greatly on enhancing the level of cost consciousness and the company recommends design to value sessions for every company that wants to improve the value of their products.

Company B measures development projects by using different metrics like project costs and schedule keeping. Used metrics are used mainly for monitoring project execution and for guidance purposes. Furthermore, the company uses same metrics as incentive mechanisms. Projects are finalized in the project end meeting where a lessons learned document is written.

6.3.3. Company C

Company C is a part of a large global corporation and employs approximately 64 persons. The company turnover in 2012 was 6.5 million EUR and cost of R&D is approximately 5-10 percent of net sales. The product life cycle consists of eight milestones starting from approval of the development project and ending to the termination of product life cycle. The model originates from the corporate level and all new projects are launched after a feasibility study. Lead time of the development projects is typically 3 – 24 months including the productization.

Project groups are typically composed of 2-5 people. Project or product manager leads the development project. The other members of the project group are typically the sales manager, product manager and a small development team. Project schedule and risk levels are reviewed usually on monthly basis. However, weekly project meetings are used to monitor project execution as well.

Life cycle of the products is typically 3 – 20 years depending the product in question. Project manager has the main responsibility of project cost management. However, sales manager and product manager also participate in cost monitoring. In addition to the early mentioned, financial manager and a project controller are available for the use of the project when needed. Role of management accounting in the benchmarking company is to ease learning. Organization has focused on educating the employees with basic principles of project cost management. Furthermore, the employees know how they can influence the product profitability levels. The following management accounting techniques are used during a typical development project:

- Project budgeting
- Cost monitoring
- Cost calculations
- Price estimates

The company measures the performance levels of projects by using metrics such as customer satisfaction, gross margin and conformity of product when compared against requirements. When a development project is finalized a lessons learned document is drafted. Moreover, lessons learned are collected throughout projects. Project outputs, such as the requirement compliance, are compared to the targets set as the early project definition phase.

6.4. Research observations and conclusions

As materials dominate the product cost structure at company, the design engineers are key persons to influence the cost levels of future products. In addition, by using design for manufacture (DFM) and design for assembly (DFA) methods the engineers can reduce direct work and production overhead costs. Furthermore, as the direct material costs of the product are reduced also material overheads become lower.

The key focus point for engineers is to recognize all the design features that generate majority of costs for a new product before the design is frozen. Without clearly stated and communicated cost targets, products are very likely to become too expensive and cost reductions are needed directly after the NPI-project has been terminated. Also when the project schedule is considered too demanding, the product costs will more likely reach a higher level than with a longer time scope. Benchmarking study supports the argument that when time to market is prioritized as the most important driver, a cost reduction project after the initial development project is usually needed.

New Platform A case showed that the active use of financial controllers during projects allows the comparison of different design alternatives and supports decision-making situations. Furthermore, when the financial controllers are used actively in decision-making situations the cost levels of the products will most likely end up being lower than without the use of controllers. Developing products with cost targets requires a close co-operation especially between the R&D organization production and sourcing. By increasing the level of cost consciousness of engineers it is possible to make trade-offs between costs, functionality and quality. Moreover, design engineers should be aware off cause-and-effect relationships of alternative decisions.

Survey phase of thesis revealed that most of the costs are committed after the second gate – 50-60 percent. This underlines the meaning of early phases of the project and co-operation between cross-functional project groups. Furthermore, when cost saving projects is executed it is important to recognize that most of the costs usually fall under classified components. Thus, when cost reduction project's is aiming for remarkable cost saving targets the gear unit need to redesign and classification material need to update.

All benchmarking companies recognized the importance of cost consciousness during development activities. Furthermore, all companies would like to put more focus on cost management than they currently do. However, limited resources seem to be a common reason why management accounting techniques are not used effectively. When costs are transparent and the information is available throughout the organization, especially for design engineers, the possibilities to influence the cost level of the future product are greatly increased. Project managers are typically the key stakeholders responsible for the project including the project cost management and supported by a project controller. The idea of using product manager as the project sponsor to challenge the project from the business point of view is interesting. For this reason the product manager should participate to the development project throughout the project.

Majority of the work time of financial controllers is used for monitoring already occurred costs not for estimation for future costs. Moreover, cost management is typically not a defined function within the development process and financial resources are borrowed only when needed. The relationship of borrowing resources from the financial department to the project level causes a gap between the interests. Role of the financial controller should not only be the monitoring of costs. The role should be more proactive where the controller gathers cost information from organization and calculates between different business scenarios. Project controller should also participate actively to the project execution and support the project group and the decision-making situations.

Role of the management accounting in development projects seems to be most advanced in company B. The company uses several management accounting techniques and new development projects are not triggered without proper cost estimations. Furthermore, every item has to have a cost estimate before the design is launched. However, product costs are an important factor during the NPD. Main focus should be more on the product pricing and life cycle management as stated by the company A. After sales and service business should be considered also when new products are launched. When the product life cycle is relatively long, the after sales and service business typically generate revenues for the company. The development organization should also consider this when making design decisions.

7. IMPLEMENTING MANAGEMENT ACCOUNTING INTO THE NPI-PROCESS

When management accounting is implemented to the current NPI-process the main idea is to increase the cost consciousness level of engineers and provide cost information that supports decision-making situations during the project execution. The project controller should be considered as a key person in this. The controller should collect financial data from the internal and external reference groups and monitor the committed costs of the future product together with the project manager. Furthermore, project controller is also the person participating to the financial evaluation of the product life cycle. Furthermore, this information can then be used to support future projects. Evaluating the success of the NPI-project should not end to the written final report after 0-series, it should continue through the entire product life cycle.

Before an NPI-project is triggered, there can be found tasks related to the early phase of the development process. These tasks are product marketing, preliminary calculation and making sales quotations for the customer. During the early stages marketing, sales and product development should discuss closely how the customers create value in their processes. By understanding value from the customer perspective early on helps the supplier to shift focus on right places during the design phase. Furthermore, Morbey (1988) has pointed out that investment to R&D activities has a strong correlation with growth in sales.

7.1. Product marketing

The current process description concentrates only on the project execution, to the time after the NPI-process is triggered. Marketing phase starts when a company recognizes a market opportunity for a new product. The recognized opportunity or idea may originate from the hunch of a sales manager or key account manager (KAM) and their view of the future market situation.

Projects can be divided into two types. Projects that the companies start together as a development co-operation together from the scratch. In the second type, the customer may have already developed a product together with a competitive gear unit supplier and Moventas is willing to offer a similar unit fitting the existing specification. Approach between the two scenarios can be very different. When the wind turbine manufacturer has already developed a product together with a competitor, the specification for the gear unit is already fixed. Second and third suppliers simply have to accept most of the constraints if they want to be qualified as an alternative supplier. Also, when the gear unit supplier is included to the development of a new turbine in a close co-operation with the turbine manufacturer the supplier can influence the product specification and be a step ahead of competitors.

As an outcome of the early phase of the development project, a marketing and sales material for the customer should be generated. Material should be used to draw customer interest into starting a development project together with the supplier. Tasks that need to be done during the feasibility study are: gear calculations, bearing selections, estimating COGS and price level of the future gear unit, 3D-models and draft of a dimensional drawing. Finalized marketing material to the sales manager or KAM should include a summary of all technical features of the product, dimensional drawing and COGS estimate.

Quality of up-front homework is important for the success of the development project. By hearing and understanding *the voice of the customer* it is possible to meet the customer needs. Ottum and Moore (1997) have argued in their studies that there is a strong relationship between processing the market information and in the success of the new product. Gathering the market information is not enough, the information needs to be further shared and used. (Ottum and Moore, 1997). So it is not just enough to communicate between the customer, sales manager and key account manager but the information needs to be relayed also to the design team.

7.2. Preliminary cost accounting and sales quotation

Sometimes contact to the customer is simply a sales quotation without marketing the product or company. Feasibility study for this type of customer is fundamentally the same as described in the product marketing phase. The most notable difference between the marketing and quotation phases is the amount of work. It is usually larger in the sales quotation phase than in the product marketing phase. This is mainly because the quotation phase requires larger amount of gear calculations and 3D-models to be prepared in order to do the quotation.

Preliminary cost evaluation of the product is required for making the sales quotation. Product costs evaluation is an analysis of the future product where costs such as labor, material, production overhead, material overhead, freights, warranties, scrap and rework are estimated. Before the preliminary cost evaluation can be completed, preliminary layout of the gear unit and gear calculations are usually required. Furthermore, a preliminary selection of the bearings is required.

If the cost estimate is based on similar product manufactured before, the ex-post calculation of that product should be studied. Afterwards the cost information can be updated to correspond with current price/cost levels. Person calculating the product

COGS has to collect the needed cost data from the sourcing and production organizations. Cost information for bearings, lubrication components, forgings and casted components is needed from sourcing. Production engineers should calculate their estimates of the cost of geared components and assembly (POH and labor). Sourcing and production organizations should be able to provide the cost estimates within a week in order to prepare the customer quotation as swiftly as possible.

Pricing of the product is crucial when the sales quotation is prepared. The used pricing method depends heavily from the market situation and strategic relationship to the customer. In following two different pricing methods are shortly discussed. First pricing method follows the idea of target costing where sales price is determined after the analysis of current market environment (see for example Tanaka 1993; Cooper and Slagmulder 1997; IMA 1998). Management team has to communicate to the sales manager what the sufficient gross profit level should be in order to compute the target cost.

Target costing method provides the high level target that the product cannot exceed. Furthermore, the target cost should be further split down to component level targets for bearings, large castings and geared components. These component level targets are then easier to communicate to the design engineers as a challenge.

Second pricing method is based on the customer value hierarchy (see for example Kotler and Keller 2009, p. 358). Idea of the method is that in the core, is the product with no extra features. Core product being the cheapest possible variant with the shortest acceptable warranty period. This core product can then be used for marketing purposes or in the first quotation round. Afterwards it is possible to discuss with the customer about further customer needs, such as extended warranty and condition management systems. By adding more rows to the quotation, the customer gets to influence on what is delivered and the product scope is transparent for both sides. At the manufacturer side price rows can be used for target costing purpose.

Figure 24 illustrates the up front process. Customer quotation can be considered as a small project whit a clear start and endpoint. Each quotation has a sales support manager who works together with the sales manager or the key account manager and is responsible for gathering the required design resources. Voice of the customer is the input for the up front process and quotation material for the sales manager or KAM the result of the process. Sales support manager is the person making sure all technical features are considered and fulfill the customer need. Sales manager or KAM finalizes the sales quotation and is responsible for gathering all the needed documentation and sending the quotation to the customer. Process owner is a management level person who is responsible for entire process and updates the process when needed.

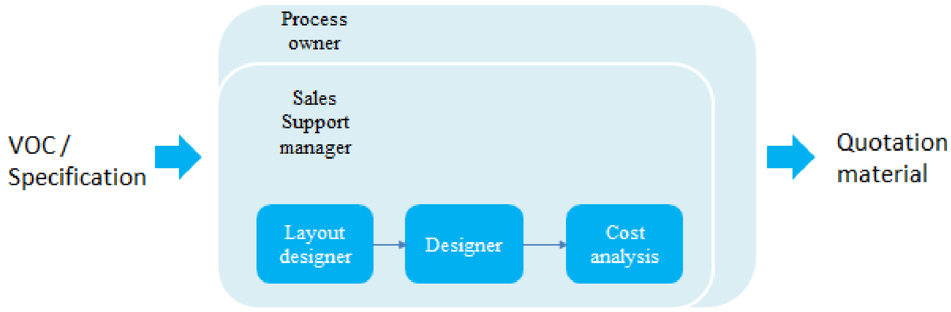

Figure 24. *Up front process.*

For cost monitoring purposes there should be a work number for all labor hours of the quotation process. The whole quotation process usually takes between one to two weeks to complete depending on the case. First, the layout engineer needs to do a feasibility study to make sure the gear unit fulfills all calculation requirements like the transmission ratio. Furthermore, the engineer needs to ensure that all safety factors are sufficient for the specific load cases. Based on the feasibility study the engineer can draft a 3D-model and the dimensional drawing. The 3D-model is also the volume of control reservation of the gear unit and can be used for weight estimation. Cost analysis can be completed after the concept has been fixed. Geared components and bearings provide the initial information for the person analyzing the future product costs. Cost of large cast components can be estimated by using €/kg prices. Once the cost information of bearings, geared and cast components has been gathered, the remaining can be evaluated by analyzing other similar products.

Outcome of the benchmarking study reminded that service and after sales topics should also be discussed in the preliminary design phase. Furthermore, by calculating different business scenarios it is possible to estimate the profit level of the future product. Costs and profit levels should be computed for both prototypes and serial production units.

7.3. Project scope, budgeting and scheduling

Determining the project scope and the business case are the first actions to be taken before fixing the project budget and schedule. Project scope describes what will physically be developed in the project and how it matches the voice of the customer. Deviations can be discussed and mutually agreed with the customer in order to reach the correct project scope. Project schedule is the execution timeframe of the project and budget is the cost framework. If the project scope is changed during the project, the budget and schedule should also be checked and updated accordingly. Project manager is responsible for the project budget and schedule.

Budgeting the new NPI-project is one of most important tasks of the project manager before the company management team gives their approval for the project. Project budget forms the baseline to which cumulative costs are compared while moving from one stage to another. Scheduling the project backwards is probably the most used method for setting the project timeline. In backwards planning the shipment day of the finalized product is the last milestone and prior actions are backwards calculated from that date. Shipment day will determine for example when the assembly must be completed in order to have sufficient testing in time.

After the NPI-project is approved, a kick-off meeting can be held. Project management team should give targets to the development project before the project is actually launched. By using financial targets more detailed cost targets for the new product can be defined. In the kick-off the project scope, schedule and cost targets are presented for the project group. These three fundamental cornerstones of the project: scope, budget and schedule form the baseline for managing new product introduction projects.

7.4. Cost targets

Cost targets are pre-stated financial targets for chosen components of the product. Project manager, head designer and the project controller can together decide the cost targets for specific components in order to achieve the desired overall cost structure. Furthermore, the project controller can calculate different scenario analysis for cost monitoring purposes. Calculated cost models can then be compared to similar products and to accumulative costs during the development project. Product manager or KAM can give cost reduction pressure for the project managers as the benchmarking study suggested. Moreover, product manager or KAM should have a more active role during the project execution as the project sponsor. KAM is often most aware of the customer status and product manager will inherit the product once the development process is finalized. For this reason they both should be included to the R&D project more intensively.

Used cost targets should be based on market information with the aim of putting pressure to product development engineers and to supply chain (see for example Cooper and Slagmulder 1997). Use of cost targets in an NPI-project requires some consideration though. Firstly, the specification and scope of the future product must be clearly understood. Secondly, the targets must be clear for all personnel involved in the project. Thirdly, the cost-objectives must be realistic and achievable but nonetheless challenging.

In order to achieve a certain cost target requires usually several iteration cycles. This needs to be taken into account when the project schedule is created. Furthermore, the project management team should communicate to the project manager what are the most important priorities, targeted gross profit of the product or the time to market. The NPI-project should always have a stated cost target that is well communicated and monitored throughout the project. Cost targets and estimated production volumes must be discussed together with sourcing and production.

If target costing method is used to achieve a certain cost level, the time to market for a project can not be too rushed and project manager must follow the cardinal rule *"the target cost must never be exceeded"* during the gate reviews (Cooper and Slagmulder 1997). For example, the component-level target cost for bearings is set to 20 000 €. Thus the Gate 1 can not be passed until selected bearings costs less than 20 000 € or other product features allow the re-allocation of additional funds for bearings. This added cost to the bearings is then taken off from somewhere else, for example from casted components. For this reason, learning the principle of target costing method should be started from smaller projects than NPI-projects. Moreover, it is important to notice that too strict target costs may affect negatively on the engineers and their innovation levels.

Pre-stated target costs or cost targets can be used in cost reduction projects as well. In cost reduction projects the actual product COGS can be printed out from company reporting system and by using COGS-report. Furthermore, it is possible to analyze components that contributed to the majority of the costs thus putting the focus on right places. Typically cost reduction projects are originated from the customer interface. Often the customer pressures the suppliers to reduce costs of the product. On the other hand, cost reductions are also in the interest of the supplier in order to achieve better gross profit margins. To achieve the cost reduction goals set by the customer and management team, the cost targets and reasons behind the targets should be communicated to engineers.

Cost targets can also be used for performance measuring purposes and as incentive mechanisms. When the engineers know that there is an incentive or reward if the cost target is achieved, the targets could be used for motivating engineers. When pre-stated targets are used for incentive purposes the targets should be challenging but not impossible to achieve and it should be possible for the engineers to affect directly on the targets.

7.5. Monitoring product costs during the NPI-process

Project gates are milestones where the cumulative costs of the product are monitored systematically. Accumulated product costs can be reviewed during the gate meetings and Go or No-Go decisions can be made based on the realized cost levels. As the project progresses the cost estimates become more and more accurate thus decreasing the project risk and uncertainty. If the sourcing or production organizations have not given the required cost information before the gate reviews, the gate-decisions cannot be done, and the decisions should be No-Go. The fundamental idea should be that nothing is frozen without cost information and the project is stopped until the required cost information becomes available. The management team has to support this principle or otherwise the whole idea becomes obsolete.

In the first gate meeting the product layout is presented together with the selected bearings. Sourcing should have the cost information of the selected bearings available before the gate review. Bearings generate a significant portion of the overall cost thus it is highly important to evaluate the costs of the selected bearings. Possible bearing alternatives should be considered as well before releasing the final bearing BOM. Procurement manager(s) is accountable for providing this cost information for the engineers and to the gate meetings. After the first gate review about 15 – 25 percent of the product costs are committed.

Before the second gate meeting can be arranged a technical meeting together with the production should be held. Technical meeting should be 2-3 weeks before the gate meeting with the aim to encourage production to participate actively in the NPI-process and to review the component drawings. During the technical meeting drawings of all geared components should be discussed. Based on the preliminary drawings the production can estimate the direct and indirect costs such as labor and POH.

Calculating the costs of own production falls to the responsibility of production development engineers. They should provide the needed cost information to design engineers and to the gate meetings. Production engineers should know current cycle times of different machines and base their estimates of manufacturability, costs and need for new tooling on that information. Furthermore, sourcing manager(s) needs to provide cost information of alternative materials and billet prices for the geared components. After the second gate-meeting about 50 – 60 percent of the product costs are committed.

After the third gate meeting all major cast components are launched for ordering. Casted components are designed in co-operation with the foundries. Design of casted components requires consideration of aspects such as weight optimization, castability, structural analysis, material selection and costs. Sourcing manager(s) is responsible for providing cost information of the casted components for the project group and to the gate reviews. Especially when a project has a cost target it is important for the designer engineers to see the cost effect alternative materials and design choices. During the quotation the costs of cast components can be calculated by using €/kg prices. Foundries usually simulate the castability of the components before the drawings are released. Based on the simulation and material information a more accurate cost estimation should be available. Sourcing should also start investigating where the casted components can be machined and at what cost. After the third gate meeting about 75 – 85 percent of the product costs are committed.

The fourth gate releases all remaining components of the product. Remaining components are composed mainly of C-parts, fasteners and lubrication components. Lubrication unit usually has a long delivery time and it is delivered after the second or third gate meeting. Engineers must discuss together with the suppliers in order to take into account manufacturability aspects as well. When making the drawings, the engineer should use tolerances carefully in order to avoid over-quality. Furthermore, used component materials should be discussed with the supply chain. After the fourth gate meeting it can be considered that all product costs are fixed. Figure 25 sums up how product costs are committed during the project execution.

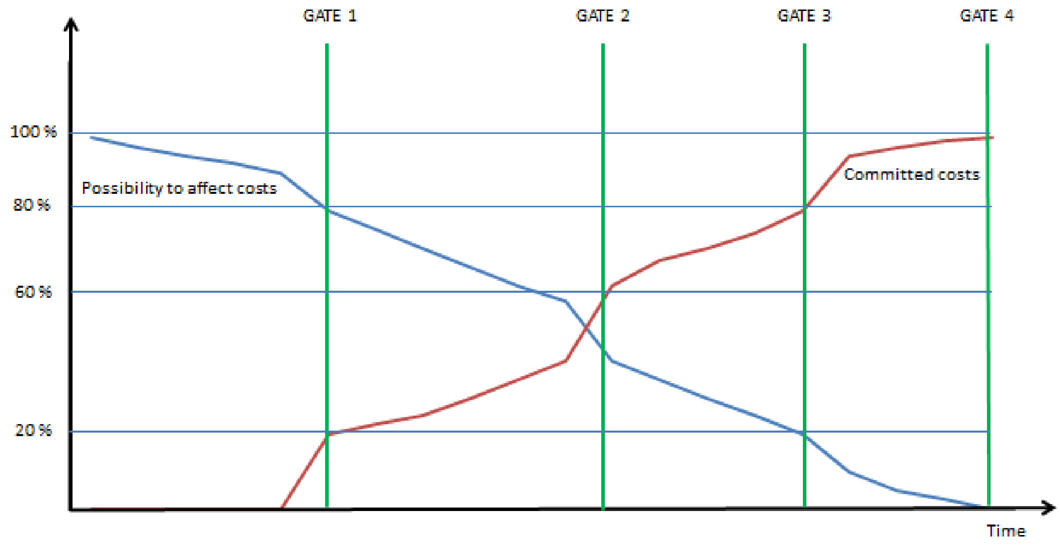

Figure 25. *Costs in the NPI-Project life cycle.*

When the cumulative cost curve is presented in every gate review the project group can clearly see the present status of the project from the financial perspective. Cumulative cost curve can be compared to the project budget and furthermore to the project schedule enabling the possibility to discuss about earned value (see for example Artto et al. 2011). By monitoring costs during the NPI-process, it is possible to enhance the level of cost transparency and improve cost consciousness of the development engineers.

7.6. Cost transparency

Cost transparency is assured in the new NPI-process by creating a database where costs of the future product are stated. It has to be made sure that all project members have an access to the database and the full cost structure is visible. Cost information is provided by the project controller. During the early phases of the project, costs can be evaluated based on calculations made in the quotation phase. If there is no customer commitment to the project, the cost structure can be estimated based on other similar products. If the future product is fundamentally new, then the cost structure has to be based on pure estimates. Feature-based costing method is used for gathering the cost information of the new products (see for example Sandström 2001).

Idea of the cost database is to provide the design engineers an easy place where they can find cost information. Furthermore, the cost information enables the engineers to better make trade-offs between costs and different design alternatives. For the first gear calculations the MOVE environment is the tool being used to generate different layout alternatives. After the design matures the cost data has to be updated manually. The database should include cost information of alternative materials and components like different cast iron types and strengths sorted by using unit price (€/kg).

Cost transparency is crucial when cost consciousness is build into the design process and it is promoted to the design engineers. Figure 26 illustrates the main dimensions of cost consciousness. When a new project is introduced to the design engineers, aspects such as market situation, customer demand and competitors situations should be analyzed.

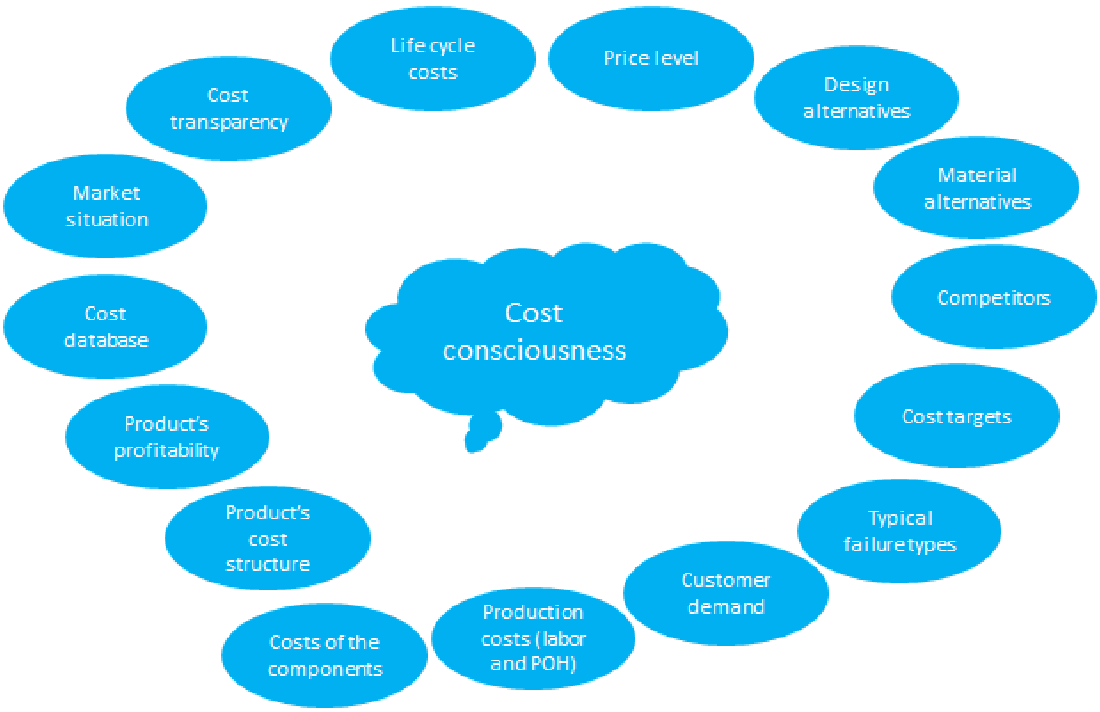

Figure 26. *Characteristics of the cost consciousness.*

Prior to starting the actual design work, characteristics like the price level, cost targets, product profitability and typical failure types should be addressed. After the design and development process has started, cost consciousness is supported by the cost database. Geared components are very similar between products, thus standard solutions could be used. Manufacturing organization could calculate standard costs for standard design solutions where the design engineers could choose the needed features that are based on standard solutions. If non-standard solution is picked, the engineer should reach out to production in order to find you the consequential production costs.

When the engineers and managers recognize the origin of costs, the probability of making better decisions increases compared to a situation with no cost information available. The ultimate goal of managing cost transparency is that every decision-maker knows the causal cost effects of their decisions. First step in costs consciousness is to increase knowledge by offering cost information to the design engineers and by creating a transparent cost environment within the company. Product profitability should be one of the key topics during the first step especially the question what are the key factors influencing product profitability? After a certain level of cost consciousness has been gained, the next phase is to analyze the product life cycle and moreover how different phases of the life cycle influence on the NPI-process.

7.7. Break-even point

Defining the break-even point at an early stage of the product development project is naturally based on assumptions. Therefore, alternate scenario analyses are required based on the particular assumptions made. Calculated scenarios should include so called best and worst cases and the most probable outcome that normally lies somewhere between the worst and best case. Calculating the break-even point and estimating the project justification requires certain data. The needed data can be listed in following:

- product development costs
  - salaries of the R&D personnel (hours from LEAN system)
  - productization investment costs needed (machines, tools, assembly benches, test benches)
  - cost of testing (gold test, HALT test)
  - certification costs (materials, auditions)
  - quality costs (scraps and rework, documentations)
  - obsolete inventory (components and materials that are leftover from proto survey phase, obsoleted because of product changes)
  - logistic costs (shipment)
  - travelling expenses (customer and supply chain visits)
- cost of the product (COGS)
- sales price of the product
- sales forecast of the product

When the product development costs, sales price and COGS have been estimated the break-even point can be calculated by using the following formulae.

$$Break - even = \frac{\text{Development costs}}{(\text{Product sales price} - \text{Product costs (VC)})}$$

When calculating the break-even point it is important to notice that the cost of the product is not always the same thus product costs can also be called as variable costs (VC). Cost structure of a certain gear unit is based on price information collected from the company ERP system. Used price information is calculated by using weighted averages resulting to the variance in COGS. The weighted average cost gets updated automatically when an item with new purchase price is added to the inventory. Cost of the components changes over time, because components are purchased at different price levels. Variables influencing the unit cost of components are for example, the batch size and the price of raw material.

With sensitivity analysis it is possible to estimate different outcome scenarios. Product price is typically fixed. However, the manufacturing cost of the product may differ from estimates. For example, different sales volumes can be used for estimations when a new project is justified. If the break-even point of the product is 100 gear units and the customer is asking quotation for 200 gear units, it can be assumed that the project is profitable to execute based on the financial estimations. Of course, there are several other aspects to be taken into consideration as well. Aspects such as customer loyalty, reference value and market situation etc.

Accuracy of the product break-even point during the front end of the development project is based on rough estimations. Estimate can be drawn from similar products manufactured earlier or featured-based cost estimations. When the NPI-project is moving from gate to another, the accuracy of the break-even point is increasing as well. The fundamental idea of calculating the break-even point is to find reasons supporting the project execution and to defend the project justification.

7.8. Ex-post calculation

After the first prototypes have been shipped to the customer the product costs should be further studied before launching the 0-serie. Ex-post calculation study reveals the actual cost level of the product. The main idea of the ex-post calculation is to learn from the decisions made during the development phase of the project. Furthermore, study of the actual costs of the product gives feedback for improving the accuracy of the preliminary cost estimates that were done.

Study of the actual COGS-level of the prototypes may reveal some design features that caused unexpected costs that were not recognized during the project execution. If the ex-post calculation of the prototypes reveals some costly design features there is still time to influence them before the launch of 0-series. It is not unusual that the design engineers have to do some changes between the prototypes and the 0-series. Usually design changes that are executed after the manufacturing and testing of the prototypes are communicated and decided together with the customer. Unexpected product costs can be a consequence of expensive material choices, over-quality and poor manufacturability.

Second feedback round of profitability is done after the 0-series. It will reveal if something surprising has occurred during the 0-series manufacturing. After the 0-serie survey is finalized and the product is transferred to series production it is highly important that the product has a sufficient profit margin, quality and functionality. Ex-post calculation should be included to the final written report before the project group gets dismantled. The project controller and project manager should be responsible for making this study.

7.9. Measuring performance of the NPI-process

Measuring the success of NPI-projects is important in order to get feedback and learn from the project execution. By analyzing both unsuccessful and successful projects, important lessons regarding the factors that drive to good performance can be learned. Measuring the performance of development projects enables this learning process and helps in communicating with the organization. Many studies stress the importance performance measuring in new product development and chosen metrics can be used to set the focus towards strategically important topics of the company (see for example Suomala 2004; Neely et al. 1995; McMann and Nanni 1994). Furthermore, as stated before, the performance of the development process is a multidimensional subject that requires comprehensive metrics.

NPI-process produces new products to the company product portfolio and managing a portfolio successfully requires that it is build on valid product information. Product profitability is the key piece of information when the product portfolio is managed. Recognizing profitable products from unprofitable products in the portfolio is important for a company. After recognizing the product profitability level it is possible to discuss what are the reasons behind this?

As stated before the current metrics are directed at measuring the success of the project, not the performance level of the NPI-process. For example, by measuring the amount of design changes during a NPI-project would tell how the current process supports design quality. Selected performance metrics should support the goal of a certain project. If the main target is to cut off the development lead time, the time to market is a needed metric. Selected performance measurements of the product should be included inside the written final report of the NPI-project. Furthermore, used metrics should be stated clearly before the project is launched. The final report should consist of basic product and project performance measurements. For example, product profitability (achieved gross profit), cost level of the product, torque density, time to market and break-even point.

Statistical measurements such as product failure rate and warranty costs provide information for life cycle management and help to point the focus towards reliability aspects of the product. Measurements like these effects on product profitability levels in the later stages of the life cycle and provide information to the engineers.

7.10. Conclusions

The updated NPI-process model makes the costs an equal metric of the project as schedule keeping and technical aspects related to the product. Cost monitoring and enhancement of cost consciousness of the decision makers will increase the probability of making better decisions. However, designing cost effective products with cost targets is an iterative process that has to be taken into consideration when the project schedule and resources are planned. The quality of preparation materials before the gate reviews is an important factor when gate decisions are made. If the quality of the preparation material is poor the gate review should be postponed until all tasks are fully completed.

Implementation of management accounting to the NPI-process starts from the early stages when new products are marketed to customers. Preliminary cost accounting gives the first estimates of the cost levels of the future products. The price levels can be determined on customer basis or by for example using target gross margin. Used cost estimates can be based on existing similar products. With brand new products, a feature based method can be used for making the cost estimates.

After the product has been marketed for a customer and an NPI-project is launched the next step is to calculate the component-level cost targets. The cost targets should originate from the sale price and from the gross profit margin target set by the company. Pre-determined product and component-level cost targets are then introduced to the project group so that the targets are understood and furthermore monitored throughout the execution. Evaluating the performance of projects enables a learning cycle and transfers lessons learned to future projects. The learning cycle and the role of management accounting during project lifecycle are illustrated in Figure 27.

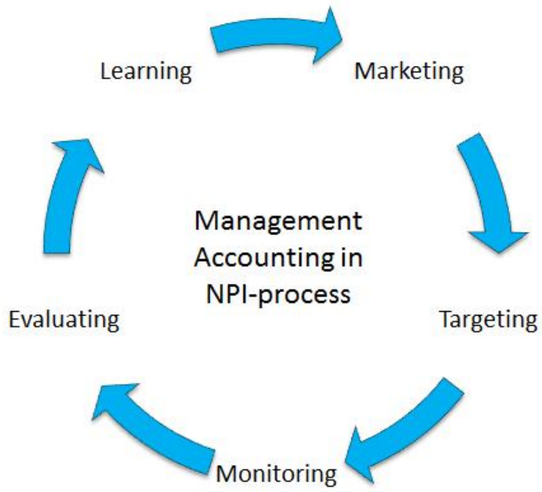

Figure 27. *NPI-process learning cycle.*

Management accounting methods provide tools that support decision-making situations. This enables the development of new products with sufficient cost levels and profit margins. One of the major reasons for implementing cost accounting to the NPI-process is to give engineers the ability to simulate cost implications of alternate product designs. Different production options and various cost activities inside the value chain generate the main challenge for the use of the model.

Monitoring the cost level of the future product should be done in the project gates. However, the iterative process to achieve a certain cost target must be done before the gates, Gate reviews are simply milestones where the current status of the project is presented to everyone and a Go or No-Go decision is made. First four gate reviews fix the majority of all product costs even though the costs are realized later on when the component manufacturing has started. Furthermore, each gate freezes a piece of the design so the possibility to affect costs decreases when the project matures. Monitoring the costs of the NPI-project ends when the product is transferred to serial production and the final report is written. The product COGS-report should be included to the final report.

Summary of gate meetings is presented below.

- Gate 1 – fixes the cost of bearings
- Gate 2 – fixes the cost of geared components
- Gate 3 – fixes the price of casted components
- Gate 4 – fixes the cost of C-parts and other components

The NPI-project is a process aimed at developing a new product for a customer. To underline this goal the four key elements of the project will be introduced (see Figure 28). These elements are the product cost level, project schedule, product quality and product functionality. From the customer point of view the same characteristics can be translated to product price, delivery time, perceived value and perceived functionality. In order to develop successful products it is required that the company listens to what customers perceive as value and design the product around that. Designing over-quality inside the product increases the price for the customer and thus all unnecessary costs should be designed out from the product.

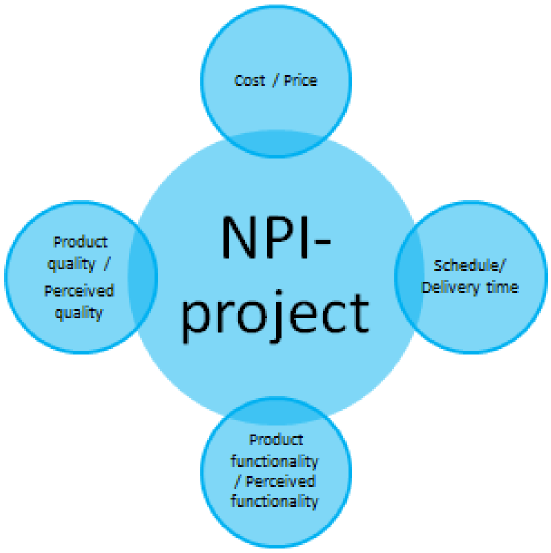

Figure 28. *Four key elements of the NPI-project.*

Although, product cost level may be an important aspect in the marketing and sales situations the focus should be on broader. Executed projects continue to generate costs even after the shipment to the customer. Moreover, the profits are also generally received after the shipment. Customers may also cause “hidden costs” that are not usually reported. For example, costs can be a consequence of introducing new loads that the customer asks to be checked or other tasks that are related to the customer and product support. For that reason when product and project profitability are studied the total costs including for example, logistic, warranty, O&M and other product life cycle costs should be taken into consideration. Furthermore, the later stages of the product life cycle should also be considered in the development phase. This is also the reason, why measuring the success of the product should be limited to the development project – measuring the product performance level requires a life cycle perspective (Suomala 2004).

Updated NPI-process underlines the meaning of overall cost awareness and cost targeting. Development engineers require at minimum rough cost estimates based on technical and quality features of the products. Project controller is the person monitoring the financial performance level of NPI-projects and supports the project group in financial matters. Cost information is required to make better decisions during the NPI-process and product costs should be discussed in every gate meetings. In general, the management accounting techniques should be an integrated part of the NPI-process developing successful and cost-effective products for the market.

8. DISCUSSION OF RESULTS

This master's thesis integrates the basic literature review on NPD practices with a benchmarking study of actual development processes used in industrial companies. Combined, they provide an overview of the most important aspects to be considered when new products are introduced to the market. As an outcome of this thesis management accounting can be implemented and used in the new product introduction process at the case company. Several academics and a wide range of literature sources support this integration of management accounting with the NPD-process (Horngren et al. 2005 and Suomala et al. 2011). Furthermore, like Sandström (2001) argues the development engineers can influence greatly on product cost levels if the cost information is available before they fix the product design. Chapter seven of this thesis provided a framework on how and where the management accounting techniques can be used throughout the NPI-process.

The updated NPI-process model will enhance the overall cost consciousness in the case company. When cost information is available it can be used for several different purposes (see for example Atkinson et al. 2004, p. 38). Furthermore, when cost accounting becomes a part of the daily work it is possible to find answers to questions such as which products are most profitable and what are the activities in the value chain that operate the most efficiently (Uusi-Rauva and Paranko, 1998, p. 2). When the company is able to answer these questions, it is the first step towards cost effective business.

The NPI-process is considered as a sub-process in Moventas. It is used for developing new products and for upgrading existing products that require significant design changes. When management accounting techniques are used from the beginning all the way to the end of product life cycle, the overall cost consciousness is increased step by step. Figure 29 illustrates the main areas where different management accounting techniques can be used. The actual NPI-process is described in the middle but there are other areas as well before and after the NPI-process. Stages prior to the NPI-process are concept design and sales & marketing. After the NPI-process products are transferred to serial production and operation & maintenance stages are stressed. By studying the later stages of product life cycle it is possible to get feedback that supports both new concept and new product introduction stages (Suomala 2004; Kumaran et al. 2001; Ansari et al. 1997; Dell' Isola 1997).

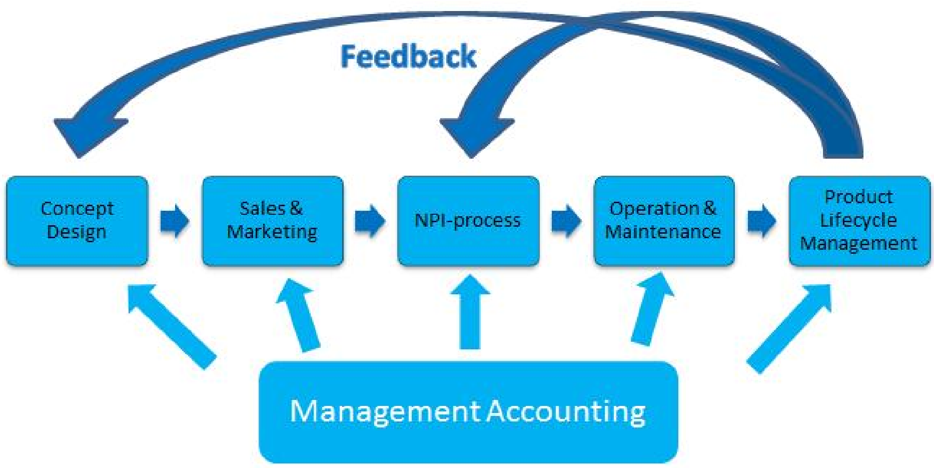

Figure 29. *The new role of the management accounting through different stages.*

Sandström (2001) argues that the design engineers are in the key role when new products are defined. Results of this thesis underline the same view since the head designer of the gear unit takes part in almost every decision-making situation throughout the development project. One goal of this thesis was to discuss how cost awareness could be increased among design engineers and what it takes to implement management accounting techniques into the current NPI-process in order to develop successful products. During this thesis, literature review and study on Moventas Gears four key elements related to the NPI-project were identified. These elements can be divided into two based on whether an internal or an external point of view is used. From the internal point of view the key elements of the NPI-project are costs, project lead time, product quality and functionality. From the customer point of view elements are price, delivery time, perceived product quality and functionality. When these four main characteristics and their both sides are kept in the mind, the starting point for designing successful products is at a much higher level than before. Even though, these characteristics are important they should not all be considered at the same time. Prioritizing the main characteristics is required to achieve optimal results. If the project schedule is tight, cost targets are most likely exceeded (see for example Cooper and Slagmulder 1997).

Furthermore, this master's thesis provides the basic knowledge on how to calculate the break-even point for a product. Secondly, how costs can be targeted and monitored during the new product introduction process in order to increase the probability of making better decisions during the project execution. Sensitivity analysis for each business case can be done by calculating different break-even scenarios. The fundamental idea of the updated model is to calculate cost estimates and the project budget before the project has been launched creating a cornerstone for the project. After the project budget and cost targets have been set the project manager needs to communicate stated financial plans to the project group. Thus, everyone involved in the project can recognize and understand the project targets.

When the actual development work begins the cost information of different design solutions needs to be discussed with the cross-functional project team in order to make trade-offs between cost, quality and functions. This outcome goes hand in hand with Nixon (1998) who argues that the collaboration between the R&D organization, manufacturing, supply chain, the customer and the financial controller is highly important. During the project life cycle a cumulative cost curve of the product will evolve and give a real-time feedback to the project group and to the management level. Moreover, when the cumulative curve is compared to the project budget everyone can see the project status in financial terms and decisions can be made based in both technical and financial information.

By implementing performance measuring and ex-post calculations to the NPI-process it is possible to evaluate past and ongoing projects and anticipate future projects. However, choosing the right metrics and the amount of metrics is a big challenge. In general, the used measurement system should be transparent and as simple as possible by nature (Brown and Souder 1997). In addition, performance measuring should be a dynamic phenomenon as Suomala (2004) points out. The ex-post calculation is the learning phase where the actual cost level is compared to the preliminary calculations and can be used to adjust preliminary assumptions in the future. Furthermore, when the actual product cost structure is attached to the project final report, level of cost consciousness is increased and also cost transparency gets enhanced throughout the organization.

This thesis was aimed at improving cost consciousness in the development process and to provide ideas on how to monitor the product cost structure during the design process. The scope of this study was limited to the NPI-process, used for designing new products. Costs generated after the development process were left out for further studies. This thesis can be considered as the starting point for studying product life cycle management. In addition, this master's thesis can be used as a workbook for training development engineers in cost and performance measuring of the new product development process.

During this thesis actions have been made in the case company especially in cost allocation topics. For example, a work number for quotation purposes has been opened. The work number enables the communication to management level on how much development engineers participate on sales support activities. Furthermore, it reduces the R&D overhead costs when the hours used for sales support are allocated correctly. This was the first step towards more accurate cost allocation. In addition, one development group is discussing how different types of project costs can be allocated more accurately for in a certain project. When the reporting systems enable allocation of project costs in a sufficient level, the project and product cost monitoring will take the next step.

9. CONCLUSIONS

The global wind market is facing interesting times because of the moderate growth expectations. Emerging regions and offshore wind are one of the few drivers that will shape the future of the industry. Achieving grid parity in the mid-term basis is urgent when the wind industry is competing with other forms of power generation. Furthermore, it is required that all value chain members work together in a close co-operation in order to lower the cost of wind energy.

The big questions of this thesis were; how management accounting techniques can support and produce relevant information for the NPI-process decision-making situations? Secondly, to discuss where product costs originate from and how they should be monitored during the development process. The work started by studying literature theories of management accounting and project management. All the theories underlined the importance of monitoring pre-set targets throughout the development project. Theories also pointed out the meaning of up-front homework before launching the project. In addition, investments in research and development activities are crucial when maintaining competiveness and aiming for growth in sales.

The development process is the most crucial phase of the product life cycle where costs and product profitability should be managed. Often the design and development engineers tend to pay attention to product reliability and performance level, but not to the costs. For this purpose management accounting techniques should be implemented to the current NPI-process in order to develop future products with acceptable cost levels. Methods such as target costing and value analysis can be used for achieving this goal.

One target of this thesis was to address the relationship between management accounting and new product introduction process. This study underlines some challenges that typically occur in project management when management accounting techniques are implemented into the development process. It is also demonstrated how management accounting information and cost awareness can be used in designing future products. The benchmarking study pointed out good lessons learned by other companies. For a company it is important to recognize profitable and unprofitable customers and understand the reason behind that. Overall, it can be said that profits are managed by understanding customers and products.

During this thesis the main factors driving the costs of a wind turbine gear unit were recognized. Furthermore, a systematic framework presented in chapter 7 has been introduced in order to manage and monitor costs throughout the NPI-process. The new product introduction process itself has basically remained the same. However, the role of the financial controller has been highlighted in an attempt to bring more cost discipline to the project execution. The key idea in the updated NPI-process is to discuss costs that are related to the project and product before fixing anything. By setting pre-set targets for the project and communicating these targets to the project organization enables project performance measuring. Targets should originate from the strategic goals of the company and the whole project organization should understand the targets that are set for a certain project. Although, the cost targets are a highly important aspect of any development project, the costs cannot be the one and only driver. Innovation levels may suffer if everything new and more expensive is forbidden. Most essential for the R&D organization is to hear and understand the voice of the customer.

In adaption of management accounting techniques to the product development stages and in sharing the cost information to the design engineers, it should be kept in mind that the engineers are interested in costs that the individual can influence whereas the company is interested of the total costs of the product. Minimizing the product total costs is one of the most important topics of the development engineer to take care of. However, engineers cannot do this without proper cost information and targets. Only when the cost consciousness of the design and development engineers is on a sufficient level, can they make decisions that lower the cost structure of products.

First step towards overall cost consciousness is to learn and know products and the related manufacturing processes required for making the gear units. From the cost perspective it is important to focus on where the material costs originate from and what is the level of in-house production. All variable costs require more accurate estimations than overhead costs. This is because cross margin of sales is one of the most important factors when a company is suffering from overcapacity. Allocating overhead costs is always more or less a political decision. The products themselves do not cause the overcapacity so why should the product profitability suffer?

When enhancing the level of cost awareness in development organizations the second step is to discuss which design decisions influence the majority of occurring product costs. However, the focus should not exclusively be in the product costs. Other costs such as distribution, O&M, warranty and life cycle cost should be discussed as well. To sum up it all following aspects should be considered during the development process:

- Voice of the customer
    - What customer actually wants and needs?
    - What is the product scope?

- Design and manufacturing process
    - Which decisions influence majority of the product costs?
        - In which stage of the process are these decisions made?
        - Who or what group makes these decisions?
        - How the decisions influence later stages of the product life cycle?
    - Challenging the traditionally ways.
- Target setting
    - Use targets and different scenarios throughout the development phase and learn from ex-post calculations
        - Communicate clearly what is the specific business target.
        - Favor simple and standard solutions.
        - Improve general level of the R&D cost consciousness.
    - Manage supply chain by using cost targets
- Transparent environment
    - Create transparent environment that supports trade-offs between functionality, quality and costs.
    - Gather information from internal and external reference groups.
- Product life cycle
    - Discuss how different phases of the life cycle influence on the development phase.
    - Define where the majority of O&M and warranty costs derives from.

Product time-to-market is usually considered as more important than development and product costs. This is usually the main reason why products are not developed with sufficient cost levels and cost reduction projects are required later on. For this reason implementing management accounting techniques to the development process is a challenging task that requires good product and production knowledge. Cost information that the design engineers usually need already exists inside the company. However, the information is fragmented inside different organizations and systems resulting easily to a complex calculation system.

This master's thesis was limited on improving the existing new product introduction process and the purpose of this study was not to improve the accuracy level of the product costing or cost accounting principles used in the case company. Also, the total life cycle costs of the developed products were left outside of this study. In the future, work should continue around themes such as product life cycle management and life cycle costing. Both of them would support the development process and increase the overall level of cost consciousness. It would also be interesting to investigate which components generate most of the warranty and O&M costs, and how expensive the product components originally are.

The fundamental idea of this thesis was to start the conversation of costs related to products and to development projects by implementing management accounting techniques to the NPI-process. Furthermore, the updated process model is a starting point for improving the level of cost consciousness step by step towards product life cycle costing. I hope that this study will encourage the people working in the development activities to study how they can develop products not only from the technical point of view but also how to create successful products measured in financial terms as well.

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APPENDIX 1: COST STRUCTURE OF THE GEAR UNIT

Appendix is removed from public version.

APPENDIX 2: THE QUESTIONNAIRE USED IN THE SURVEY (in Finnish)

Kysymykset

1. Kuinka monta henkeä yrityksenne työllistää?
2. Mikä oli yrityksenne liikevaihto vuonna 2012?
3. Monessako maassa yrityksellänne on liiketoimintaa?
4. Mikä oli vuonna 2012 tuotekehityksen kustannusten osuus yrityksenne liikevaihdosta (%-osuus)
5. Onko tuotekehitysprosessi vaiheistettu tiettyihin osiin? (esim. Stage-gate)
   a. Jos on, niin montako porttia / milestonea tuotekehitysprosessissa on?
   b. Mitkä ovat kunkin vaiheen sisältö lyhyesti?
6. Mikä laukaisee tuotekehitysprojektin?
   a. Asiakas
   b. Havaittu mahdollisuus
   c. Joku muu, mikä?
7. Kuka hyväksyy uuden tuotekehitysprojektin aloituksen ja mitä sen hyväksyminen vaatii?
8. Minkä kokoinen tuotekehitysprojektin projektiryhmä yleensä on?
   a. Ketä siihen kuuluu?
9. Kuinka pitkä prosessi tuotekehitysprojekti on? (esim. 6 kk, 12 kk)
10. Kuinka usein projektiryhmällä on katselmus?
    a. Mitä projektipalavereissa yleensä käydään läpi? (aikataulu, sitoutuneet kustannukset, haasteet jne.)
11. Milloin ja kuinka tuotekehitysprojekti päätetään?
    a. Verrataanko saavutettuja tuloksia ennalta asetettuihin tavoitteisiin?
    b. Tehdäänkö “lessons learned” tyylinen yhteenveto?
12. Kuinka pitkä elinkaari tuotteillanne on?
13. Kuinka tuotekehitysprojektin kustannuksia seurataan läpi prosessin?
14. Kuka vastaa kehitettävän tuotteen kustannusten hallinnasta? (esim. projektipäällikkö)
15. Onko tuotekehitysprojekteissa erikseen nimettynä kontrolleri, joka vastaa kustannusten seuraamisesta
    a. mikä on hänen roolinsa läpi projektin?
16. Kuinka suunnittelija saa kustannustietoa tuotekehitysprojektin aikana?
17. Mitä laskentatoimen haasteita olette kohdanneet tuotekehitysprojektin aikana?
18. Mitä laskentatoimen työkaluja tuotekehitysprojekteissanne käytetään?
    a. Projektibudjetointi / ennakkolaskenta
    b. Kustannusseuranta
    c. Jälkilaskenta

    d. Ennalta määritetyt kustannustavoitteet
    e. Tuotteen kustannusarvio
    f. Tuotteen hinta-arvio
    g. Tuotteen elinkaarikustannusten arviointi
    h. Target costing
    i. Value analysis / Value engineering
    j. Jotain muita, mitä?

19. Mikä on laskentatoimen rooli tuotekehitysprojekteissa?
    a. Tuottaa erilaisia skenaarioita projektihallinnan tueksi
    b. Edistää oppimista (projektinhallinnasta, kustannuksista, kannattavuudesta)
    c. Tukea projektien valintaa
    d. Tukea tuote portfolion johtamisesta
    e. Joku muu, mikä?
20. Miten tuotekehitysprojektin onnistumista mitataan?
    a. Mitkä ovat käytössänne olevat tuotekehityksen mittarit?
    b. Mikä on kunkin mittarin käyttötarkoitus?
    c. Mitä mieltä olet käytössä olevista mittareista?
        i. Tukevatko ne hyvin tuotekehityksen johtamista
        ii. Mittaavatko ne todella haluttua ilmiötä
        iii. Ovatko mittarit luotettavia
    d. Käytetäänkö mittareita kannustin ja/ tai palkitsemistarkoitukseen?