



Support for Designing Resource Efficient and Effective Solutions: Current Use and Requirements by Swedish Industry

– Report from “Product and Service Design Support for REES”
Project of Mistra REES program

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1 Foreword

This document reports on the results of work packages (WPs) 2.1 and 2.2 in Project 2 (Product and Service Design Support for REES, i.e. resource efficient and effective solutions) of the Mistra REES program (www.mistrarees.se). WP 2.1 and WP 2.2 aim at documenting current use of design support and deriving requirements for design support, respectively. The document only covers results from interviews with companies, while the other reports will cover results, for instance, from scientific literature review (ISRN: LIU-IEI-RR--17/00264—SE) and the design session with industry partners in the Mistra REES consortium. The results of this research into industrial practice will be a foundation for WP 2.3, which aims at developing new design support for designers.

The document describes current use (i.e., “as-is” status) of product and service design support when designing REES, as well as requirements for product and service design support for REES (i.e., information soon-to-be). Both of these are results of analysis in different phases of an early phase of design for REES. Those phases consist of requirement specification, conceptual design, and analysis and evaluation, which can be ordered temporally along the design process.

Eight Sweden-based companies that provide products and services in different sectors and work on resource efficiency participated in the interviews. They vary in terms of the size: from small to large. 24 individual interviews were conducted in total with the length being between 54 and 117 minutes (with two additional shorter follow up interviews via phone/skype). The 24 interviews were carried out all with face to face between May and July, 2016. The result from each company is described per section in this report, while cross-company analysis will be made in a separate document.

2 Company A

2.1 Identified current use

This section includes how the development process currently works.

2.1.1 Entire early stage

Projects at Company A can either be based on developing a *value stream* or a *knowledge stream*. Here product development is based on the value stream and technology development is based on the knowledge stream. The technology development has a focus on increasing technologies maturity and product development has more focus on realisation and integration of the developed technology. Projects can be of different size and scope but all of them are based on the *same process*. The process includes several *gates* where the status of the projects is controlled. The development is *feature-oriented* features (e.g. environment, emissions, fuel efficiency, maintainability).

To define the long term strategy the product-planning group who try to estimate what the customer wants and need. It is their responsibility together with property feature leaders to interpret and be the voice of the customer. Other actors e.g. society can also be considered as a customer as one interviewee also mentioned. In the ordering phase targets from the product-planning group are used as main requirements that set the base for the project. As one interviewee expressed, the project is *requirement driven* development. This means that conceptual design is done in parallel to the development of the requirements to find the best trade-offs.

Each project team is cross-functional and that differs in size depending on the project. The project leader is responsible for communication between the involved members. Communications is mainly aided orally in meetings or written in e.g. documentation in reports, templates or emails. More or less everyone in the project is included in all activities in the development, which has both pros and cons.

Early design phases are the most important since there is the highest ability to influence and therefore it is also important to avoid late ideas in order to avoid *costly late changes*. As several interviewees highlights it is important to do the right thing from the beginning.

Several interviewees mention the fact that numerous changes have been implemented during the last few years in the organisation and it is hard to change things where stability is missing. They need to have patience and be consistent.

Education is provided both internally and externally for e.g. changes and new implementations some are mandatory and others optional. There is also a possibility to shadow a person of interest to get a better insight of what that role works. Mentorship is also an available option to develop personal skills. One interviewee also motioned a knowledge-sharing seminar to increase the knowledge about exchange between differed departments in the company. Another interviewee mentioned, "*Speed dating*" between *designers and feature leaders* to get a better understanding between the two roles, and how to fulfil the affected feature in the designers design. There is also a possibility to invite so-called *facilitators* who are experts to participate when methods are used.

Exchange is the commercial term used for taking care of worn parts and providing spare-parts in the aftermarket, and remanufacturing is one way to solve it. *Logistics and coordination* is key for exchange transactions when sending parts all over the world.

2.1.2 Requirement specification

The product-planning group *translates company strategy into* targets and these goals *set the scene* for requirements in the product development. Lessons learned from earlier projects is used as input to new projects. Other sources can also be e.g. EU's barometer based on society's attitude towards the environment and what will be the most important environmental issue in the future. targets are written by the product-planning group following a template for that includes the targets are handed to the project as a starting point. Having the right targets is one of the most important things in the development process in order to do the

right thing from the beginning in the development process. Here understanding the underlying issue of a need is key, e.g. why is a new legislative demand set and what it will imply in the product? Project targets are always unique for the projects.

A requirement manager processes the targets are **broken down** into measurable requirements in the levels of the entire car, systems, subsystems (can be several layers) and components. The requirements specification is documented. Requirement breakdown has a **specific work process** that should be applied. **Verification** is also planned in the requirements specification, and needs to be considered in the requirement settings. Some requirements can be hard to break down and verify as component since it has a higher importance on system level, e.g. noise.

Balancing between requirements is done in parallel to conceptual design depending on what solutions are developed, the concept maturity and how much knowledge exists. It sets as an agreement between subcontractors and the company in the later phases of the project. Prioritization is made after the aim and purpose of the project. Requirements that are closely related to the customer e.g. safety are always prioritized. Between environmental requirements, it is therefore more thankful to work with e.g. fuel economy over material issues.

The company have blacklisted materials that are not allowed to use in the products. Internal requirements are often set higher than what is demanded by the society in order to stay competitive and preventive of future possible laws, etc. Society set the frame for what solutions can be developed; governmental politics can affect both lead-time and set other limitations. Looking at aftermarket aspect, these need to be able to influence from the earliest phases and set requirements.

2.1.3 Conceptual design

Several different actors are active in the conceptual design e.g. **designers, production, after market, product planning and purchasing**. It is the designers' responsibility to find solutions that work. This role is stated as one of the most important roles in the entire project since this is where everything needs to come together. The designer needs to match requirements on functions, design interfaces and several different properties. The designer can set up a meeting with e.g. the **feature leader** to discuss ideas or get a greater insight on the requirements. The designer who is responsible to realise the requirements confirms that a given requirement can be fulfilled and the one who has set the requirement in turn confirms that the requirement has been met.

Some different approaches e.g. **design for remanufacturing** and **design for assembly** is used in the product development. In design for remanufacturing, properties include that the components has to be able to be taken apart, have sufficient grinding material, etc. It is also important to put markings on recyclable material.

In the realisation of designs both **CAD and other software** are used. Both **virtual and physical concepts** are developed during the process, depending on what is to be developed. Clinics are sometimes used to investigate the **customers experience** when physical prototypes are developed. About 3-4 different solutions are desired and all developed concepts have to fulfil the requirements and when the trade-offs cannot be met.

2.1.4 Analysis and evaluation

Some mentioned methods used during analysis and evaluation is: **FMEA, LCA** (hard to apply in conceptual design when not so much information is available), **Pugh-matrix**, but anything from specific calculations to engineering judgement is used. One of the positive features of the Pugh-matrix is that it is a good way to document decisions and arguments.

There is always a **balancing between time and economy** what concept is suitable to develop. One danger that is stated is that it is to choose the easiest concept instead of the best.

Sometimes customer clinics are put together when physical products or prototypes exist, and can help in the evaluation process. One thing to keep in mind though is that different customer markets have different needs and wishes.

Several interviewees highlight that it is hard to evaluate all environmental aspects and therefore *material is mainly focused at the moment*. Materials are easy to relate to and can be defined as a list on what materials are appropriate to have in the product or not.

To handle uncertainties and risks a *steering committee* exist where severe uncertainties can be lifted and discussed. Risk analysis is used to identify possible risks in the project. Another issue is that different features might get down prioritized due to uncertainties. One issue that is mentioned by an interviewee is that it is *hard to verify requirements* e.g. materials when it is depending on the supplier and the supplier is not yet determined in early stages.

2.2 Derived requirements

This section describes identified needs in order to develop more resource efficient and effective solutions.

2.2.1 Entire early stage

Several interviewees emphasize the importance to do the right thing from the beginning. They therefore also desired *more resources in early phases* to define the right project and not missing important aspects. risk that a pressured actors get a tunnel vision and only focusing on its own task, and therefore reducing communication and also missing out the holistic view. In pressured situations involved actors might to haste through the process.

Important is to take the time to do all expected activities so nothing is neglected. In addition, important is to spend time on using the methods right and documentation of results so nothing is missed. It is mentioned that the methods are used and applied inconsistently, everyone wants to do their best but they might not do it the same way. People might to *change their role* within the company and the hand-over process might to lose a lot of knowledge.

Methods need to be *easy to use*, it can be a *complex tool but the interface towards the user has to be easy to understand*. A good method should *bring people together* and *create engagement*. It can be perceived as an administrative burden to use methods that the practitioners are not well experienced in. Results from the methods need to be *clear, understandable, and based on facts*. If a method's result differs depending on how it is applied, it can lead to internal political issues.

One interviewee states that the standardised process itself is not as important as the *actors* and how they interact within the process. There is a risk in this that competent employees, so the process needs to *support creativity and knowledge development* as well.

The set requirement list from aftermarket does get some feedback from project leaders who would prefer to get more project specific information. The argument is that with *too much information*, it can be hard to see the forest through the trees.

One interviewee emphasise that there exists a need for acceptance in the company to move toward (natural) resource efficient and effectiveness. It is hard to motivate environmental issues "it's like asking someone to quit smoking today since they might get cancer in fifty years".

2.2.2 Requirement specification

One issue stated is that it is not always easy to know and translate what the customers want. Another interviewee suggested to include what the product should not be or do, for the designer to get a better understanding of the customer needs. Setting upper and lower limit on the requirement is also a good thing to leave some design freedom to the designer. One interviewee stated a need for good computer systems that easier can get a starting document for the requirements. This software should facilitate to put in and extract relevant requirements. One interviewee compared the traditional product development with *software development* that is more agile and saw potentials in learning more from that division.

Strategy and requirements seem to be the only way to influence how resource efficient and effective a developed solution should be. One has to be aware that the break down of requirements from entire car down to component does not ensure that requirements set for the entire car is fulfilled only because the components requirements are fulfilled. Sustainable development can sometimes be considered even though it might not be specified in the requirements specification, but in these cases it is up to strong minds of the involved actors. One interviewee states that the company always should strive to make a better product no matter if it is specified or not. At one interview it was discussed that the requirements should be set according to risk analysis, and be set in a way to lower risks in the project.

One risk with requirements is that if they are hard to understand and apply they easily get avoided so it is important to build a **knowledge base** so all involved can understand. As one interviewee raised the question on: How well does a requirement need to be described? There is also a risk that requirements that are not “cool” might get a lower prioritization.

2.2.3 Conceptual design

Some interviewees see that there exists a need for a better understanding on what to consider in the conceptual design. This is why the designer is stated to need more support. One example is how choices about e.g. materials or production processes highly influence the development of more resource efficient and effective solutions. In the current development there exists **clinics for customers** to try physical products or prototypes and it should be interesting to have a similar approach for sustainability questions. Methods can also enable the designer to compare with earlier versions of the product and secure that certain properties are better fulfilled. In order to secure the sustainability aspects are considered throughout the development, each involved actor needs to have knowledge about how environmental aspects affect their work.

2.2.4 Analysis and evaluation

Virtual testing is a good way to get faster (and cheaper) onto the market compared to building physical prototypes to perform tests on. It is though hard to incorporate environmental assessment within the development process when so little information is available. One interviewee mentioned that missing is a role that actively works with environmental parameters the same way as it is worked with quality parameters.

There is a stated need to support the designer to **evaluate and make decisions** about sustainability in the development process e.g. choose an appropriate material. Durability can also be seen as an important environmental criterion, if it lasts longer less need for new products. The V-model that is currently used for verification of requirements should be more like a T in order to work up and down in the system levels and get a better holistic perspective.

2.3 Discussion

One thing that is highly important for the company currently is **cohesiveness and consistency**. In order to incorporate a more resource efficient and effective perspective of the development process it has to be adaptable and simple.

The development process seems to be highly depending on the requirements for the product. Therefore, there is a possible solution to work with adapting requirements to work better for the rest of the development process as well as other identified opportunities in the other phases.

3 Company B

3.1 Identified current used

This section includes how the development process currently works.

3.1.1 Entire early stage

Product planning group that works with strategically choices for the product portfolio. This group represents market needs and customer opinions. They write a product guide as a starting document and order for R&D to develop. Development of new products can either be as a new product or a new technology that is later implemented and integrated in new product development. *Economic, law or other legal drivers* are most likely to prioritize what projects are started. Benchmarking competitors and other markets of interest (e.g. clothing industry for forecasting news on textiles) is another way to identify areas in need of improvement. Starting with the product guide, a conceptual study with only a few persons is engaged that determine into more detail of what the project is supposed to deliver. After this, an actual development project starts.

From 2014, a sustainability board was initiated that has a general responsibility for sustainability issues. There are several different drivers for sustainability issues but it always comes back to what the customer and other external stakeholders are asking for. "The world best window opener doesn't sell the car, it only costs money." Thanks to the company's size and well-being, it enables possibilities to develop hybrids and electric cars even though they are not the most popular on the market.

The organisation of *product development is divided into attribute areas* (e.g. environment, after market) and design domains (e.g. interior, platform) as a matrix. The *attribute leader* for each attribute is responsible to secure the functions in the design are fulfilled. A gate system is used within the development process to ensure that the offering meets expectations. Communication is mainly oral through regular meetings and formalities are documented as reports. E.g. a deviation system is used to report everything that is not going according to plan in the development process. Education and training is provided for employees when necessary.

3.1.2 Requirement specification

Product planning makes in the *product guide* a description of what coming products are supposed to fulfil, what the *most important* properties are but can also specify what it *should not focus on*, which is perceived as a good way to help prioritising base requirements. Here primary customers and markets are defined. Specially *assigned roles* for each property work with deriving the requirements from the product guide as a starting point and breaking them down to the different design packages. Requirements are set at a complete vehicle, subsystem and component level. There are specific roles assigned to work with balancing requirements between the different properties. When the designer receives there addressed requirements for its specific design domain the designer has to do a sign off as a confirmation that it's understood what the requirement implies and most possibly can fulfil it.

Verification process for each individual requirement on different levels is also included in the specification. Specific e.g. hazardous or scarce materials are listed on a so-called blacklist that is not allowed be used in the vehicles. Requirements are set in the beginning of a project but are worked with as a living document during the entire development process, but in agreements with suppliers a technical regulation is set as a part of the business deal. Prioritizations of requirements are based on many aspects, where strategic alignment is overriding most others. One issue identified is the more *knowledge and information* a requirement is based on, it gets *higher prioritisation* compared to requirements with a lower information basis. Prioritization also highly depends on *how well the attribute leader argues* for the requirements he or she is responsible for. Few requirements with rather low prioritization on remanufacturing are set as a part of the after sales attribute. Requirements for different offerings are compared with each other so that they fit into a hierarchy of performance, e.g. a small car should have less environmental impact than a big one.

Time is an important aspect to bear in mind when setting requirements and keeping up to competitors. Does this requirement have to be fulfilled now or can it be waited for until next vehicle generation? It's not

enough to see what the customer needs today but it has to be forecasted what the customer needs in 5-7 years is an estimated lead time from conceptual idea to end customer delivery.

3.1.3 Conceptual design

R&D is responsible for realisation of a *product guide*, where the *main track for concept* is more or less set. Communication between a designer and a requirement setter is commonly to understand what individual requirements mean and imply. The development is primarily virtual and with less and less physical models. When including decoupled technology projects the design phase is not so much about new development but rather implementation and integration of the technology with today's interface. The vehicle is divided into different domains with interfaces where different teams are responsible for the individual domains. In the designing process, the designer starts with assessing the requirements that is easy to understand and common for the designer. More difficult requirements are added and assessed later on in the process. Investments and new technologies might influence what types of solutions are preferable. For remanufacturing, there is currently a lower priority of integration in the development process. The process for identifying remanufacturing opportunities today consists of that the remanufacturing group sits down and go through fairly far in the development and analyse which parts could be of interest to remanufacture, and *not by being included early in the process* demanding some part to be possible for remanufacturing. Reference panels are used to get customer feedback and evaluate qualitative aspects of the product.

Employees can also be used to role-play the customers and think about what the customer wants. Hard to interpret what the customer actually wants. All customers who buy a newly fabricated product get to participate in a customer survey about their product. *Customer contact is often used in late stages* of the development where physical prototypes can be shown and tested, but input can be used for upcoming projects.

One example of a resource efficient and effective design today is that the AC system in the hybrid car is used both for cooling the inside of the car as well as for the batteries.

3.1.4 Analysis and evaluation

Each project has a budget and can only afford to do some things; the performance of the concept therefore has to be evaluated thereafter. How well a concept fulfils a requirement is put against its *cost*. Is it worth to deviate from the requirements in order to save some money? Earlier there was an *environmental FMEA* but it didn't work well enough to be used continuously. The actual document that was worked with and the *results did not give anything of value* to the development, but it did though provide value with a *good dialog* through structural discussions. The value generated by remanufacturing has no defined process in effecting future product requirements.

Early test e.g. simulations and calculations, how reliable are they? One interviewee states, it is rarely the calculations them selves that are weak it is more often the numbers and *information used in the calculations that is lacking or are uncertain*. Verification is done in several steps to be able to feel secure and minimize risks. Verification process starts with an engineering assessment, is this reasonable? Continuing with calculation models and simulations against earlier generations of vehicles. Finally physical testing is done. *Confidence levels* are used as an indicator for how well a virtual test stand against a physical test. The V-model is used for verification of requirements, but can be hard to fulfil at times where *subsystems highly depend on other subsystems* performance. For some components the supplier perform the verification.

Each attribute has an index that is used to evaluate if each property fulfils its role in the development project. This index is a quantifiable number (1-10) based on qualitative assessments how a property is fulfilling the requirements. Deviation from requirements lowers the number and can therefore show how well each attribute is performing in the development. This way it is used as a reporting system to managers at so called attribute status review meetings.

3.2 Derived requirements

This section describes identified needs in order to develop more resource efficient end effective solutions.

3.2.1 Requirement specification

To make the offerings more resource efficient and effective, it is required that it be stated in the product guide from the product-planning group. Environmental properties are today down prioritized in the development due to that it is **not included in the guide**. More requirements on a generic level is desired but it should then be customized how it is applied in the individual projects. Several interviewees highlight the need for **core values** (e.g. durability or cost) in order to work against the same goal.

Carbon dioxide is not the only important environmental aspect to focus on since it has become a natural part of everyday work. It is time to focus on other aspects e.g. material resources. This also implies a need for metrics on how to measure and compare different environmental aspects against each other. There is a need to include manufacturing, marketing, sales, aftermarket and service since these possess **key competence** about how some investments in the long run can be beneficial. An improvement suggestion in connection to this could be involving manufacturing staffs to look at how to make requirements to minimize spillage when manufacturing. Material choices are also difficult to set requirements for, since these only can be set as functional requirements for the material properties and not on preferred materials and such.

Requirements should not be set as **a point** in a space but rather as an optimization plot to give the designer a more understandable **solution space**. **Connection between need and the actual requirement** is an important part of the requirements but understanding that is not sufficient today. There is missing traceability to see how a requirement affects the final customer. The requirement system that is worked with today is perceived as good in theory but rather **workload heavy** in practice.

Decoupled projects for e.g. new technologies require a higher level of understanding of the offering requirements and what types of conflicts can occur when integrating these solutions in a product development project.

3.2.2 Conceptual design

Many times too few actors are involved in the development process due to **cost** limitations and other prioritizations. Preferably all design domains and properties should meet and talk to each other. It is necessary that resource efficiency and effectiveness is an obvious part of the development process for each individual designer in order to move toward that goal.

Time is one of the biggest challenges in the development process; when do you get the time to find a perfect solution? **Modularity** is used as a suggestion on moving toward resource efficiency and effectiveness, where then more focus on few good solutions that can be reused is possible. Sub optimization of environmental performance is though a risk when the main objective is not clear on environmental performance. Interfaces between different design domains are raised as one of the trickiest things to handle in the development process and how **trade-offs** between are managed.

Recycled materials are hard to incorporate in the design because the material supply needs to be secured before manufacturing begins. This implies material for the entire manufacturing period of the vehicle and for spare parts after the manufacturing as well.

Design for recycling has been on the table but without success. Due to how the recycling process currently is working, there are no economic incitements for the company to design components for better recycling. The recycling company did not have a process that was adapted for how the product was designed for recycling either.

3.2.3 Analysis and evaluation

Several times there are only one solution to evaluate which make the decision making process harder to assess if it performing excellent or just good enough. Quantitative values are easier to assess but qualitative ones are also important as a complement. Physical testing is too time demanding and can't be performed early enough in the project in order to make design changes after the test.

In order to achieve more resource efficient and effective solutions, there is a need to be able for **assessing environmental performance**. Energy consumption is used as a suggestion on what could be able to be used

as a measurement. It can be translated into fuel economy and therefore *customer benefits* can be easily shown, which in turn also can give an indication on driving distance and thereafter be *translated into vehicle properties* e.g. weight and type of power. There is a need to *give environmental issues a value* in order to be able to measure it against the other properties in the project. All environmental aspects need to be considered and weighted against each other. Some times it might be worth investing more money into environmental issues and it does not always have to be free. E.g. electric cars can even bring a higher value to the vehicle, in the same way an automatic car is more expensive than a manual car. Life cycle management and sustainability reports how well the vehicles perform today and what key issues need to be addressed are mentioned as ways of improving how to make awareness on environmental issues internally.

Lifecycle assessment is mentioned as an evaluation method but limited internal competence seems to be available to perform them. Collaboration with universities solves this issue at the time but the interviewees see a *need to have this knowledge internally* at the company. Remanufacturing is something that could enable resource efficiency and effectiveness in a sustainable way for the company if the *economic benefits could be demonstrated*.

3.3 Discussion

The strategic direction towards resource efficiency is set in the decided environmental strategy. Stakeholder dialogue is constantly on going and strategic updates are made on regular basis.

Customer satisfaction is the foundation for the entire development process where activities only exist to fulfil this as good as possible. *Developing with a clear aim* is the one thing all interviewees mention as a success factor.

4 Company C

4.1 Identified current use

4.1.1 Entire early stage

Company C is a relatively small company, which enables the actors within the product development process to communicate for example ideas and concepts more frequently and face-to-face, than in larger companies where actors are not always located close to each other. This helps to make *the decision-making process short*.

Respondents state that information does not always follow a linear way and can go in different directions in the product development process. Information can therefore go "backwards" in a product development process, meaning that designers have to go back to earlier phases of the process when new information is received. Early on, in the product development, designers want information from the purchase department and from construction, of existing problems. At the same time, in order to be able to make the right orders, the purchase department depend on e.g. that documentations have been made correctly regarding materials and parts that are needed to assemble the products. The assemblers are dependent on the fact that the parts to be assembled are available, i.e. that purchase department have ordered right parts. The assemblers require information from the designers of how things should be assembled. Installation instructions need to be handled between production and the product development department.

Not many methods or tools are used during the development process, but one example of methods mentioned by respondents *being used is FMEA*. This method is used to treat requirements in an early stage, and in addition, Company C uses CE-labelling. To make sure too meet the standards of the labelling, Company C performs risk analysis. Company C uses PULSE meetings as a way to communicate information within the company.

Company C consider themselves to be an environmentally friendly company. By looking to the energy consumption of their products, and having a manual for the materials to be separated and recycled at the end of life. The company also focus on high quality that can be seen as an environmental aspect since products of high quality usually lasts longer, which affect what requirements that are set for the products.

The first step in Company C's product development process starts with idea identification. The idea could either be of an identified or unfulfilled need or simply a new idea for a product. The idea petitioner, that raises an issue, a need or a wish of solutions, can be anyone internal or an external actor. External actors can be a customer that has improvement requirements, suggestions and wishes, but can also come from new standards and legislations. The identification of requirements can come from performed market surveys. Internal requirements are often based on finance, but they might also come from the internal stock department, the department of installation, and purchase department. Specific requirements for the products include, the CE-labelling for the European market, and UL-labelling required for the US market. Other important requirements are work environment requirements, such as vibration and noise of the machine, and requirements about all the materials in the product.

The product development process of the designers starts with individual work, to think of solutions of brought up improvement requirements, raised problems and wishes, which continues to discussions of in smaller groups. Company C *don't have a method to help document new ideas*. The ideas of improvement are discussed in the Product Board, they decide whether the idea is good enough to be taken further, or not.

4.1.2 Requirements specification

If the idea is taken further, the *Product Board request a requirements specification* as a basis for what the product must achieve. The marketing department determine the requirements and the product manager is responsible of compiling the requirements specification by using Microsoft Word (no tool or specific method is used). The requirements specification is also used as a checklist to secure that all requirements are met. When compiling the requirements specification there is a lot of *focus placed on market requirements*,

specific functional requirements and effects of the product. Legal requirements are always considered and followed.

The requirements vary widely depending on the product. A product family may have different requirements specification either related to that a product should have a high technical standard, and then the costs will be higher, while another may have a requirement to be cheap, resulting in a lower technical standard.

4.1.3 Conceptual design

No specific design method is used during the conceptual design. The product development department uses the requirements specification as a foundation for the design of the product. According to respondents the requirements specification is communicated within meetings with concerned actors, which are not further specified. Respondents state that it is the project manager's responsibility to ensure that all actors included in the product development process receive important information for them to be able to do their part of the development.

The product development department works in groups to develop potential concepts, usually focusing on the volume of a product, with features that responds to the requirements specification. They make a ***pilot study (with mock-ups)*** of a concept and present its result to the Product Board, who decides whether the concept will be further developed or not. If the concept is taken further, the product development department continues by creating a prototype of the finalized concept. The prototype is presented to the Product Board that takes a decision whether to produce a pre-series with a limited number of products, or not.

4.1.4 Analysis and evaluation

According to Company C, the outcome of a product development process is successful, if the product works as intended, and if the product sells well on the market. Company C has an analysis and evaluation phase, where they test vibration and noise etc. of the product over a long period of time. The ***test phase is their way to analyse and evaluate the result of a product concept.*** Respondents consider awareness of risks as the most important, when it comes to evaluate the finalized concept. Depending on the size of the risk, the product manager sometimes needs to take unanimous decision of how to reduce the risks.

Due to that Company C follows different kind of certifications, such as CE-labelling for the European market and UL-labelling for the US market, they analyse and evaluate so that they comply with all of these certification requirements.

4.2 Derived requirements

4.2.1 Entire early stage

Company C have a standardised product development process, but respondents state that it is not followed in daily work. Respondents points out that, either the company have to start following the existing one, or look into if it needs to be modified, in order to enable them to follow it, in daily work. Another improvement possibility that was raised was to have a Product Plan that extend a few years into the future, to increase the ability to plan ahead.

Some respondents stressed the necessity of inclusion of all actors in need of information early in the product development process. The communication could be improved between some important actors, such as marketing and the product development department. The respondents stated that ***customers, and the department of maintenance, and aftermarket should be included in an early stage,*** this in order to get in required information as early as possible in the process. In order to improve maintenance and thereby increase resource efficiency, maintenance and aftermarket departments must be involved from the beginning, included in the Product Board and within the conceptual design phase.

Respondents stressed that Company C should look more into, e.g. what material to use in order to reduce weight. If there were better regulations of how to recycle or who is obliged to do it for their products,

Company C might take more responsibility. The *responsibility of recycling a product is placed on the customers*, but Company C as a provider could provide a system for taking back the product to recycle materials and/or reuse components that are not worn out. It would be possible to create higher value for Company C as a provider by reusing components.

The *communication could be improved by including all actors* that are involved in the product development process, since some respondents thought many being left out. Today, the production can end up getting tasks that they have never heard of before, as for maintenance department who can get updates to a product they have never seen before.

Respondents state that a method would be of use to better structure different tasks within the conceptual design and to analyse and evaluate results.

4.2.2 Requirements specification

The requirements specification should set the basis for the product development process. If involving someone from all areas of the company, the outcome of the specification would be better. The *customers should also be involved by including the department of market and sales*. The respondents claim that *more than one person should be involved in putting together the requirements specification*, this in order to prevent that important requirements are forgotten or overlooked.

The requirements specification is defined too quickly, and without consideration of the product development department and their opinion. It is *important to inform all concerned actors* of the goals and the requirements specification, so that everyone is on the same page of what should be made before the concept generation starts.

Input data regarding requirements need to be improved. The current situation at the company often ends up in discussions about the requirements specification that could have been avoided if the input data had been correct before the development process started.

4.2.3 Conceptual design

Respondents state that the product manager, purchasing and production should be included in the conceptual design phase to a larger extent than in current state at the company. Furthermore, *respondents state that marketing and sales should be included in order to get more customer perspective*. Company C have an area of improvement in including the market's opinions, because of their tradition (family owned business that cared mostly about the production).

The demands for a method to be used during the conceptual design, are that the method needs to be *clear and simple to use, and also that the purpose of the method is clearly stated*, to avoid resistance when implementing the method at the company.

4.2.4 Analysis and evaluation

Uncertainties and risks could be further reduced by longer tests. Sometimes tests get stressed to be finished in time because of a tight schedule. Some respondents bring up that by including customers during the test phase, some uncertainties could be omitted. To make sure that the *right decisions are taken, codetermination is important* where *all actors are involved*, which is not the case today.

Customers should also be included in an early phase, to be able to test and evaluate the product concepts. This would require a clear understanding of what kind of feedback the company are looking for from the customers.

4.3 Discussion

Company C is a company with high awareness of the impact on the environment. However, they lean back on that the use of their products does not have a large environmental impact. This shows improvement potential in *evaluating and working more towards environmentally friendly* products. Respondents also felt that looking to more environmentally friendly solutions to their products could be an improvement

opportunity for the company, which is positive since a change requires that employees are committed or at least not opponents to the change.

The ***development process is only focused, by the respondents, on product selling*** and there where never any discussions of selling a solution instead of a product. An implementation of solution based selling could potentially improve environmental awareness, as it opens up to new solutions such as take back, and reuse of components and products.

A method or a tool could be of help for Company C to support and improve their way of working towards resource efficient solutions. One of the more important potential changes in the company that need to be considered is inclusion of all concerned actors and their way of communicate in an early stage of product development. One example of new solutions for the development process and, in particular, for testing and evaluation, is involving external sources e.g. customers. Since analysis and evaluation of concepts or finalised products is not made in any other way than by testing the product concepts, thoughts should be given if there are anything that could help Company C improve their way of working.

5 Company D

5.1 Identified current use

5.1.1 Entire early stage

Company D have a strong focus on satisfying their customers, and have many products that are customized according to the customer's requests and needs. This results in product development projects that differ substantially. Quality, cost and time are considered the three essentials to consider in the product development process and work as a decision basis. Throughout the product development process there are several decision points, which help to determine if projects should be taken further, or what is needed in order to continue the product development. ***What Company D find most difficult is to manage multiple development projects at the same time.*** The lack of time and the absence of a sufficient number of product developers results in a shortage of needed resources in product development projects.

In the product development process, Company D are very limited to the materials available on the market. ***The R&D for research of new materials is located abroad, and designers in Sweden have limited influence on the development process of new materials.*** Respondents state that this results in a feeling of ***not being fully able to affect the environmental aspect of their products.***

It is becoming more common that products are purchased directly by the customer. However, in Sweden it is mostly contracts by public procurements. This has slowly started to affect the Swedish market, and causes requirement changes based on e.g. the appearance of the package as well as colour prints on the products, and not just the function of the products. Since Company D work in a fast-changing market, the respondents state that employees at the company are used to introducing changes in their daily work.

Product development communication within the company occurs mostly via e-mail, as all product development functions are not located in the same place. For those who are located in the same place, communication is mostly verbal and in meetings. The requirements are communicated in the product development process via a method called A3. This method summarizes improvements and collects documents for each product development project. In addition, a ***checklist is used to assess a product's environmental impact.*** Furthermore, the marketing department has a document called "product initiative plan", which is communicated to all market managers, and includes changes to the projects. Respondents state that the marketing managers are responsible to forward this plan to concerned actors within the company.

5.1.2 Requirements specification

Respondents state that Company D are not using an advanced requirements specification, but rather ***a list of requirements*** that guide a product development project to assess different variables, and ***describe what and why things happen*** in the product development process.

Project owners and departments heads are involved in the setting of requirements. The internal requirements come from the top of the company, and are often based on how much the product will cost. Both Company D and their customers have ***high demands on the products' materials, which is why material requirements are considered to be of the utmost importance.*** The requirements received from the ***customers are often very specific.*** Some requirements are difficult to measure, e.g. "fragrance-free", a feature that makes the product soft, and the feel of a worthy product to use. Company D categorize the requirements into two groups, ***strict requirements and the "nice to have" requirements.***

Strict requirements concern ***regulatory requirements and internal requirements*** such as cost, materials and performance. The measurements of those requirements are done with ***individual ratings by customers*** when making orders. They often use a four-grade scale based on how they for example experience the softness of the product. This makes it very difficult for Company D to test and measure the quality in advance.

Performance is controlled by a very old ISO standard that calculates a total performance value of a product. The current ***ISO standard inhibits some of the solutions that could be developed,*** state

respondents. Respondents also stress that instead of measuring the total value of a product, the focus should be placed on different parts of the product that need to have a higher performance value. One respondent had a proposal that depending on the type of problem, the products would follow a minimum and maximum value for different kinds of products.

5.1.3 Conceptual design

Company D product line is largely based on customer requirements, and the idea of the need for an *improved or a new product could come both internally and from customers*. The project owners have *meetings once a week* where they *discuss new ideas for products*. If an idea is considered to be good, a project proposal is set including information about the customers that they address and how much can be earned from it. The first step in the conceptual design is to start the pilot study. The respondents stress that the most important step in the conceptual design is to perform a *detailed pilot study*, where various alternatives of the product design are considered. However, this is difficult to achieve since the market changes very fast and all product development projects look very different. The result from the pilot study is *presented at a decision point*, where it is decided whether or not it is sufficiently profitable to implement as a product at Company D. If it is, it will be passed on to production and marketing.

The users are involved when a finalized concept is tested, which is late in the conceptual design, the respondents state. However, the respondents stress the importance to meet users in person to establish potential problems with their products.

5.1.4 Analysis and evaluation

Company D perform risk assessment as a way to analyse their products, but they do not use any method systematically. Risks could be for example that there is a new material on the market that their machines are not capable of processing, a lack of resources, or that suppliers do not deliver what they have expected. Respondents state that they can never release a product to the market unless it has been properly tested. The test is used as a way to analyse and evaluate the result of a finalized concept. If the tests show uncertainties they are redone, but “we cannot keep on testing forever, at some point we must trust that we have a good product”, one respondent says. To see how a new product works, the marketing department does tests and respondents state that the outcome of the tests is preferred to be quantitative. The tests are both performed internally by using an ISO standard and by letting users try out a product to get accurate feedback on how customers perceive new features.

The actors involved in the phase of analysis and evaluation are *the project manager, the development department, production, and the quality control department*. In the evaluation of the finalized concept the stated document, as mentioned in Section 1.2, is used to analyse if the outcome was what they had expected, or to answer why it may have not been. Respondents state that *not all set requirements are analysed and validated, only some based on assessments of which are considered more important to achieve*. An estimate is made for each new finalized concept of how many tests should be conducted, and for how long. All potential changes made from the original solution will be documented.

5.2 Derived requirements

5.2.1 Entire early stage

The biggest challenge respondents see for Company D in the current development process is that the market is moving towards more disposable products, which are more resource-demanding when it comes to material, while Company D advocate a more traditional concept of products with washable parts.

Respondents thought that Company D *could be more resource efficient if they would implement LCA* as a method in the current development process. Some also stressed the *need for better communication and the inclusion of more actors earlier during the product development process*. One respondent expressed that procurement and the coordinator (consultant in materials) does not have a lot of insight in the importance of innovation and the need for constant change of the products to follow the market. To increase this knowledge, the respondent thought it would be necessary to include more actors such as procurement

and the coordinator in the development process. There is also a ***lack of communication between some important actors, such as marketing and product development***. To increase communication, respondents state ***more strategic meetings are needed***. Another example of improvement is that information needs to be better communicated back to the developers regarding the products that do not meet the requirements. One respondent brought up the ***lack of a broad description of the business case, which hindered her/him from looking for improvement potential***.

All involved in the product development process would be in need of ***a method that is easy to use and that clearly documents the requirements***. Respondents stressed that it would be good if it could help in ***describing problems*** occurring during e.g. the product development process, ***rather than by studying the finished solution*** of a product and thus finding out what may occur as a problem. In addition, a method would be ***useful if users of the products would be included*** in some way so that it reflects reality, respondents state.

5.2.2 Requirements specification

Respondents stressed that the requirements should be communicated through a ***more accurate*** requirements specification. The requirements should also be ***better fitted for the different sizes (in dimension) of their products*** to meet the needs of various users. Respondents also brought up that the ***user needs should be at the centre of the design***, versus being excessively based on and measured by an ***ISO standard***.

One respondent brought up that it would be interesting to see if the quality of the products would change if the environmental demands changed from being based on a ***company level to a product level***.

5.2.3 Conceptual design

Potential improvement lies primarily in the initial phase of the conceptual design, with better planning needed in order to be better prepared for potential future problems. ***Improved cooperation between actors*** is greatly needed, as well as allowing more time for the pilot study to ***avoid decisions being made too early*** in the conceptual design and ***being unable to change them later***. The ***marketing department should be more involved in the conceptual design*** than they are today, respondents stress, to get the customer perspective early on in the design process. One respondent stated that ***marketing are keeping a lot of information to themselves until they have all the answers***, leading to the development department only having a short time to develop products, which needs to be changed.

5.2.4 Analysis and evaluation

Clearer job roles could help reduce the uncertainties of a product development process, one respondent expressed. In addition, more discussions are important to avoid risks or uncertainties. One respondent brought up that the company must ***be better at highlighting the risks*** and discuss how to handle them when they are recognized, and not later on in the product development process. Respondents stated that it would be preferred if the tests were designed as neutral as possible so that the user can test the company's products. The evaluation would then reflect the new product in relation to the old one in a clearer way for the customers.

If the requirements specification were to be developed, it could be used to analyse and evaluate finalized concepts. All involved in the product development process would be in need of a method, and according to respondents the ***FMEA method should be used*** more. There is also a need for some sort of training in product development for employees.

5.3 Discussion

Respondents state that the company are used to a frequently changing market, and therefore often change their products. Since the product development projects differ greatly from one project to another, it is difficult to describe a standardised early product development process for Company D. This shows that employees are used to adjusting to some changes. However, there are no answers regarding change within the company such as structure or new ways of working and how such changes are perceived.

Both the marketing and product development departments mention that the marketing department should be more involved in the development of products. However, why is this not done today? The ***lack of a structured way of communication*** seems to be one of the problems, which was also brought up by respondents.

The fact that Company D only analyse some of the set requirements, based on assessments and which are considered to be more important to achieve, is likely not entirely effective. This seems to bring forth uncertainties if they have actually been able to meet all set requirements. Another method or some sort of support is assumed to be needed.

6 Company E

6.1 Identified current use

6.1.1 Entire early stage

The initial stages of projects (early design stage) are outsourced to architects and then followed up by a project manager to be built (actual construction) according to the customers' specifications. *The process is defined* but there is *no formal documentation* of it.

6.1.2 Requirement specification

The requirements can come from different actors, for example from customers that want to live in a "healthy" house or from construction companies. In addition, some requirements can come from its own sales personnel, from the architects or other companies. Other requirements can come from the Government. For example, in Sweden, *sustainability reports* are now demanded for all large companies. Company E can help the customer with arguments and facts for the customers' environmental reports.

6.1.3 Conceptual design

There is no formal phase for conceptual design. However, there is a process for planning and delivering products. The early stage of design is mainly outsourced to architects, the concept is then provided to the project manager to follow up and build the required products. Other actors involved in the early stages of the design also include sustainability consultants and customers.

6.1.4 Analysis and evaluation

There are no formal phases identified as analysis and evaluation. Those that work with numbers at Company E do some risk analysis and there is also insurances in place but *analysis and evaluation is not something that is done in a systematic manner*.

6.2 Derived requirements

The main interest of Company E is to develop new markets and products. The company is also interested in becoming more sustainable and follow up on their sustainability efforts. There is also a need to communicate better among different actors and to change the mind-set of employees to a more strategic and sustainable manner. According to the interviewees, *methods should be visual, clear and useful for the company* and those that implement them should follow up their use in the long-term. Workshops were also indicated as useful for learning new methods.

6.2.1 Entire early stage

A more ordered structure in the process from beginning to end could help the company in order to carry out follow-ups of their projects and measure their progress.

6.2.2 Requirement specification

The requirement specifications could be more aligned with the company's strategy and take into account future needs from the market.

6.2.3 Conceptual design

A more structured and specific procedure could help in better planning other phases like production and resource efficiency.

6.2.4 Analysis and evaluation

Internal reporting on sustainability and the participation of different actors could reduce uncertainty and risks. At the same time common understanding of circular economy from different actors could help Company E in decision making.

6.3 Discussion

The type of work Company E does can vary with time and it fluctuates. *The company is highly dependent on certain key personnel*, for example, Production Manager and CEO. *Company E seems to be interested in a more structured way of working* so that there is more control over all its processes from design to production and therefore better planning and overview of them. There is also an *interest in looking at new markets or new products than can be developed*.

The company also stressed the need in society to prioritize the environment before the economy and this entails a change in the mind-set of different stakeholders, namely, customers and the market.

7 Company F

7.1 Identified current use

This section includes how the development process currently works.

7.1.1 Entire early stage

Company F work with IT solutions where unused IT equipment is remanufactured and restored to be used by their customers again. This makes the development of offerings at the company highly depending on what types of IT equipment is available to them. What type of IT equipment that is suitable or able to remanufacture is also depending on policies that in many cases constricts the practical possibilities of what is potential to offer, e.g. it is not legal to send broken IT equipment over country borders.

The development process for an offering starts with either an identified need for an IT solution or identification of unused IT equipment. Depending on the start point, it then continues with identifying the other end of the line, i.e. if it starts with identifying a need of an IT solution the company then need to find suitable unused IT equipment to fulfil the need. Then refinement of the IT equipment is necessary to make it suitable to fulfil the need. Identifying unused IT equipment is the biggest challenge in this process.

Needs or wishes can come from internal issues or externally from customers or other partners. When solutions are to be identified, anyone at the company can be involved. The ideas are then documented in an excel sheet where a go or no-go decision can be taken. This decision can depend on the size and magnitude of execution and is taken either by a division manager or the steering committee at the company. The ideas that then are supposed to be realised are done primarily as a *small scale try out*. The concerned division executes the try out. The try out is highly depending on the person who is responsible for the execution on how it is run and when. The try out is thereafter assessed and evaluated and a decision is taken on if it should be executed at a larger scale or closed. If the offering is perceived as a good opportunity during the development there can be cases where it is offered to the customers even before it is finalized. It exists a project template that is optional to use.

The current size of the company makes the development process able to be *flexible and agile* with *short time for decisions*. This is a property that is important for the company and they do not want to move toward a too strict process. The process today is supported by different software solutions that can trace the status of different projects. Regular meetings are also used as a way to secure the quality and status in the development.

It is also highlighted that the development needs to be at a sustainable balance with the daily work. Here, therefore, the key issue is the amount of *free work resources* in the company. The aggregated responsibility of development in the organisation is seen as an advantage in order to not decouple development from the daily work. Development can however be down prioritized by the daily work and therefore responsibility allocation is important to consider. The solutions offered to the customers can be individualized but the internal processes are kept as a common process no matter what customer or solution that is offered.

One example of methods used is *NÖRA*. This method works with identifying and defining the current situation, desired situation, what resources are available and from all this information specifies actions.

7.1.2 Requirement specification

Some internal requirements are based on the company's work foundation; mission, visions and business concept. It is therefore important to consider primarily the *profitability*, secondly the offering should be in line with the company's vision and also the ability to deliver. Some other examples of internal requirements can be considering *environmental impact, production, revenue, or ISO-standards* (e.g. ISO9000 and ISO14000). The steering committee of the firm has the biggest input on requirements, where the individual divisions have to fight for their needs rather than a co-creation of requirements. Few requirements are desired in order to not narrow down the possible solutions.

Most customers have high demands on security on the managed information that may be available on the equipment. The customer provides with their specific requirements and wishes on the offering. One interviewee stated, that it is easier to discuss requirements with private sector compared to public sector costumers, because the public sector more often have problems with procurement and agreements.

7.1.3 Conceptual design

Except for the division who has responsibility for the specific development project, the *IT division* is involved in most of the projects. Customer needs can be identified either externally or internally. When solving different issues, either someone thinks for a moment and come up with a solution or more organised sessions are performed.

One example of a more organised session comes from a division who had a long-term issue with layout of the premises. Anyone who did not work at this location was invited to participate to find a solution. The participants were not informed about how premises currently were planed in order to start from a blank sheet.

7.1.4 Analysis and evaluation

Environment and safety requirement has to be fulfilled; revenue is the driver after that. Environmental issues that are considered are e.g. to minimize e-waste and less transportation. Some projects are driven by strategic reasons rather than profitability.

Company F can in comparison to traditional IT business use their business model as an argument for a reduced environmental impact. The more of their solutions sold the less environmental impact compared to if the customers would have bought new equipment. One interviewee still pointed out several things that internally can be improved, e.g. in production processes and logistics in order to reduce the environmental impact even more.

Uncertainties are handled by the support of IT-systems along the development. Humans make mistakes and it's never a computer that makes a mistake. Higher tempo brings higher risks.

Depending on the decisions it is primarily based on gut feeling. For more important decisions, e.g. *A3-reports* and statistics are used as a basis for the decision.

7.2 Derived requirements

This section describes identified needs in order to develop more resource efficient end effective solutions.

7.2.1 Entire early stage

Company F is strongly driven as a company to grow and improve in their mission, vision and business concept. New methods should therefore help the company reach their future goals and visions.

One aspect that was pointed out at several times is that the lead-time is important. Specifically mentioned is the need to *shorten lead-time* between that an idea comes up and the beginning of the try-outs. As the current development process is flexible the new methods should not be too strict. It has to fit the agile way of working that is in the company today. Desired properties were e.g. that it has to be specific and require little time to perform.

The company once tried to implement *lean* a couple of years ago but with no rather success. Would have been better if it would not have been implemented in the entire production at the same time but rather start with a small section and show off the benefits and improvements.

One suggestion was to *involve e.g. suppliers and customers* in the development process.

7.2.2 Requirement specification

This company desire that requirements should not be static. They should follow the company and context as it evolves. Therefore they also feel that more input on how the surrounding world looks today could be beneficial. E.g. what works and doesn't work at the customers or in the production.

7.2.3 Conceptual design

The IT division is often involved in the development and it is often a bottleneck. Due to this, it could be desirable that they are involved from the beginning of the development in order to shorten lead times. One interviewee also stated that it is more fun to co-develop an idea rather than assigning as a task to IT division. The other interviewee also mentioned that it should be interesting to involve the customers more in the development, e.g. in idea generation.

7.2.4 Analysis and evaluation

Currently e.g. carbon dioxide emissions and amount of waste can be quantified but Company F is missing a way to **assess societal changes and attitudes**. It is hard to assess when the change is coming.

There is a stated need for a structured way to assess and evaluate try-out projects, both economically and strategically. The need is for both during development but also to be comparable with the actual outcome. More resources would be reasonable to put on analysis and evaluation if an underlying evaluation method existed. The more the method is used it would then reduce the amount of decisions based on gut feeling. Making decisions based on gut feeling is unsure and is highly depending on context and current situation. The same issue can get completely different decisions depending on e.g. if the monthly report is highly positive or negative.

One suggestion is also to let the customer participate to evaluate solutions and choose which one they prefer.

7.3 Discussion

Company F is with their business concept a company with high awareness of sustainability issues. They still feel like there are some improvement opportunities. One of the more important properties of the company that needs to be considered is their flexible and agile way of working. The development process should not be restricting and limiting, it should **support a process to get the best offering**. One example of new solutions for the development process is involving external sources e.g. customers or suppliers.

8 Company G

8.1 Identified current use

8.1.1 Entire early stage

There is a process for obtaining an order and processing it until the cleaning is done. This process can take from one day to up to 1 year depending on several factors, for example, the company that is being served, the price of the service and time needed for the cleaning.

8.1.2 Requirement specification

The requirements are mainly *set up by Company G* since they are experts in cleaning without chemicals which is very different from competitors. *There is no guarantee of the service although some customers ask for it* and depending on the conditions of the façade there can be a certain guarantee. Internal requirements could be to clean from top to bottom and to have protecting gears when cleaning.

8.1.3 Conceptual design

This is done in the form of a project where two key persons were named; Charlotta who has several responsibilities as *support for sales, administration, economy* and Tom in charge of *project planning* who is another important actor that knows how the industry and the service provided by Company G work.

The sales persons, Mikael or Kenneth, do the job calculations. The sales persons are, with support of Charlotte, calculating on bids involving both services and products. One of the products is the fireproof planks for transformer pits. The drawings, and the fireproof planks, are made by a company called Meiser located in Germany.

All product development projects are made in close collaboration with both customers and suppliers.

8.1.4 Analysis and evaluation

Charlotta is in charge of analysis of data and economic valuations. Relationships with customers are based on trust and customers believe in the service provided by Company G. For customers the price is one of the most important priorities and Company G has problems finding customers that want to pay a premium price. However, some companies take the environment and the work safety very seriously.

8.2 Derived requirements

8.2.1 Entire early stage

More independence by the sales staff in terms of having in advance the budget and cleaning plan and standardising how and when the service could be provided would be an improvement.

8.2.2 Requirement specification

None mentioned in terms of the service but some internal requirements could help in setting goals with the aim at getting new customers.

8.2.3 Conceptual design

It could help to include the cleaners in the planning of budget and cleaning plan so they could work faster and more effectively.

8.2.4 Analysis and evaluation

To digitalize some of the forms that they hold in physical folders so they can work more effectively but this can take time for them to learn a new system. They have already bought a new system (called Dokiv) to process the orders and schedule the cleaning but employees don't use it yet, there is resistance to change.

8.3 Discussion

The company seems to be dependent on specific persons for the planning and delivery of their service. Two specific staffs were several times mentioned as *key personnel that do economic analysis and knowledgeable*

on how the industry works. Relationships with customer and suppliers are built on trust. Customer usually believe in the service provided by Company G. Customers usually want fixed prices. One of the biggest challenges faced by the company is to find new customers that want to pay ***a premium price*** for the cleaning service.

9 Company H

9.1 Identified current use

9.1.1 Entire early stage

There is no formal process. The company is *very flexible* in how it handles its projects. Sales persons register the projects in an application and then this goes into an internal database that is later managed by a project leader.

9.1.2 Requirement specification

The requirements mainly come from customers. If there is a need, Company H offers a service for that need as a complete solution. The requirements will vary depending on what the customer wants and the prioritization will also change depending on customer needs. *Company H communicates closely with customers to provide quality services.*

9.1.3 Conceptual design

The conceptual phase of the service design is not a formal activity. The services provided are personalised to customers. If several customers have the same need, then a service might be developed and provided accordingly. Company H provides web-based solutions to their customers. It is a web platform where customers can see what has been done and can see statistics and documentation. Company H provides recommendations or suggestions on the web-based platform and later *customers provide feedback* on what they think of them and choose what they want or need. This process can take up to 4 weeks.

9.1.4 Analysis and evaluation

There is risk identification when technicians visit the customer, and also security of workers is prioritised. However, there is no method to analyse or evaluate a design. The activities of analysis and evaluation are based on discussions with customers and what they want to have as service. In order to manage uncertainties Company H look at trends in the market to see possible changes that could affect them and how they can adapt to the market. For instance, they monitor the increase in the use of biogas or changes in the paper and mill industry which tend to use the services and products provided by Company H.

9.2 Derived requirements

9.2.1 Entire early stage

Digitalizing some of the manual work like scanning and filling in documents manually could help the company in working more efficiently. However a major requirement for the early stages of design is that Company H would like to see *how their services can affect their customers' internal operations* regarding costs and depending on that Company H could adapt the type of service it provides. This can also help in convincing customers why they should pay a premium price for the quality services of Company H.

9.2.2 Requirement specification

There is need to have a more clear way in how to fill in protocols when servicing equipment, a more structured way. In addition to digitalizing their forms and orders, Company H would like to automatically upload orders and documents in their internal system. One way for improvement could be to think *how can I simplify customer care?* During the interview it was made clear that with regards to *methods, these should be quantifiable or give an overall view of a process. This needs to be more visual.* It is also important to show why employees should use a method, why it is better this way than another way. Another important aspect regarding methods is that implementation might also need *change of mind-set* and willingness to use them.

9.2.3 Conceptual design

Services are provided according to demand from different companies. A specific service can be formally provided when there is a need from several customers. Company H can then create a *new service offering* based on similar demands by different customers.

9.2.4 Analysis and evaluation

During the interview it was suggested that a better process could help internal control and documentation. Some proposals regarding how to better analyse and evaluate focused on *paying attention to what customers ask for* and what employees have to say about it.

9.3 Discussion

Some of the problems identified during the interviews regarding the process of providing a service were the following. There are *no guarantees that can be provided* for the expensive products or services provided since in some instances this might depend on other circumstances out of the hands of Company H. For example, customers not following the recommendations provided by Company H on how to maintain the equipment can impact any type of guarantee. Moreover, since the equipment provided by Company H is in many cases very expensive (2-3 million SEK), to provide a guarantee for the service or equipment could mean changing equipment at high costs to Company H. The industry is driven by costs, hence, most customers will want a cheap service while quality and the environment will come after. No environmental certifications are required in this industry, however, Company H is ISO 14001 certified and one employee is fully dedicated to maintaining this certification. Customers lack a *long-term view of resource efficiency* and will *prioritize costs* before long-term benefits. Employees at Company H could benefit from training regarding resource efficiency. Company H would also like to identify what type of services can be most valuable for its customers.

10 Interview guide

This section describes the guide used for the interviews including the questions as well as the purpose etc.

10.1 Purpose

Get a wider understanding of how products and services are and could be designed for resource efficiency and effectiveness in industry.

10.2 Scope

An early stage of design (from the beginning of design to obtain a concept that will be further developed in detailed design) of products and services for resource efficiency and effectiveness. Not design of products and services in general.

10.3 Interviewee

Someone who:

11. Works with (issues related to) the design processes
12. Carries out requirement specification, conceptual design, analysis and evaluation

Someone who work with e.g.:

13. Product design
14. Service design
15. Sales
16. Aftermarket
17. End-of-life

10.4 Preparations

Send out information:

- Describe briefly the program and the project (PJ2), and the purpose of the interview (WP 2.1 and 2.2).
- Explain the format of the interview (actor system map).
- Say how they can contact us for further questions.
- Explain how confidentiality is managed.
- Time (length) available?
- Check if it's possible to film, explain that it's focused on the "painting" and not the interviewee.

10.5 Interview procedure

The entire interview is to be conducted together with the method actors and system map so the respondent visually can explain her/his answers as well as orally.

10.6 Introduction

Recap a little bit about the program and us, and the purpose of the interview. Inform the focus on early stage of design for resource efficiency and effectiveness. Inform recording with video.

Collect information about both formal and informal process.

Remind the interviewee about the scope throughout the interview

10.7 Respondents experience

1. Describe your main tasks.
 - a. For how long have you been doing these tasks?
 - b. For how long have you been working in industry?

10.8 As-Is

10.8.1 Activities

1. Describe the design process of how you develop an offering.
 - a. What are the key-activities?

If not mentioned in the answer ask following:

- b. Describe the process when working with requirements. (Both deriving and managing)
- c. Describe the process of conceptual design.
- d. Describe the process for analysis and evaluation.

10.8.2 Actors

- e. What actors are involved in the design process? (internal and external) (E.g. buyers, users, suppliers, service technicians, legal experts?)
 - i. What are their roles/responsibilities?
 - ii. When in the process are they involved?
- f. What actors are perceived as the most important?
 - i. Why are these important?
- g. How do different actors interact?
 - i. What do they communicate?
 - ii. How do they communicate?

10.8.3 Requirement specification

- A2. What types of requirements are considered in the design process?
 - a. From what do the requirements originate?
 - b. What type of information is needed to create the requirement specification?
 - c. How is the information found?

If requirements about the environment are mentioned:

- A3. Which environmental categories do the requirements belong to?
- A4. What types of aspects are considered besides requirements? (Manufacturing, environment, costs, differentiation, innovation, etc.)
- A5. How are these prioritized, among each other?
- A6. Which requirements are most difficult to fulfil?
- A7. How are requirements communicated to involved actors?
- A8. What methods are used to work with requirements? (Both deriving and managing)

10.8.4 Conceptual design

- A9. How are the requirements used in the conceptual design?
 - a. How are the other aspects than the requirements used?
- A10. How are different actors involved in the conceptual design?
 - a. When in the conceptual design are they involved?
- A11. What methods are used during conceptual design?

10.8.5 Analysis and evaluation

- A12. How are requirements used to evaluate concepts?
 - a. How are other aspects than requirements used? (e.g. economic, environmental)
 - b. What environmental issues are considered? (e.g. materials, energy)
 - c. How important are economic versus environmental aspects?
- A13. How are uncertainties addressed? (e.g. customer requirements' change, market trends, new regulations)
- A14. What methods are used during analysis and evaluation?

10.8.6 Methods

- A15. Describe the purpose of the earlier methods mentioned

- a. Who uses them?
 - b. What input is required?
 - i. Are the required data qualitative or quantitative?
 - ii. How do you address subjectivity issues?
 - c. What output do the methods deliver?
 - d. How do you perceive the quality of the outcome of the method? (e.g. trust)
- A16. How are the methods perceived to work with?
- A17. What type of training is offered to the users of the methods?
- A18. What are the biggest challenges with current methods available?
- A19. What indicators are used to evaluate performance in the design process? (e.g. time, cost)

10.9 To-Be

10.9.1 Activities

- T1. What changes of product/service design would make your offerings more resource efficient and effective?
- T2. What would you say are the biggest challenges in the current design of offerings?
 - a. Where in the process do you see possibilities for improvements?
 - b. What should be changed in the process?
 - c. How should it be changed?
 - d. For what reasons hasn't this been implemented? (If improvements are mentioned)
- T3. What changes would make your offerings more resource efficient and effective except for changes of product/service design? (e.g. change of business models, change of regulations/laws)
 - a. If those changes would be implemented, what needs to be changed in development process? (e.g. knowledge, information, resources, costs, technology)

10.9.2 Actors

- T4. What actors do you think should be included in the development process that currently isn't?
 - a. When in the process should these be involved?
 - b. What should their roles/responsibilities be?
- T5. How would you like to improve cooperation between actors?
 - a. For what reasons hasn't this been implemented? (If improvement is mentioned)

10.9.3 Requirement specification

- T6. What type of requirements should be considered in the development process that currently isn't?
 - a. From what sources should requirements be derived?
 - b. What type of information would be needed to create the requirement specification?
 - c. How could the information be found?
- T7. What type of aspects should be considered beside requirements? (e.g. manufacturing, environment, costs, differentiation, innovation)
- T8. Where in the process should requirements and aspects be considered?
 - a. How should these be prioritized? (Among each other)
- T9. How should requirements be communicated to involved actors?
- T10. What methods (both existing and non-existing) should be used during requirement specification?

10.9.4 Conceptual design

- T11. How should requirements be used in the conceptual design?
 - a. How should other aspect than requirements be used?
- T12. How should different actors be involved in the conceptual design?
 - a. When in the conceptual design should it be done?
- T13. What methods (both existing and non-existing) should be used during conceptual design?

10.9.5 Analysis and evaluation

- T14. How should requirements be used to evaluate concepts?
 - a. How should other aspects than requirements be used? (e.g. economic, environmental)
 - b. What environmental issues should be considered? (Materials, energy, etc.)
 - c. How should economic versus environmental aspects be weighted?
- T15. How should uncertainties be addressed offerings? (e.g. customer requirements' change, market trends, new regulations, etc.)
- T16. How should decisions be ensured to be "the right one"?
 - a. How should risks be managed in decision-making?
 - b. Which actors should be involved in the decision-making process?
- T17. What methods (both existing and non-existing) should be used during analysis and evaluation?

10.9.6 Methods

- T18. What would be the most useful outcome from a method?
 - a. Why?
 - b. Should the outcome be quantitative or qualitative?
- T19. What characteristics make a method more useful and less useful? (e.g. modularity, simplicity, clarity, customizability, tangibility, flexibility)
- T20. What are the biggest obstacles when implementing changes? (e.g. costs, time, big organisation)
 - a. What would help to overcome these obstacles?
- T21. Which of the actors could benefit from using methods in the design process?
- T22. What indicators should be used to evaluate performance in the design process? (e.g. time, cost)

10.10 Summary

10.10.1 Reflections

- 1. What are your reflections after visualizing the design process in this way?
 - a. Have you done this before?
- 2. What others reflections do you have on the interview?

10.10.2 Final Questions

- 3. Is there anything you would like to add regarding previous questions?
- 4. Is there something you think we should have asked you?
- 5. Is it okay to come back to you if we have any additional questions?

Thank for their participation

10.11 After the interview

For the companies with several interviews, the actor maps are combined and confirmed with someone responsible at the company.