Valuable waste flows at company X – Matching administrative and physical flows to improve their accountability and traceability

Public Summary
Master Thesis Industrial Engineering and Management

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1. Research topic and purpose
The thesis describes a research project performed at company X. Company X is a manufacturing company and produces different types of products.

In manufacturing industries the main focus is production of key products instead of focusing on waste. However, if the waste is valuable and the amount of valuable waste is high, it could be wise to pay attention to waste too. Due to a lack of waste registration and waste identification, there is not a direct link between the administrative waste flows in the ERP system and the physical waste flows at company X and at other stakeholders like recycling companies, copper suppliers and transport firms. This results in difficulties for the financial department with accountability of this valuable waste.

2. Research approach
So, the challenge is to improve the accountability of the waste flows of company X. To reach this challenge, the first step of the research approach is to learn the company and the corresponding current situation. To analyze the current situation, we have to gather data regarding the current situation. This will be done by conversations with employees of different departments, visiting suppliers, visiting recycling companies, using information from the existing ERP system, reading the annual report and by observations at the production plant of company X. Finally, we give an overview of the current bottlenecks in the current processes for the different stakeholders.

The next step of the research approach is a literature study. Given the bottlenecks, we use literature to find the core problems of company X. After that, we study several theories about aspects which could be applied in the current situation of company X. These aspects are Circular economy, Stakeholder analysis and Industrial waste management.

After identifying the current situation, choosing core problems and gather data from literature, in the third step of the approach we can think about solutions for these problems. First we will look at the short term solutions. These are solutions that are simply to implement and should help to structure the current problems.

After addressing the current problems with short term solutions, we will design some medium term solutions. These solutions require more effort to implement and therefore more time is needed to bring them into practice.

The short term and medium term solutions we invented were based on the current ERP system. For the design of long term solutions we go a step further and think about conditions for a new ERP system that contributes to a match between the administrative and physical waste flows.

The last step in the research approach is to look at the expected results. We analyze and calculate what the effects of our invented solutions are and how they improve the challenges of company X.

3. Research questions

Based on the research topic and purpose, we formulated the main research question as follows:

"How can company X match the administrative waste flows (in their ERP system) with the physical waste flows connected to product Y, to support the financial department with improving the accountability and traceability of this waste in both internal and external processes?"

To be able to answer the main research question, we use different sub questions in this research.

***Question 1.** What is the current situation at company X?*
1.1.   Which process steps constitute the production process of product Y?
1.2.   What do the waste flows in the current situation look like?
1.3.   Who are the stakeholders in the current waste flow processes?
1.4.   What are the bottlenecks and problems in the current processes?

***Question 2.** How can the chosen core problems be clarified?*

***Question 3.** How could the theory be applied to identify the core problems and how can theories contribute to improve the current waste flows?*
3.1.   The problem bundle
3.2.   Circular economy
3.3.   Stakeholder analysis
3.4.   Waste management

***Question 4.** What are appropriate short term solutions to mitigate the current problems regarding the waste flows at company X?*
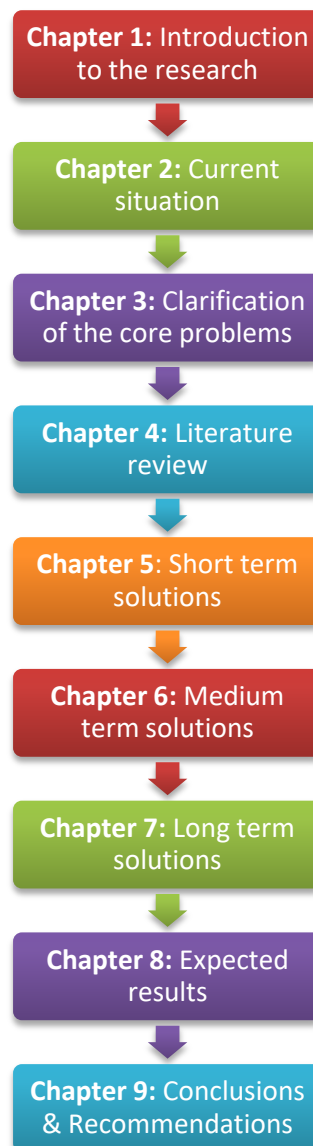
***Question 5.** What are appropriate medium term solutions to decrease the gap between the administrative and physical waste flows?*

***Question 6.** What are appropriate long term solutions to improve accountability and traceability by matching the administrative and physical waste flows?*

***Question 7.** What are the expected results of the conducted research for company X?*

4. Research design

In addition to the research approach and research questions, in Figure 1.1 the structure of the (confidential) research thesis can be found.

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Chapter 1: Introduction
     to the research
          ↓
Chapter 2: Current
     situation
          ↓
Chapter 3: Clarification
  of the core problems
          ↓
Chapter 4: Literature
     review
          ↓
Chapter 5: Short term
     solutions
          ↓
Chapter 6: Medium
   term solutions
          ↓
Chapter 7: Long term
     solutions
          ↓
Chapter 8: Expected
     results
          ↓
Chapter 9: Conclusions
 & Recommendations
```

Figuur 1.1. Structure of the research.

5. Literature review

5.1. The problem bundle.

We gathered a lot of information about problems and bottlenecks in the current processes at company X. In this section we will use scientific literature that helps us by finding the most important problems and choosing the core problem(s) that we will treat in the thesis.

In Heerkens & van Winden (2017) we found the Management Problem Solving Method (MPSM). This is an adaptable framework for problem solvers in any organizational context and at any time. The different models that can be applied in the framework contribute to a weighted solution by a step by step systematically problem solving method (Heerkens & van Winden, 2017).

A part of the MPSM method is the problem bundle. A problem bundle is a model where arrows present the relation between problems in form of causes and effects. After that, the problem(s) that have to be solved are chosen. The chosen problem(s) is (are) the core problem(s) (Heerkens & van Winden, 2017). For our research, the problem bundle is a very useful model, but due to confidentiality, we cannot present the problem bundle in this summary.

In the problem bundle, we distinguish three different types of problems. In the red square placed centrally in the problem bundle, the research problem can be found. The core problems are selected in the orange squares. These problems have a high contribution to the research problem and we recommend solutions to these problems in the thesis. Next to that, there are problems marked with a blue color. These problems also have a relatively high impact on the research problem but are in our opinion quite easy to solve. Therefore in our recommendations we will also mention advice regarding these blue marked problems.

According to Heerkens & van Winden (2017), we have to follow four rules to select the core problem(s):
- The problem has really occurred and it should be in a relation with other problems.
- Go through the problem bundle and go back to the problems that do not have direct causes.
- Problems you cannot influence, cannot be a core problem.
- Choose the problems that are most relevant. That relevance means which solution contributes most to the research problem taking the costs of the solution into account (Heerkens & van Winden, 2017).

5.2. Circular economy.
The term circular economy was used for the first time in an economic model by Pearce & Turner (1990). They took a critical look at the traditional linear economic system with the thought that ''everything is an input to everything else''. With that in mind they developed a new economic model, named the circular economy (Rizos, Tuokko, & Behrens, 2017).
From that moment on, a lot of different definitions emerged in the literature. Definitions of circular economy vary from "an economic system with closed material loops" to "an approach that would transform the function of resources in the economy".
According to Kirchherr et al. (2017) a common aspect of almost all definitions are three R's: Reducing, Reusing and Recycling. Implementing a circular system has to result in a reduction of the materials that are needed and in the amount of waste that is created. To reach that, reusing products and product parts can be a solution. Next to that, companies can recycle materials to decrease the amount of waste (Kenniskaarten, 2018).

According to the abovementioned definitions of a circular economy, we can conclude that also company X is applying circular economy. For instance, the copper waste that is created during the production processes, goes to recycling companies and returns to company X as copper raw material. To analyze this process, we can make use of the concept system thinking.

According to MacArthur (2015), system thinking means that all involved participants (businesses and people) act in a network in which the actions of the one impact other participants. System thinking is particularly used in complex problem situations, since for solving these problem situations not just one actor is sufficient, but many perspectives have to be taken into account [(Sustainability, 2018) (Bonfilius, 2014)]. The fact that actions of the one influence other participants is taken into account in the decision making processes in a circular economy. It is taken into account "by including both short- and long-term consequences of a decision, considering the impact of the complete value chain, and aiming for the creation of a more resilient system which is effective at every scale" (MacArthur, 2015).

To be able to apply the system thinking concept practically, there should be an analysis of the inter-relationships, perspectives and boundaries (Sustainability, 2018). A part of this analysis has already been done to map the current situation. Additionally, a stakeholder analysis would be valuable to map all actors and their inter-relationships.

5.3. Stakeholder analysis.
To make sure we can complete the listed stakeholders in the current situation, it is necessary to identify all stakeholders of company X involved in the current waste flow processes. Therefore we studied literature about stakeholder analysis. Various methods and approaches of stakeholder analyses exist since stakeholder analysis means many things to many people (Reed, et al., 2008). Firstly the definitions what or who are the stakeholders vary a lot.

The definition of a stakeholder, according to Freeman & Reed (1983), is as follows: "A stakeholder in an organization is (by definition) any group or individual who can affect or is affected by the achievement of the organization's objectives" (Mitchell, Agle, & Wood, 1997). This is a very general definition of a stakeholder, a narrower definition of a stakeholder are those groups or individuals "without whose support the organization would cease to exist" (Reed, et al., 2008).

In some theories stakeholders of a company with an actual relationship and with a potential relationship are distinguished. Clarkson et al. (1994) quite clearly include potential when he refers to stakeholders as those who "are or might be influenced by, or are or potentially are influencers of, some organization" (Mitchell, Agle, & Wood, 1997).

According to Reed et al. (2008) a stakeholder analysis consists of three steps: firstly identify the stakeholders, secondly differentiating between and categorizing stakeholders and finally investigating relationships between stakeholders. A graphical representation of this analysis can be found in Figure 2.1. Also different methods to accomplish the specific steps of that analysis are given in that figure.

In the figure (Figure 2.1) can be seen that the level of interaction between research analyst and stakeholders plays an important role in several methods. Therefore, the level of participation of stakeholders is an important factor to succeed a stakeholder analysis. That level of participation can vary from "passive consultation to active engagement" (Reed, et al., 2008).

Passive consultation means that stakeholders provide just the information that is needed for the analysis. Active engagement is a "two-way exchange of information between stakeholders and analysts as equal partners" (Reed, et al., 2008).

5

The first step of the stakeholder analysis is the identification of stakeholders. There are different methods to do this and Figure 2.1 presents the following ones:
- Focus Groups. Focus groups are small groups of involved persons, who brainstorm about stakeholders, interests, influences and other attributes.
- Semi-structured interviews. The conversations are conducted with different types of stakeholders and are used to check and complement the information received in the focus groups.
- Snow-ball sampling. Snow-ball sampling is the concept of interviewing individuals "from initial stakeholder categories" (Reed, et al., 2008), to identify new categories of stakeholders or other valuable contacts (Reed, et al., 2008).

Depending on the main goal of the stakeholder analysis, either all stakeholders have to be included or only a few. For example, if the goal is to reach an equal distribution of costs and benefits of a project, it is important to include all stakeholders of that project in the analysis (Grimble & Chan, 1995). However, if the goal is to reach more efficiency in a project, then analyzing just the stakeholders who are most likely to affect the efficiency could be sufficient (Reed, et al., 2008).

When all stakeholders are identified, the next step in the process is the differentiation between and categorization of the stakeholders. We can split up the differentiating and categorizing step into two parts: an analytical categorization (top-down) approach and a reconstructive categorization (bottom-up) approach.

Analytical categorization (top-down):
An analytical categorization is conducted by the research analyst and is based on the observations of the researched phenomenon and a theoretical perspective. The following two methods are types of an analytical categorization:
- Interest influence matrices. The identified stakeholders are placed on an interest influence matrix. Their position is determined by the fraction of relative interest and influence they have (Reed, et al., 2008).
- Radical transactiveness. Where the snowball sampling is used to identify fringe stakeholders, this method contains the "development of strategies to address their concerns" (Reed, et al., 2008).

A popular categorizing method belonging to interest and influence matrices, is classification of stakeholders in "Key players", "Context setters", "Subjects" or "Crowd". The "Key players" have high interest in the specific phenomenon and high influence over it. The "Context setters" have high influence, but lower interest in the phenomenon. The "Subjects" have high interest but low influence. And finally, there is the "Crowd". They have little interest and little influence over the phenomenon and possible outcomes. Classifying the stakeholders by their interest and influence will help analysts to judge how the different stakeholders will behave on different outcomes.
One of the drawbacks of analytical categorization is that often the same individuals or groups are involved in the analysis and that "lead to the under-representation of marginalized or powerless groups" [(Grimble & Chan, 1995), (MacArthur, 2015), (Kurland & Calton, 1996)]. Ignoring groups of stakeholders and their values, those groups can form alliances to affect the outcomes when they disagree or feel threatened by the phenomenon. Therefore it is important to include them in the

analysis. Because such analyses are often performed based on the perceptions of the researchers instead of the stakeholders, legitimacy based on these categorizations is discussable (Reed, et al., 2008).

Another method of analytical categorization is radical transactiveness. Instead of the most common stakeholders, this approach focuses on two way dialogues with stakeholders that are often forgotten. This group includes those that are "remote, weak, poor, uninterested, isolated, or non-legitimate, but whose views may be disruptive" (Hart & Sharma, 2004). According to Hart & Sharma (2004) these groups of stakeholders hold knowledge and perspectives that can contribute by at least identify innovative opportunities for future management [(Hart & Sharma, 2004), (Reed, et al., 2008)].

Next to the analytical categorization methods, there are reconstructive categorization methods. These will be explained in the next paragraph.

Reconstructive categorization (bottom-up):
A reconstructive categorization is conducted by the stakeholders themselves. That results in an analysis that reflects the concerns of the stakeholders more closely. The following two methods are types of an reconstructive categorization:
-        **Stakeholder led stakeholder categorization.** The stakeholder- led stakeholder categorization aims a categorization of stakeholders, categorized by themselves and into categories which they created (Reed, et al., 2008).
-        **Q methodology.** The Q methodology lets stakeholders sort statements by how much they agree with these statements. This analysis allows social discourses to be identified (Reed, et al., 2008).
The last step is the investigation of relationships between stakeholders. According to Reed, et al. (2008), there are three methods presented to investigate these relationships:
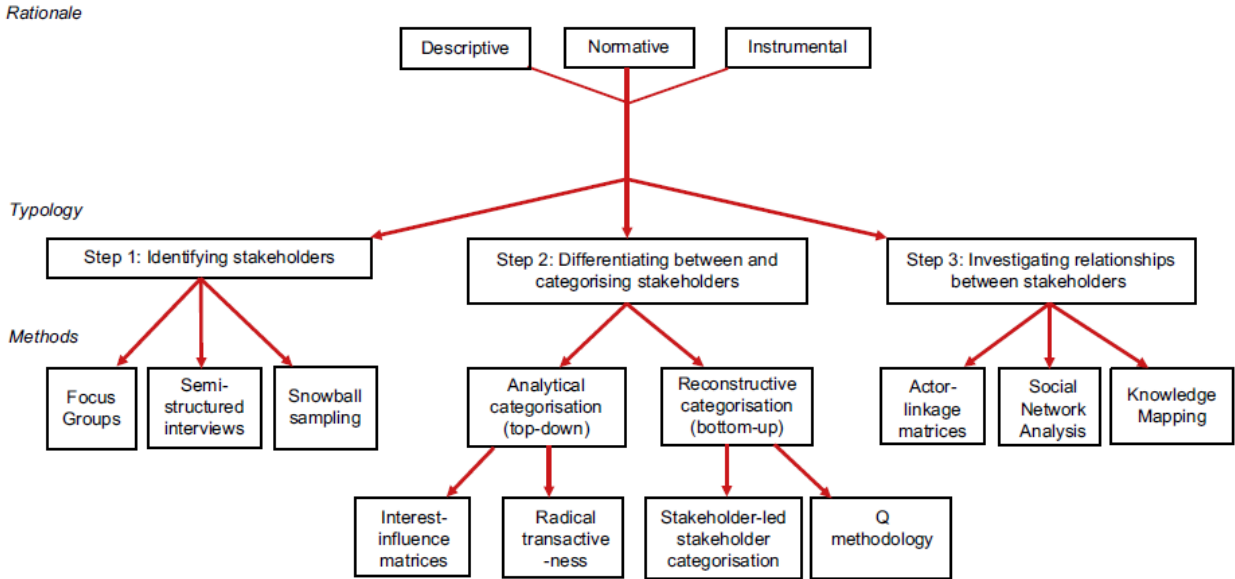

Figure 2.1. Graphical representation Stakeholder Analysis.

- **Actor-linkage matrices.** In actor-linkage matrices the stakeholders are listed in rows and columns of a table, so they create a grid. The squares of this grid are used to describe the interrelations between the stakeholders, using key words. Advantages of this method are the simplicity of use and flexibility (Reed, et al., 2008).
- **Social Network Analysis(SNA).** The Social Network Analysis (SNA) is used to organize data on the relational ties linking stakeholders together. This is done by using matrices. Instead of using key words to represent the relational ties, SNA uses numbers. With these numbers is represented if the relational tie is presence or absence, and the strength of a tie. "Each matrix represents a unique relation" (Reed, et al., 2008).
- **Knowledge mapping.** Knowledge mapping is a multi applicable method and could be an important method for:
    - Visual representation of "who knows what" (Wexler, 2001);
    - Identifying the dominant flows of knowledge (Eppler, 2001);
    - Identifying knowledge bottlenecks and areas of latent knowledge;
    - Locating and explaining knowledge;
    - Assisting individuals within the system to understand the other types of knowledge of different individuals and groups within the system;
    - Helping researchers to group stakeholders more effectively in order to promote learning (Reed, et al., 2008).

Knowledge mapping is a relatively new method within stakeholder analysis, which supports the development and diffusion of knowledge concerns a specific phenomenon within a company (Reed, et al., 2008).

5.4. Industrial waste management.

To invent how to deal with waste that occurs in industries like company X, we consult the existing theory about industrial waste management. According to Awuchi (2017), industrial waste can be defined as "the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, industries, mills, and mining operations." Industrial waste has their existence since the Industrial Revolution and examples are paints, paper products, industrial by-products and metals (Awuchi, 2017).

The fact that there are opportunities for improvements in waste management in industries is due to several reasons. First of all, industrial waste management involves several actors and organizations. In addition, the main focus in industries is on production of the main products instead of focusing on waste. For the opportunities to improve waste management is the challenge "to develop methods that support participation, visualization, and integration of operational environmental management" (Kurdve, et al., 2017).

As described above, the participation could be a difficult aspect. According to Kurdve, et al. (2012), to involve everyone you want and let them work in the direction you prefer, it is important that it is easy for them to understand what to do, how to do this and why it has to be done.

In their report, Kurdve et al. (2012) mention the following potential waste management process improvements. This are improvements on plant level and can be found in all sub-processes. Examples of such potential improvements are:

- Underused bins
- Lack of bins for some waste fractions
- Lack of and poor quality of signs and instructions
- Inefficiencies in handling and internal logistics
- Poor quality of information management
- Container and equipment inefficiency
- Inefficiencies and unnecessary costs of external transports
- Inefficiencies in choice of final treatment

Next to Kurdve et al. (2017), also Hogland & Stenis (2000) have analyzed waste management systems in production processes. They state that most of the manufacturing plants are in need of detailed analysis of their waste management system at all stages of production. They describe that by implementing appropriate waste management, companies can gain large economic as well as environmental benefits.

Hogland & Stenis (2000) describe the implementation of a new waste handling system. For a successful implementation, it is important to create an interest in, or motivation for, waste management activities among the involved employees. Activities to achieve this are for example information activities and educational programs (Hogland & Stenis, 2000).

In Figure 3.1 a visualization of the methodology used by Hogland & Stenis (2000) to implement a new waste handling system can be found.
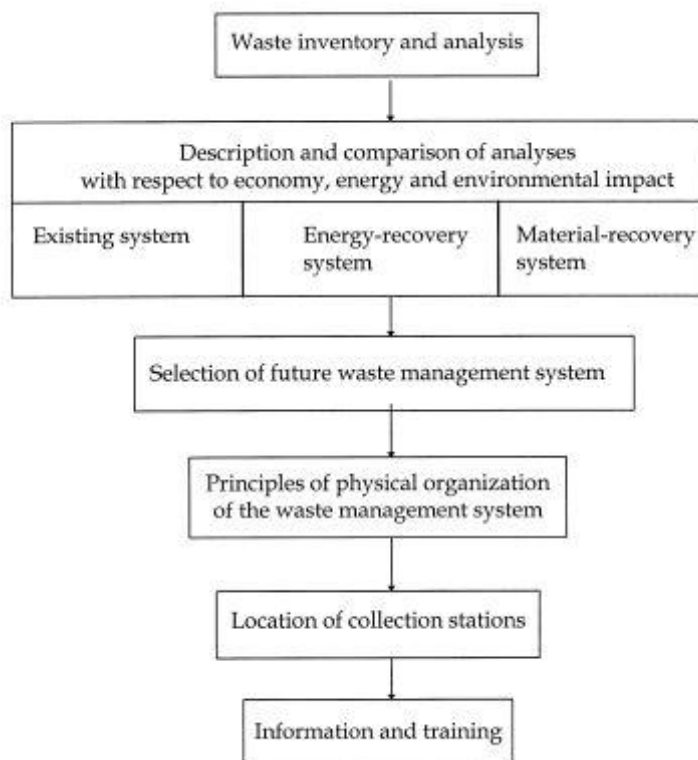

Figure 3.1. Visualization of waste management methodology.

6. Solutions

To solve the core problem of company X, we designed several solutions during the research period. The solutions design is divided into three categories: short term solutions, medium term solutions and long term solutions.

- Short term solutions:
1. Catching up the current situation:
The catching up is needed to assess the amount of waste that is stored at company X. That amount was unknown and therefore difficult for the accountability of the financial department. With a rented crane all waste is weighted and labelled. The weights are used for calculations to identify the amount of copper. These calculations are made with specific article numbers, ratio's valuable materials per article number and ratio's of the article number in the debited waste.

The calculations in this catching up help the financial department with accountability of the copper flows. Especially, since it is now known how the total amount is composed and at which specific location of company X it is located. Due to this, we have a starting point for improvements.

2. Stakeholders analysis and stakeholder network mapping:
"To map out the relevant stakeholders and identifies the different kinds of stakeholders as well as their interrelations" (Stakeholder Analysis and Mapping, 2015), we design a stakeholder network for stakeholders involved in the current waste flows of company X.

The first step for this solution is identification of stakeholders. We mainly used the semi-structured interviews and snow-ball sampling methods as described by Reed et al.(2008).

The next step is the differentiation between and categorization of stakeholders. This is done with a so called interest influence matrix. In this matrix the stakeholders are grouped by their level of interest and level of influence according the current problem.

The last step is the investigation of relationships between stakeholders. Although the literature prescribed different methods to map stakeholders, during the research it became clear that these methods are not sufficient in this specific situation.

Therefore, we used the order of the production process of product Y, starting with the stakeholders at the first production department and ending at the location of the customer.

The stakeholder network results in an overview of all stakeholders involved in the waste flows, varying from external copper suppliers and recycling companies to internal purchasing and production departments.

3. Improve working procedures to mitigate current situation:
Improved working procedures and control them will lead to mitigation of the current situation. Since all waste is weighted and labelled in the former solution, we want to maintain this transparency. Therefore, all new originated waste has to be stored at a separate location. Next to that, all new waste has to be labelled with information about the amount of waste, the article number, production order and date. We facilitate these labels and instruct the involved stakeholders about the new working procedures.

These new procedures will result in more information about stored waste and physical waste flows. Next to that, we made new procedures for machine operators

to hand in waste notifications on time, so the waste can be registered in the ERP system at almost the same time the waste is originated.

- Medium term solutions:
1. Improvements in current software:
To improve the match between the administrative and physical waste flows, the ERP system plays an important role. To optimize the usage of the ERP system, we invented several improvements. These improvements have to contribute to a better match of the waste and improved traceability.

Transfer orders: "Transfer orders are mainly used to for transfer of inventory from one location to another location. They involve posting items as shipped from one location and posting them as received at the other location" (CloudFronts, 2017).
In the situation for company X, the transfer orders can be used to transfer waste from company X to other locations, for example internal storage locations or external recycling companies. Instead of debiting it in the ERP system, as a result of transfer orders the waste is at least in the system until it is actually recycled.

Locations: For a clear overview and traceability of stored waste at premises of company X, it is valuable to know the specific locations where the waste is stored. In the current ERP system there exist already several locations. These locations are used in administrative flows to document where raw materials and finished products are stored. If these specific locations could also be added to the waste debits, this will increase the traceability. The existing locations in the system are numeric variables and are therefore not clear. Therefore, we made new, well formulated locations added to the ERP system and facilitated the system that these new locations can be added to the corresponding waste debits.

Bill of loading: By transporting the waste to recycling companies, the expedition department makes use of bills of loading. If the previous solutions are adjusted, the bills of loading can be created according another way than the existing one. Due to the previous solutions, there is more information known about the waste and registered in the ERP system.
By using this information, accountability and traceability of the waste can be improved. We made a connection between the bills of loading and waste registered in the system. The expedition department just has to fill in some numbers of the waste label of the waste that is transported, and the system will automatically fill in the other information at the bill of loading. Therefore, at each bill of loading can be seen details about which waste is transported, the amount, the weight of valuable materials, the original production order and so on.

2. Development of a recycling plan:
Instead of recycling the valuable waste at recycling companies, another possibility is to recycle it internal at company X. Although company X invested in a recycling line, the line was still not operational. Work instructions for machine operators were missing and it was unknown how to manage the administrative part of this internal recycling.
Therefore, we wrote a recycling plan with the different recycling steps and clear instructions of the corresponding tasks and expectations. During the implementation phase we observe and control to look for improvements in the plan. Also the

administrative tasks to control the internal recycling processes in the ERP system were described.

- Long term solutions:
1. New method to handle waste flow processes:
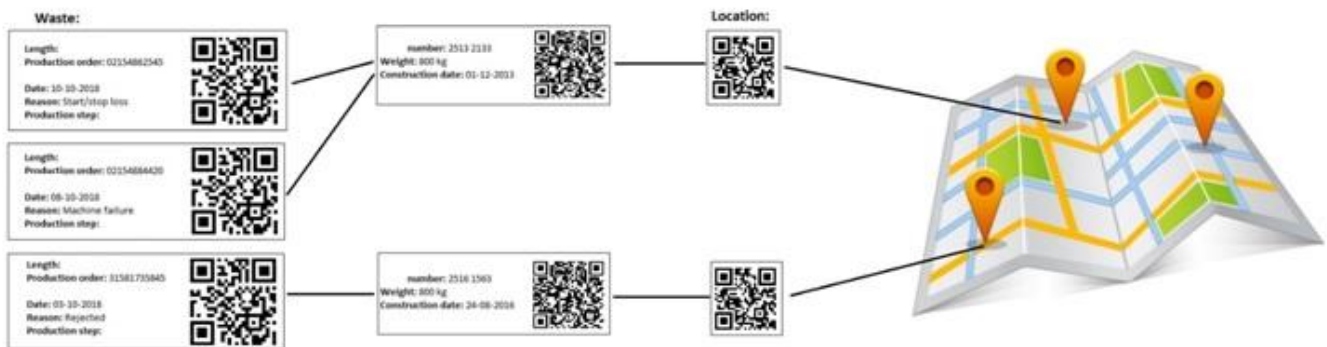
The idea is that improved traceability of the waste can be provided by working with QR codes. For each part of waste that is produced, a corresponding QR code should be made. The QR code of the waste should be provided with information of at least the length of the waste, production order, date, reason and production step where the waste is created. After the waste is produced, a label with this QR code has to be printed and attached to the bin where the waste parts are collected. The bins are already provided of unique QR codes, but these codes are not used in the current situation.

By scanning the QR codes of the waste, the corresponding bin and the location where the waste is stored until it will be recycled, and connect these scanning activities to the WMS or ERP system, company X can improve the traceability and accountability of their waste enormously.

Another fact of the new process that improves the administrative waste flows relates to the transportation of the waste. If the bins with waste are transported to recycling companies, the QR code of the bin or code of location of storage could be scanned. The system has to recognize the waste linked to this bin or location. After scanning the bin or location, there should be several possibilities:

Firstly, after scanning the QR codes of the waste that will be transported, there should be a possibility to debit the waste in the system. Next to that, there should be the possibility to create a bill of loading from the scanned waste. This relates to a previous solution, but instead of filling in some numbers from waste notifications, just a QR code has to be scanned.

2. Increase awareness of employees:
A next long term solution is the increase of awareness of employees. All employees, working at the different departments of company X or who are involved in other ways to the waste flows, have to realize the impact of their individual actions to the general waste flow processes. This is of course not just a long term solution, but starts already in the short term. However, the effect and duration will be that time consuming that in this thesis is chosen to classify it as a long term solution.

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Conversations have pointed out that the stakeholders have insight into their own tasks, but cannot grasp what happens in the greater ecosystem of waste management. If all employees are aware of the whole process according waste flows, of the total values of the waste, the consequences of their activities and all involved actions that have to be taken to get the right settlement of a waste creation, we are convinced that this will make clear a lot and stakeholders will be more accurate in their tasks.

To increase the awareness we organized information sessions. At these information sessions the whole process and corresponding sub-processes of the waste flows are explained. This will contribute to an increase in understanding of the entire process.

A second way to increase the awareness is to share experiences between stakeholders. This is not just an explanation of the process, but goes more in depth about sharing experiences to make clear what are the highlights and pitfalls. With such meetings, stakeholders are confronted with the existing problems in the different processes and get an idea about the importance how their own behavior impacts the success and failure of waste management activities.

The last way to increase awareness is the way how different stakeholders and departments communicate with each other. Improving communication between stakeholders will result in a decreasing amount of defaults and confusion.

For example, by informing the next stakeholder in the network by sending an email about fulfilled activities, curiosities, particular details and/or points of interest. Then the next stakeholder knows what he/she has to expect and can act in an appropriate way. We gave several departments these insights and they added these communication activities to their daily tasks.

3. Aspects for a new ERP system:
Due to the confidential information we cannot go in depth about this solution. But we listed several aspects of the current ERP system that are bottlenecks for an optimal waste registration. We explain why these aspects are bottlenecks and what should be changed. Company X can use this information if they decide to adapt the current system or invest in a new ERP system.

7. Methods used for validation of the solutions design
Since the solutions are invented to help the financial department, but the implementation and execution of the solutions are at the production departments, we used different methods to validate these solutions.

First of all, the case description written by the financial department of company X, is checked continuously. That is done to ensure we stayed at the right track and within the research scope.

Next to that, we used the Management Problem Solving Method (MPSM). That method helps us to find the core problem(s) at company X. So, we know the invented solutions had to contribute to one of these problems.

As already mentioned, there is a discrepancy between the production departments and supporting departments, like finance. Therefore, the invented solutions could be seen as valuable for the supporting departments, but for the production departments maybe as extra work, not applicable or other disturbing reasons. Therefore is chosen for a stepwise integration/implementation of the solutions. This is done by making the

involved stakeholders aware of 'their' problem, involve them by thinking about adaptations in the invented solutions, usage of their feedback and facilitate clear working instructions.

The results of the solutions are per solution monitored by physical observations and observations in the ERP system. Where some solutions gave almost directly the desired result, implementation of other solutions was harder. Sometimes due to discipline of employees, other moments the invented adaptations in the software were not that easy to implement as expected.
During the research we implemented the short term and medium term solutions. The long term solutions are just invented and explained to the company, but implementation should be done by them.

Due to the continuous contact and conversations with both the financial department and the production departments, we knew the solutions are validate and could be implemented with the current available resources. Sometimes after implementation we made a few adaptations in solutions, because for example it became clear that practice the upfront invented solution was not the most optimal one.

8. Expected results & Conclusions
We can conclude that this research, and in particular the above mentioned solutions, contribute to several expected results. Due to confidentiality of the report, we cannot explain in detail, but just mention the expected results and give a short explanation.

- **Provision of information:** Due to different improvements regarding the waste reported in the ERP system, the provision of information for stakeholders changes. After weighting the waste, the kilos waste in the system are no longer based on assumptions, but are based on facts. Therefore, stakeholders are no longer dependent on the weekly, monthly or annual reports made by others, but can read the information in the ERP software by themselves at every moment they prefer.

- **Real time reporting:** The time to report waste is long. By implementing the suggested solutions we are convinced this time of duration will be shorter. With the new improvements we believe this takes a maximum of one or two days before the waste is reported in the ERP system. A shortened time between waste creation and waste reporting will result in a more real time reporting of waste. As a result, this gives a more actual representation of the originated waste during production processes and corresponding waste handling at every moment in time.

- **Improved decision making:** As a result of the real time reporting and a more actual information provision, stakeholders could make decisions faster and more substantiated than before. These faster and better decisions could result in higher revenues for company X and could be related to the moment of transportation of the waste and the decision to recycle the waste internal or external.

- **Less waste:** In the research the current situation is analyzed and we documented bottlenecks in the current processes. The analysis of the processes and the identified bottlenecks gives us insights in possible causes of waste during the production process. Some of the bottlenecks are tackled by the suggested solutions in this

thesis. That will result in less production waste and therefore lower costs for company X.

- New or improved ERP system: Another expected result is the investment in a new ERP system or adjustments in the current ERP system. The analysis in this research listed all the bottlenecks in the current system and also the ideal applications for a new one. A new or adjusted system with clear waste registration will improve the provision of information, contribute to real-time reporting and increase the match between physical and administrative waste flows.