Evaluation of Waste Management at the Hogeschool of Amsterdam

J. Knuit

TU Delft

Universiteit Leiden

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by

J. Knuit

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Student number (TUD):	4164318	
Student number (LU):	s2388650	
Thesis committee:	Dr. ir. G. Korevaar,	TU Delft, supervisor
	Dr. J. M. Mogollón,	Leiden University

TU Delft

Universiteit Leiden

Abstract

This report provides suggestions to improve the sustainability of the waste management of the Hogeschool van Amsterdam (HVA), a higher educational institute located in Amsterdam. The HVA as an institute has an outspoken ambition to improve their waste management with a focus on sustainability. They previously asked several student groups to research specific elements of sustainability within their waste management. This report however, will approach the waste management as a whole and will shed light on what is important to successfully improve their waste management considering all its aspects.

The report starts off with a literature review which explains the holistic nature of waste management dilemmas. The literature also shows that the success of sustainable waste management largely depends on the willingness of all involved parties to comply. Therefore, it is important to first create an in-depth understanding of the organizational structure behind the waste management, to ensure all individual management bodies within the organizational structure are on the same page. This is also reflected in the explained mythological approach and the formulation of the research questions. Following the research questions, first the organizational structure of the HVAs waste management will be evaluated with a series of interviews and a survey. The interviewees were chosen based on their close involvement with a specific management body within the organizational structure.

After the waste management as an organization is established, the waste streams within the HVA are estimated. For a holistic understanding of the waste streams an estimation on the quantity, quality, and composition of all the waste that comes through the HVA is determined. The estimations were made by using data that was made available by the HVAs current waste disposal partner RENEWI, and where later confirmed by verifying them with comparable data sets. Additionally the material based waste streams were evaluated on their environmental impacts, when disposed of on different levels in the waste Hierarchy.

With the full understanding of the waste itself and the organization, potential improvement areas are determined. To find fitting solutions the literature on waste managements of higher educational institutes around the world were looked at and experts where approached for in-depth interviews.

The results once again emphasized the importance of a holistic approach, pointing out that the success of a sustainable waste management can be significantly harmed by a single unwilling or unknowing actor. It is therefore suggested to involve the students as much as possible, to establish a continuous spread of awareness. Another result is the importance of knowledge on the waste, this can be achieved by better regulating the purchases and drawing information from them. As well as performing waste audits to determine the outflow waste. Putting these two data sets next to each other can uncover preventable problems.

Contents

1 Introduction

1.1. Introduction

The looming dangers of resource depletion are becoming more and more apparent, in the 20th century the use of resources increased by an eight-fold (Branch, 2011). Taking the growing population into consideration the world will have to increase the recycling rate of materials, moving away from a linear and towards a more circular economy. Namely the extraction of raw materials will not be able to satisfy the increasing demand for resources without resulting in an over extraction of material resources or in the degradation of environmental resources. This problem was recognized and put into words when the United Nations General Assembly agreed to the Sustainable Development Goals (SDG) in the form of SDG 12, responsible consumption and production (Nations, 2020). The Dutch government followed by expressing the will to work towards a Circular Economy (CE) (Rijksoverheid, 2016) by focussing on the reuse and recycling of materials. One of the attention points the national government focusses on is the steering away from linear practises by individuals and professionals (Rijksoverheid, 2016).

The Hogeschool van Amsterdam (HVA), is one of the main Higher Educational Institutes (HEI) of Amsterdam. The HVA feels that with the growing climate pressures and the national and international outspoken ambitions, they can provide an exemplary function. Therefore the HVA aims to improve their own sustainability, one of the ways the HVA wants to improve the sustainability within the faculties is a more sustainable and circular waste management. The faculties of the HVA are scattered over the whole city of Amsterdam , but the focus of this research will be on the faculties within the cluster name “Amstelcampus”, located mainly in the Amsterdam-oost and the wiebaustraat. The HVA has a large population the uses the facilities within the faculties on a daily basis, this population exists out of students, teaching staff and faculty management and assisting staff. As can be imagined the large population creates a large amount of waste every year which needs to be dealt with. At the moment the waste disposal service RENEWI is the sole waste collector of the HVA. However the HVA is not satisfied with the recycling rate currently achieved and they believe their waste can be recycled better than is currently done. By doing so they want to reduce the material footprint of the users of the facilities. In their exploration the HVA has appointed student study groups to research diverging aspects of circular waste management, often under the supervision of Joep de Hoog. De Hoog is a lecturer at the HVA,

he also works as a project manager waste management for the HVA and the University of Amsterdam (UVA). The subjects of research preformed by the study groups ranged from motivation and behaviour analysis behind waste separation and recycling to sustainability assessments of individual products like paper cups packaging materials.

This research will mainly function as a case study and will combine the information of other HEIs and experts on waste management to determine the possible improvement areas and improvements of the waste management for the HVA specifically. With Joep de Hoog as a main contact person, this research will evaluate the current waste management structure and analyse the current waste flows. Data on the waste management and contacts within the organization of the HVA were supplied by de Hoog.

1.2. Reading guide

This report exists out of 6 chapters that all serve a specific purpose. Each chapter always start with a short introduction of what can be found in the chapter. The chapters are structured in a way that they always build on the information presented in the previous chapters. In chapter 2 an extensive literature review will be presented going into some recurring definitions, the social aspects that influence a waste management, several often used methodological approaches and three examples of waste management research on other HEIs. A conscious decision was made to first go through the literature before explaining the research question. The literature expresses how waste managements problems are approached in previously preformed research and what the most important facets are that need to be considered. This information is directly used in the structuring of the research questions.

Chapter 3 will explain the methodological approach for the upcoming research. The literature helped formulate three sub-research question that will guide the research towards answering the main research question. Namely, each sub-research question represents a step that needs to be taken in order to answer the main research question. The main research question and sub question will later be individually answered in chapter 5.

First in chapter 4 all the information necessary to answer the questions will be collected. This consists out of interviews, a survey, expert and case study information and more literature information on waste disposal.

As the sub-questions build up to the main research, so does chapter 5. In this chapter each research question will separately be provided with an answer based on all the previous found information. While using the sub-questions to build up to the main research question. The report will be concluded in chapter 6, providing closing recommendations on necessary improvements and future research.

2

Literature Review

In the following chapter a review of the available waste management literature will be given. In the search for appropriate papers the first aim was to find research that specifically looked at the waste management of Higher Education Institutes (HEI). Later the search was broadened to more general waste management related research. Within waste management there are multiple aspects that play an important role. This literature review will give an insight into the structures of those aspects and their importance to waste management as a whole. First a view reoccurring concepts found in the literature will be explained. These concepts are often used as an underlying premise for the buildup of produced research. Next some methodological tools used in several papers will be used to explain different approaches to waste management research. Another important aspect that determines the success of a sustainable waste management are social aspects, the next part will show how the behavior of a population influences waste managements. Second to last a small selection of waste management research on HEIs will give an example of how this kind of research have previously been performed and explain results that came from them. The chapter is concluded in a reflection on the literature and the role the research presented in this report has in it.

2.1. Definitions

Most literature found, stresses the importance of a well-formulated definition of waste. The European Commission Waste Framework Directive (WFD) defines waste as "any substance or object which the holder discards or intends or is required to discard" (Waste Framework Directive, 2008). The WFD defined most waste related terms for the use in later documentation, both within the legislative layers and for research performed outside of the EU as an organization. Not all definitions are all-embracing as Schneider (2013) describes in her review of food waste prevention articles. In her opinion the food waste definition does not encapsulate all food waste. The problem starts with the definition of food. This definition is referred to in the food waste definition, which leads to the exclusion of a significant segment of all food waste. Due to the formulation of the definitions, all animals or plants not destined for human consumption are disregarded. Examples of where this leads to food waste exclusion are, calves killed for the production of cow's milk, male chicks in the chicken industry and plants which do not fulfil the visual standards, like curved cucumbers. There is another definition of food waste put forth by the International Food Policy

Institute. They define food waste only as food waste when it is created before it reaches the consumer. This definition brings two limitations with it. Namely the exclusion of food waste created by the consumer and the inclusion of all food waste that is repurposed into for instance animal feed (Amicarelli et al., 2020). The contradictions and limitations of these definitions show that it is important to them into consideration to accurately understand any conclusion. Nonetheless, there are many examples of the definitions provided by the WFD used properly, Salhofer et al. (2008) used the definition in their creation of classifications of waste prevention, Zorpas, Lasaridi (2013) and Sharp et al. (2010) use the definition of waste prevention, "The measures taken before a substance, material or product has become waste, that reduce the quantity of waste, the adverse impacts of the generated waste on environmental and human health or the content of harmful substances." Waste Framework Directive (2008), in their papers on methods for the measuring of waste prevention.

Another reoccurring concept is the hierarchy of waste (Waste Framework Directive, 2019), or the ladder of Lansink (Lansink, 2017). Both explain and rank the different levels of waste disposal methods, both are displayed in figure 2.1. The waste hierarchy is the basis of many wastes related research. Turner et al. (2016)and Jamasb, Nepal (2010) both express the importance of the waste hierarchy in the beginning of their research, explaining that for the achievement of a sustainable waste management any decision taken must be in line with the waste hierarchy.

(a) Ladder of Lansink (Lansink, 2017)

(b) Waste Hierarchy (Waste Framework Directive, 2019)

Figure 2.1: Two representations of the waste hierarchy

In both hierarchies the reduction, or prevention, of waste has the highest priority. The prevention of waste entails a behavior change in the use of products and materials. This includes product modifications, designing products to minimize waste at the products end of life, and decreasing the general consumption patterns of people (Jibril et al., 2012). When prevention is not a possibility the reuse of the materials of products should be explored next. The main goal of the reuse initiative is the prolonging of a products lifetime. Therefore, making the production of new products unnecessary. Recycling focuses on the reuse of end-of-life products on a material-based level. Trying to incorporate materials into, either the same production cycle creating a closes-closed loop, or into a different production cycle making it an open-closed loop (Huysman et al., 2015). The waste hierarchy in figure 2.1b shows the fourth step as recovery, which can be explained as energy recovery as is formulated in figure 2.1a. Figure 2.1a makes an distinction between incineration as an in-

termediate solution between Energy and Landfill. In the Netherlands incineration usually includes the generation of energy, but in other countries this is not always the case. Björklund, Finnveden (2005) explains that the production of recycled materials is far less energy intensive than producing products with raw materials and makes is clear that the last 2 (or 3) levels of the hierarchy of waste are to be avoided. Eriksson et al. (2005) looked at municipal waste management not only from an environmental point of view, but also considers the energy resources and social impacts. Although they found that there are drawbacks to all waste disposal option, they came to the conclusion that it was obvious that straight landfilling was not the way to go and that incineration (with or without energy generation) would only serve as last measure to avoid landfilling. This is a conclusion that was been shared by the work of Turner et al. (2016), they concluded through their scenarios that a reduction on landfilling would have the most benefits for the environment.

2.2. Methodological approaches

Over the years there have been many studies on the approach to waste management dilemmas. These approaches often include systematic thinking and are therefore easily repeated as step-by-step plans of action. System thinking also implies that the problem is approached holistically, meaning it is not considered as an issue of a closed system but that it is incorporated and affected by into larger systems that need to be considered. An example is the research done by De Langhe et al. (2013). In their endeavor to restructure the Belgian waste management logistics, they came up with the Innovative Logistics in Waste Management for a Sustainable Environment (ILSE) project. The ILSE project consisted of 6 consecutive steps. The steps are 1) Analysis of the current system 2) Research the best practices in circularity 3) Divine the parameters 4) Coming up with new concepts 5) Setting up pilot programs to test new concepts 6) Producing a road map towards implementation. These 6 steps are accompanied by 6 tools that would be used to perform the mentioned steps and create the mentioned holistic overview. Namely, Academic research, SWOT-analysis, parameter-impact modeling, Pilot projects, giving opportunities to local businesses, dissemination.

Zurbrügg et al. (2012) took on a different approach, they came up with a comprehensive list of indicators and representative questionnaire questions, categorized under 5 important elements, Technical functionality/appropriateness, Health and environmental impacts, Costs finances and economics, social aspects and Organizational strength and institutional support. They believed that a successful functioning waste management that improves the environmental aspects, should not only be dependent on technological progress. A strong social mobility and acceptance, well arranged legal and institution roles and financial viable structures should all be considered in the decision making process. This is an example of the holistic nature of their approach. With the use of the proposed indicators Zurbrügg et al. (2012) analyzed a waste project in Indonesia. From the analysis they identify barriers and obstacles, which they used in a strategic way for a waste management transformation. To better understand the nature and influence of specific indicators in their system, Zurbrügg et al. (2012) advises to use a method called Analytical Hierarchy Process (AHP). An AHP is a useful tool when constructing a multi-criteria decision model. It relies on subjective managerial inputs on multiple criteria. After converting these inputs into scores, the connected indicators can be used to evaluate scenarios (Handfield et al., 2002).

Another method to identify waste streams and their prevention potential is proposed and utilized by Salhofer et al. (2008), they used 4 possible classification criteria. The criteria are, waste stream, target group, instruments, purpose. By classifying a case study by these criteria, Salhofer et al. (2008) wanted to quantify and analyze the prevention potential within waste streams. Furthermore, they concluded that for a successful waste reduction more rigorous measures are required including a reduction in consumption. Without, only 1-3% of waste can be prevented.

The use of Material flow Analysis (MFA) and Life Cycle Analysis (LCA) also play a large role in many wastes management related research. Amicarelli et al. (2020) researched the possibilities of waste prevention within the Italian potato industry. There they used an MFA approach to keep track of all the processes and see where the most benefits could be achieved. Part of their conclusion was that the use of an MFA was very suitable for the analysis of a single stream within an industry or sector. However, it is less useful for the measurement of general waste streams with more than one material. It is also dependent on the access to information, often a lack of information on processes within the industry can be a limiting factor. To complement the scenario sketching abilities of an MFA, a LCA can be used to evaluate the scenarios on environmental impact. Turner et al. (2016) use both tools in their analysis for the decision making in solid waste management. The MFA is used to model multiple scenarios which are tested on an overall management system, while the LCA helps to get a view upon the emissions related to the decisions within the MFA models. Padeyanda et al. (2016) also uses this described method on the best practice for different food waste facilities. With the help of MFAs four scenarios on composting and different configurations of wet and dry feed production were made. Which were later reviewed on environmental impacts by an extensive LCA. Both papers used the open source program STAN 2.5 for the MFA modeling, while different programs were used for the LCA, Turner et al. (2016) used EASETECH and Padeyanda et al. (2016) used TOTAL 4.0.

While MFAs are often used for measuring waste streams, a different measuring tool needs to found for the measuring of waste prevention. The measurement of waste prevention has traditionally been an objective that is not the easiest to accomplish. Zorpas, Lasaridi (2013) express that difficulties occur due to the nature of prevention. Namely, prevention measuring means measuring something that is non-existent. Zorpas, Lasaridi (2013) and Sharp et al. (2010) and Amicarelli et al. (2020) all used and explained 5 different approaches to measure the effects of waste prevention methodologies. An aggregated list of these approaches based on work done by Zorpas, Lasaridi (2013),Sharp et al. (2010) and Amicarelli et al. (2020) is show in table 2.1.

Table 2.1: Methods of measuring waste prevention

Direct monitoring of waste stream reduction
Source cost reduction analysis
The use of indicators (economic, resource, waste)
Resource productivity ratios (products produced per resource used)
Using existing methods

Zorpas, Lasaridi (2013) and Sharp et al. (2010) both developed these 5 approaches fur-

ther into 10 methods which were evaluated on their strengths and weaknesses. 'Self-weighing, monitoring and reporting', usually works best in smaller groups of around 50 people. An advantage of the method is that while it is a measurement tool it simultaneously educates people on the subject of waste, unfortunately this method is always harmed by its inconsistencies. 'Use of collection round data', is a method that can monitor geographically based waste generation. The Method, 'Use of control and pilot groups', makes use of round data collection, but does so with the use of multiple areas. Areas with different policy implementations, which means some variables can be tested. 'Attitude and behaviour surveys' is a method that is often used to set a base-line scenario. The method also plays an important role in spreading information of a project or campaign and the construct behind it. All methods mentioned above were also used by Martinho et al. (2018). They looked at the waste management of a large festival in Portugal and specifically used surveys and waste characterization campaigns to understand the waste streams generated. The measured waste streams were later turned into usable data. Another form of surveys used are 'Participation surveys'. These surveys are mainly used to monitor the number of participants. Important factors to be conscious of are, the need of a proficient sample size, estimating the involved risks, unrepresentative samples and self-reporting biases. 'Compositional analysis' is a more direct method of measuring the actual waste that is being collected per material waste stream. The benefit of this method is that there are no biases or personal interpretations that can influence the outcome. The method is however strongly dependent on the quality of data. A similar method is the 'Conversion factors, estimates and modelling'. Here the waste is not measured precisely but indicators and conversion metrics are taken to determine the waste produced. The 'Point of sale' method focuses more on an individual product than on a complete material stream. It uses the purchase and sales data of retailers and links these together with packaging and other product information to determine the complete waste stream. This way the effects of for instance the reduction of packaging material can be modelled. The last method that is discussed is a combination of all previously mentioned methods, namely the 'Hybrid approach'. The surveys and the monitoring of waste complement each other and help to produce a complete overview of the situation which enables the researcher to produce an as realistic model as possible. Zurbrügg et al. (2012) also emphasizes the importance of a hybrid approach. Their methods of inquiry do not differ much from the above-mentioned methods, with the only additions of including an historical analysis to understand the processes that lead to the current situation, they also advice the consultation of expert knowledge and looking at comparable case studies that might have already solved certain problems.

2.3. Social aspects of waste management

The Holistic nature is best expressed in the social influence on waste management systems. The influence is largely due to whether the people are willing and able to comply with introduced policy measures. In order to get an understanding of waste prevention motivation and behavior and how to exert a positive influence, four important barriers are identified ((Zorpas, Lasaridi, 2013; Sharp et al., 2010)) and shown in table 2.2

Zorpas, Lasaridi (2013) and Sharp et al. (2010) both specifically stress the negative effects of their third barrier. Due to the focus on recycling, people tend to forget about the highest priority within the waste hierarchy, namely prevention (figure 2.1). The success

Table 2.2: Social barriers to waste separation (Zorpas, Lasaridi, 2013; Sharp et al., 2010)

1	The extent to which it has not been possible to identify the reasons behind why waste is being prevented
2	The extent to which the impact of specific (or individual) intervention or campaign measures remains little understood
3	The inability of participants to make a conceptual distinction between waste prevention and recycling
4	a new and different way of intervening, targeting and messaging will be needed in order to engage new audiences, i.e. those not currently predisposed to waste prevention

of recycling therefore works as sort of rebound effect (Hertwich, 2008) on any incentives towards waste prevention. Caniato et al. (2014) emphasise the importance of an holistic approach in their research about waste management. The nature of waste management is one with many different involved actors and stakeholders. To make the whole cycle within waste management a success it is important that all of these actors and stakeholders agree on the, by Caniato et al. (2014) proposed, determinants of sustainability. These determinants are, technology, social aspects, economy, institutions and environment". In order to do so, they propose the use of precisely defining the role of all the involved actors and stakeholders with the use of tools like, Social Network analysis and stakeholder analysis. These tools can shed a light on the driving forces of actors and stakeholder, existing communication and bottlenecks.

In order to have a successful recycling management, the collected waste needs to be separated. There are to main methods differentiated. There is source waste separation where the waste is sorted by the initial disposers of the waste into several material-based streams. Or post-separation where the waste is collected into a single waste stream and separated later in a specifically designated waste separation facility.

Turner et al. (2016) concluded that as a result of effective source-separation, you potentially have a higher percentage for recycled waste due to the effectiveness of mono material facilities. Namely their research in Wales showed that mono material facilities have an average recycling rate of 80%, while residual waste streams only have a recycling rate of 42%. However, Gallardo et al. (2016) experienced the difficulties of source waste separation due to high contamination rates, which forced them to a, second post separation stage.

To make the source-separation of waste a more accessible approach the HVA asked several students to research the topic from various points of view. One group for instance focused on the use of self-explanatory trashcans, Daalhuizen et al. (2020), to make the step of waste separation easier for the users. Others like Uiterwijk (2018) added to the large array of research done on the motivations and behavior of waste separation. Uiterwijk (2018) concluded that the main factors for source-separation of waste are, awareness, habits, norms, self-efficacy and self-image, motivation and external factors. For sustainability policies to be successful, these factors need to be aligned over the whole relevant population.

This is especially difficult in organizations where the population is diverse and for the largest part unrelated. Martinho et al. (2018) found that the motivations for people to comply with introduced measures are closely related to ones upbringing which can widely differ per region of origin. But also, the frequency of visits is important, as when people

visit somewhere more often, they are more familiar with the rules and also feel more connected and therefore more responsible to a specific area. In a more related research to the HVAs case study by (Schoot, 2017) shows where you can suspect potential problems to arise. Schoot (2017) showed with in-depth interviews with students of the Utrecht University what the main motivations behind not separating waste are, table 2.3.

Table 2.3: Motivation behind not separating waste at Utrecht University (Schoot, 2017)

1	The general disbelieve in the usefulness of separation
2	Lack of trust in the continuation of separation
3	A lack of initial motivation
4	The lack of sufficient utilities

While number 1 to 3 are more depended on the intrinsic motivations of the users. The fourth motivation is something the HVA could directly change. Cecere et al. (2014) found in their analysis of surveys published over the whole European Union, that recycling is predominately an intrinsic decision. This makes the first three motivations of Schoot (2017) a more prudent matter. These three are possible to be adjusted through the right education but will be a slower change. Martinho et al. (2018) observed at the Andanças Festival Portugal, that enforcing strategies to prevent waste can be relatively effective. These waste prevention strategies were mainly focused on the caterers on the festival, which were mandated by contract to comply.

In addition to the waste prevention strategies the organization also had waste separation initiatives. These initiatives required cooperation from the festival goers and although the survey showed that people were aware of the initiatives and indicated they were willing to comply, the separation rates were minimally improved compared to the baseline measurements. From the work of Martinho et al. (2018) it can be concluded that designating a smaller group with specific responsibilities is more effective than trusting on a larger group to work as a whole and continuously preform this task. It is however not necessarily the case that people are not willing to help with waste prevention measures as was proven by Evans (2012). He looked at the possibility of a throw away culture towards food in the United Kingdom. He however found that causes of food waste usually have very diverse underlying problems, not related to the willingness to recycle.

In their research towards household waste prevention Bortoleto et al. (2012) found that a change of behavior towards waste prevention and a change of behavior towards recycling required different approaches as the motivations behind both are attributed to different sources. In their research Bortoleto et al. (2012) connected existing attitude and behavior theories with wider models from environmental psychology. They constructed a survey where they tested 12 hypothesis and analyzed them through a maximum likelihood estimation method named SEM. This resulted in a framework which explained the involvement of individuals in waste prevention. They concluded that whilst recycling is mainly underlain by normative factors, waste prevention behavior is influenced by environmental values, moral obligation and perceived behavior control. The difference therein lies in the perception of external results. Recycling shows a more obvious result which can be presented to the outside world, whereas waste prevention is hard present visibly. The authors understand this conclusion merely reflects that the normative threshold is yet to be reached for

waste prevention. It is suggested that the maximizing of participation in waste prevention can be achieved by creating a sense of moral obligation to reduce waste in a society. To effectively do so opportunities need to be apparent and barriers need to be removed, while also showing the benefits that come with waste prevention. Waste prevention or recycling are often still perceived as costly undertakings, while this is not the case. Waste prevention should be perceived as an economic alternative and not as an inconvenience to a day-to-day life.

2.4. Higher Educational Institutes

As preparation for the coming research of the waste management of the HVA. It is advised by Zurbrügg et al. (2012) (section 2.2) to draw from any expert knowledge that is available. Therefore, this section will go through three papers on the improvements made within the waste management of a Higher Educational Institute. Unfortunately, no research was available on any University or Hogeschool within the Netherlands. The papers that were found are of Universities in The United Kingdom, Canada and Spain. Due to cultural difference in campus life, the preformed research is not entirely representative of the HVAs organizational situation and waste quantity and composition. However, the information found is interesting for potential policies the HVA may be able to implement.

University of Northern British Columbia, Canada (Smyth et al., 2010)

In this paper research has been done to evaluate the waste management of the Prince George campus of the University of Northern British Columbia (UNBC) located in Canada Smyth et al. (2010). The goal of this paper is to conduct a comprehensive waste characterization of all the waste that is generated on the campus and on the basis of that characterization provide the representatives of the university with recommendations for waste minimization.

The research started with an audit of the generated waste on campus. To assure the results would be representative of the average waste generation, two time periods of 5 days had been planned. One in the winter and one in the spring to account for possible seasonal variability in the waste generation on campus. The audits resulted in a list of waste per material per campus building expressed in Kilograms, figure 2.3 shows a representation of that list expressed in percentages. Thereafter these waste streams were defined by their potential for sustainable disposal (figure 2.2).

The authors speak about three aspects to consider when constructing a waste prevention plan. One could look at the largest percentage of waste which is paper towels. This bears the most potential reduction. However financial aspects also play a large role in the decision-making process. Positive financial incentives can make it easier for a policy to be implemented. The university has a contract wherein the paper towels are free. Therefore, there is less incentive for change. The last aspect to determine a decision on, is the ecological benefits. The alternative for paper towels could be a hand drier. To determine whether or not this is more desirable than paper towels, an extensive LCA can be performed. Based on a literature review the authors chose the three streams with the largest volume and with the largest share in environmental damage. they choose these because the reduction of these streams would lead to the largest benefits to the environment. The three waste streams were determined to be Paper products, disposable cups and compostable organic

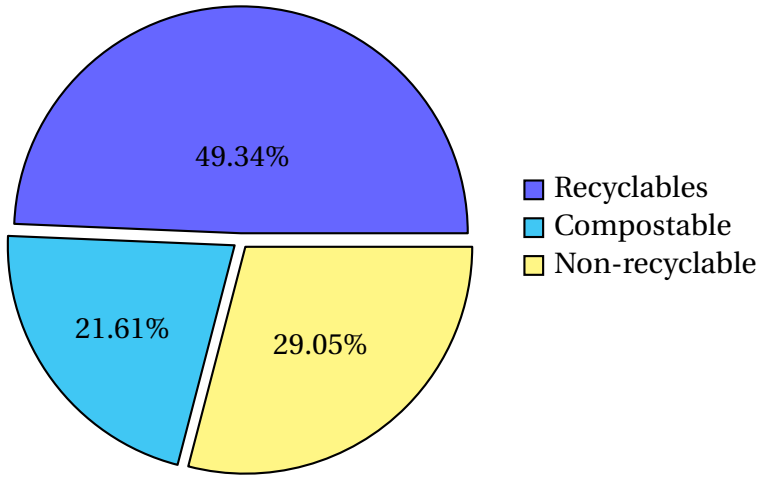


Figure 2.2: Potential of audited waste streams.

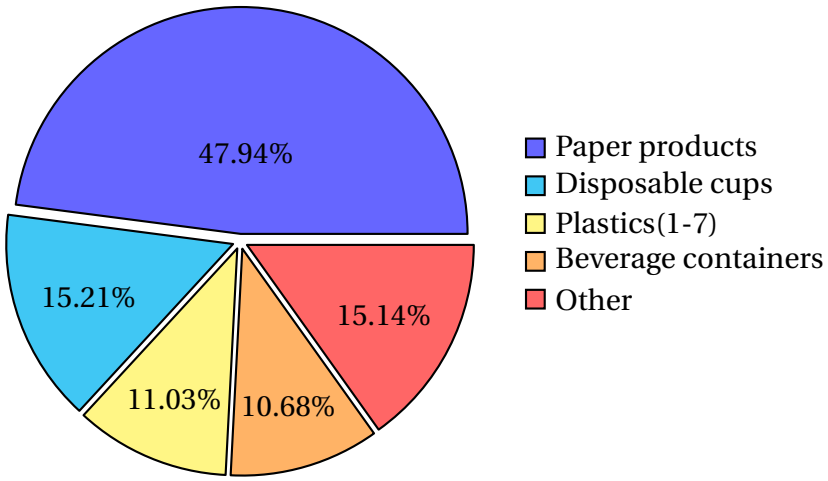


Figure 2.3: Waste composition UNBC

matter.

For the Paper stream ways of reuse were found in the form of double printing on paper and re-utilizing paper for memos. Ways of paper waste prevention were found in, switching to other hand drying methods, canceling the mandatory hard copy hand-ins of assignments and default duplex printing policy. The ensure the success of these policies, awareness was created on a large scale by placing the paper bins more strategically around the whole campus.

The recycling of disposable cups is a difficult problem for multiple reasons. The use of reusable mugs over disposable cups is also highly debatable on an environmental level. Thus, this is not necessarily the solution to the problem. However, as of that moment the cups would all end up in a landfill, the least desirable destination for waste (Eriksson et al., 2005). For the UNBC it was therefore evident that reduction should be the main focus for disposable cups. To reduce the use of disposable cups an initiative was introduced to sell reusable cups. This would lower the number of disposable cups used. In addition, an awareness campaign was started to make students more aware of the sheer number of cups that are used. This was done by displaying the collected cups as decorations in hallways,

covering the entirety of the ceilings. It was also attempted to create a financial incentive by putting surcharges on the cups. Research showed that a minimum of 0.10$ reduction or price difference is required for a significant effect.

organic waste is due its considerable weight often the most expensive waste stream to dispose of and it has the highest potential of emissions when landfilled (Turner et al., 2016). These two factors make organic waste an important opportunity when considering a waste reduction and diversion strategy. The best way to dispose of organic waste in a sustainable way is by composting the waste. This has the additional advantage of providing fertilizer for agricultural practises. Because the local government does not have any composting facilities, the authors expect that the university will build their own facilities. This also gives the university the opportunity to include options for the composting of paper towels and disposable cups.

Studies had shown that providing people with the opportunity to conveniently dispose of their waste in a sustainable way. Will have a high impact of the amount of waste that is separated. Assuming it is effectively communicated how these utilities are to be used. This will lead towards more recycling and while this is an improvement, prevention (source reduction) should still be the main goal. Well suited campaigns are a great strategy to inspire the users to reuse and reduce their paper usage.

The University of Southampton, United Kingdom (Zhang et al., 2011)

The University of Southampton (UoS) has committed to a more sustainable waste management. In order to achieve that they used the PESTLE approach. Within the PESTLE approach the goal is to include multiple aspects in the decision-making process and therefore not focus on a single strategy. The aspects are, political, economic, social, technological, legal and environmental (PESTLE). Over a 4-year period the UoS wanted to achieve financial and environmental goals to set up a sustainable waste management strategy. All goals were achieved. A four-phase strategy based on the PESTLE approach was created and with the strategy a reduction in costs of 125 thousand pound and a recycling rate of 72% were achieved.

Before the planning of the stages started, the university familiarized itself with information that would be relevant and influential to their goals. They collected knowledge on recycling activities and programs within the higher education sector (HES) (table 2.5), they identified the most important factors that influence the recycling rate of a HEI (table 2.4 and found relevant legislative standards applicable to HEIs.

Table 2.4: Influential factors on recycling

Understanding of the Higher Education institutes (HEI)
Commitment and demonstrated support of environmental actions
Sufficient funding
A University wide coordination
Adequate communication and knowledge
Well planned infrastructure
Reliable contractors

From this list the authors argue that the lack of funding is the integral factor in the effec-

tiveness of a sustainability plan. When funding is not available it is considered a defining obstacle. A second important factor that was lacking according to their research, was a large knowledge gap on sustainability topics within separate departments of an HEI. Clear and effective communication would therefore play an important role in their strategy.

Table 2.5: Recycling programs and activities within the HES

Waste aware campus: Creating awareness among the students and staff of a HE.
Ecocampus: An Environmental Management System (EMS)
EAUC, A waste management guide
Green Gown Award: A award to reward HEI's with sustainability activities
Planet and People "Green League": A ranking of HEI's on sustainability
College and University Recycling Coalition
Recycling market
Moving towards zero waste: An international sustainability network

Phase 1 of the 4-phase strategy started in the late 1990's and was complete at the end of 2004. At the beginning of phase 1 the state of the universities sustainable waste management was close to nonexistent. Phase one consisted out of 4 policy implementations. They started a voluntary paper recycling project and source separation pilot. They also setup a few management departments with the purpose of structuring a more sustainability-oriented waste management. To reduce costs the UoS negotiated a pay-by-weight contract instead of their usual contract where they paid per volume for their waste disposal. The first phase was primarily used for data collection on waste quantity, quality and material compounds. Also, the waste sources were closely identified making it easier to prevent waste in the future.

Phase two played from 2005 to the end of 2007. The goal of phase two was mainly to use the data collection strategies setup in phase one and look at ways to prevent and recycle more waste. From the start of phase two a plan was made. Outside third-party partners were used for the necessary information on waste impacts. Looking at individual waste life cycles it was determined which waste streams would generate the most environmental surplus if prevented. This resulted in purchasing products which were predominately made from recycled materials and/or products that could easily be recycled. Using a centralized ordering platform drastically reduced administrating costs, reducing the number of suppliers from 30.000 to 7.000. A environmental manager was added to the waste management team to work on a daily basis on the sustainability of the waste system. The data used from the pay per weight data, and a later audit of all the collected waste, was used to regulate the waste system more effectively. Bins were placed more strategically, and the waste pickups were planned more efficiently to reduce the total amount of pickups needed. These changes had both financial and environmental benefits. The costs were decreased by working more efficiently and simultaneously that meant significantly less emissions would be produced by the pickup system itself. To make this more successful the students and staff were made aware of the changes by organizing several "Green Awareness Activities". Later students were asked to separate their own waste in their dormitories and communal areas.

Phase three started in 2008 and ended in 2012. Phase three took a step back from source separation as a separation method. It was found out that source separation was not as ef-

fective as was desired. The alternative was a Co-mingled recycling approach. Here all dry waste was thrown into one bin and separated in a later stage. This turned out to be more convenient, safer and produced a higher recycling recovery rate, without being more expensive than source separation. The Environmental manager instructed so called "environmental champions" to help individual departments in micromanaging their environmental improvements. For instance, they helped in the setup of a phone back pilot, where old phones were collected for reuse or recycling purposes. The strategies the "champions" and the departments implemented provided useful feedback to the environmental manager.

Phase four was the ongoing phase at the time of writing and mostly speaks of future plans. It spans from 2012 onward. The main activities for phase four thus far were a pilot where organic waste would be collected separately from the rest of the waste. This was in line with the UoS future plan for introducing an organic waste composting center on the campus itself. When the funds are available this will be implemented. Before that it is important that the university works on the separation of food waste from the waste stream itself.

In table 2.6 the progress the UoS made per phase. It is visible that the total amount of produced waste goes down steadily from 2004 to 2008, and the recycle ratio goes up at the same time. The policies changes were not merely direct successes. A view were met with

Table 2.6: UoS waste reduction from 2004 to 2008

	Total waste [tonnes]	Recyclable waste [tonnes]	Recycling rate [%]	Cost per year [millions]	Cost per tonne residual waste [£/tonne]
2004-05	6000	1800	26	0,56	91
2005-06	6100	2600	41	0,49	77
2006-07	5600	3850	68	0,48	88
2007-08	4000	2900	72	0,45	112

some inconvenient and unforeseen problems that needed appropriate solutions. One of the implemented policies that met a large barrier was the pre-separation of waste due to the contamination in the recycling bins. This hurdle was approached with more information awareness techniques. For instance, the use of bigger signs on bins, more conversation with users and more open information sources on recycling, mainly on the university's website. The introduction of the improvement of the infrastructure was also submissive to some barriers, the users had to get used to the new scheme and changes had to be communicated better. The contractor responsible for the waste pick up and processing was found to be unreliable. A crisis meeting with evidence of unacceptable handling of separated waste led to improvements on the contractor's side.

The behavior change of students was something the UoS had little experience with and couldn't find any reliable sources on. Their strategy was to include the students from the very start by using their creativity and insight to come up with fruitful strategies. Waste management and recycling is not the first priority for students therefore is was concluded that this information had to be spread repeatedly. At the end of each year surveys were

conducted to see how successful some strategies were and how students thought about recycling and the performance of the UoS in this regard.

University Jaume I, Spain (Gallardo et al. (2016))

This paper investigates the waste management of the Spanish university Unversitat Jaume I (UJ). Their stance on the improvement of waste management is that the data collection is integral to improvement. In their research they will focus on the collection of data to identify the most important waste generation sources, to make a quantitative estimation of the waste generation and the determination of the waste composition. The conclusions drawn from this research can be used as a starting point to strategize a plan for waste minimization. To get data representation as close as possible to reality they stress the importance of a year long term scope, because waste generation and its composition are highly dependent on seasonal aspects. In order to determine the most contributing waste generation sources, an audit of the waste bins of all faculties was conducted. To substantiate these findings, interviews were conducted with members of different organs within the waste management. These included people of the cleaning staff and waste managers.

At the moment of research, the UJ was already financially incentivized by government regulation to separate Paper/cardboard waste, Lightweight packaging and Glass. These streams are collected separately over the campus in separate waste bins. The UJ receives money per amount of weight [kg] they collected. These streams are therefore already identified and quantified. That leaves the residual waste, called the mixed waste (MW), that needs to be examined and quantified. The estimation of the MW experienced some difficulties. The waste was not measured at pick up and since the pickup was done by a truck that was on a route with non-campus areas, the content of the truck could therefore not be taken as a representation of the MW of the university. They solved it by conducting sample measurements, spread out over different time periods and seasonal periods to create the most accurate representation. These results were checked by a calculation model based on the number of users and other waste parameters. The total waste generation for the UJ, where MW and the previous mentioned separated streams are added up, is 89.5 g/user/working day. Calculating further with 215 working days, as determined by the authors, and the 17.394 users of the campus. The total waste per year amounts to 114,704 Kg/year.

The relative composition of overall waste collected at the UJ can be found in figure 2.4. The fraction of hazardous waste, not earlier mentioned, is a very specific waste stream which needs to be collected separately by specialized contractors. Although it is not an insignificant fraction of the collected waste, it is disregarded for the rest of the research as it falls outside of the scope. Of the remaining waste streams the mixed waste is clearly the largest with 54.22%. However this stream needs to be dissected further into material based streams and as can be seen in figure 2.5, the mixed waste stream contains a significant amount of recyclable materials. The mixed waste stream exists out of a total of fourteen materials. Of which organic waste, clean and dirty paper and plastic are the largest. The other eight streams all had a contribution of 4% or smaller and were therefore grouped together. The eight streams are, ferrous and non-ferrous metals, clean/dirty cardboard, tetra brick cartons, sanitary cellulose, rubber and leather, hazardous waste and inert waste.

The research allowed the authors to provide some conclusions on the variation in waste

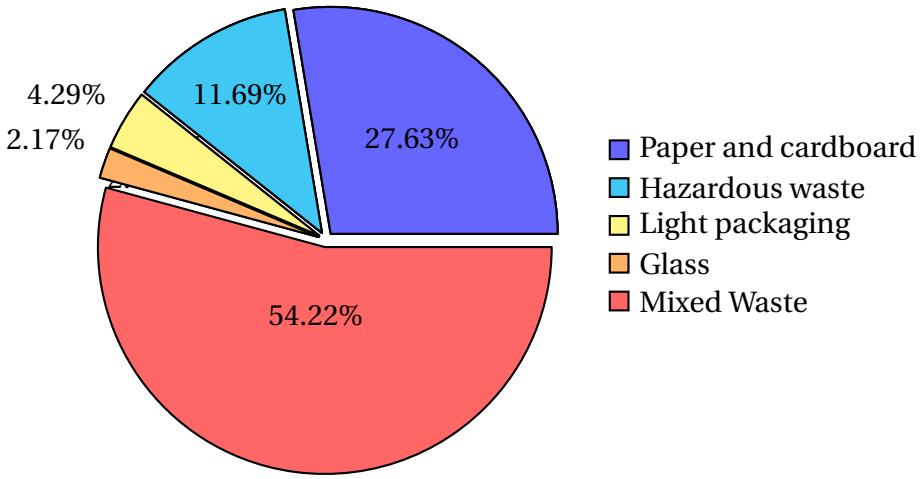


Figure 2.4: Composition of overall waste

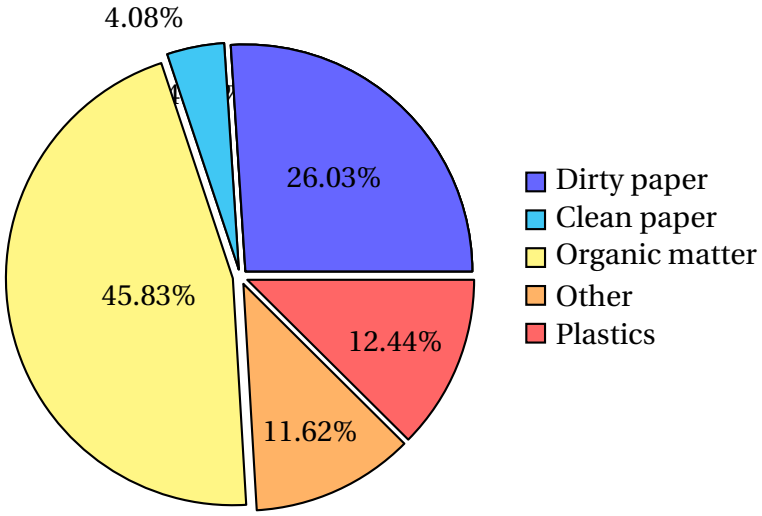


Figure 2.5: Composition of Mixed waste UJ

collection between the different time periods of auditing. Firstly, the waste collection does not vary over days in the week much, with as only outlier Saturday where less waste was collected (it must be noted the Sunday was completely left out of the monitoring). The statistical analysis also showed that the composition of waste collected in the canteens is not affected by the seasonal differences, this is not the case for the collected cleaning waste. Here there were differences measured in the amount of organic waste collected. The mixed waste fraction of the waste collected is 45.58 g/user/working day, the already separated waste, glass, paper/cardboard and light packaging add up to 43.92 g/user/working day. The authors discuss that with the implementation of simple measures most of the plastic, paper, cardboard, metals, glass and cartons can be extracted from the mixed waste stream. They estimate that this will result in a reduction of 22,314 kg of waste per year.

2.5. Literature Reflection

Looking back at the discussed papers on the several aspects and approached towards waste management, a certain few things can be concluded. The first and foremost thing is the importance of a holistic approach. To work on the improvement of waste management one cannot disregard any of its facets.

It all begins with creating a realistic overview of the current situation. This includes a comprehensive and detailed knowledge on the amount, composition and source of all the waste that is generated. It also entails an understanding of the current workings of the relevant management organs within an organization. A clear communication structure is key when implementing sustainability policies. All the involved actors need to be well informed, the wrongdoings of one group can have detrimental effects on the outcome in its entirety. Tools as Social Network Analysis and a stakeholder Analysis can play an important role this facet. The role of the users within an organization, such as HEIs, are also very important as they are in many ways the executive power. The motivation and behavior of a large group of people within a specific organization and other similar locations, has been thoroughly described. A defining conclusion is that the pursue of complete involvement is a continuous effort. People need to be repeatedly reminded to achieve results. To ensure an integrated involvement of this group several strategies are proposed. The results of these strategies not only show that their involvement is necessary and possible, but also that it can be used as a stimulus for further innovation.

A successful circular waste management is also dependent on the partners an organization is able to work with. An equally minded government can create an economic and social environment where sustainability projects can flourish. The legislative boundaries they setup can either stimulate or discourage sustainable innovation but is not necessarily the defining factor. An institute like the HVA is however reliant on the best practices of recycling partners and their technological capabilities. When there are no partners to pick up certain waste streams an organization might be forced to invest in their own facilities. This is however not always a possibility due to economic and practical limitations.

The measurement of waste and waste prevention is also an important and widely discussed topic within waste management. It can be concluded that the use of a MFA is a well suited method for the mapping of waste streams within a community. The method maps the flows of a single material flows and is able to detect hot spots, the method can also be used to compare multiple scenarios on the basis certain policy implementations. However, there is often a lack of data on the material-based waste streams. The literature explains the best practices of measuring those. In most cases this comes down to a combination of surveys and waste audits that are thereafter used to make an as accurate as possible estimation.

In this literature review the basis has been laid for the to be used methods in this report. A lot of research has been done on the inner workings of managing the waste of a large company, municipality or HEI. However, the precise effects of policy implementations are still ambiguous for the most part, as is the absolute determination of waste and impact. This is largely due to specific circumstances an organization is subject to. No two waste managements are the same and no single solution will be able to solve sustainability problems for all different waste managements. This report will be a additional case study on the sustainability of the waste management on a HEI. It will give an explanation on the

organizational situation of the HVA that will provide new insights into waste management configurations. The methods and ideas described in this chapter will be used to assemble suitable strategies to improve the HVAs waste management.

3

Methodology

3.1. Research Question

The HVA has expressed their ambitions to sustainably improve their waste management. Because there is no one general solutions for sustainability issues concerning waste management, a fitting solution must be designed. The best way to come to such a solution is by using a holistic approach as is suggested in the literature. This is reflected in the main research question.

Main research question:

> What are the best suited policies for sustainable waste management improvements of the specific management organization and waste composition of the Hogeschool van Amsterdam?

Following the literature of chapter 2, an aggregated methodology is made which will be explained here in chapter 3. The methodology consists of an evaluation phase of the current situation at the HVA, an analysis phase of the information gathered from the evaluation and an application phase where the provided literature will be the basis of recommended policy implementations. The following sub-questions illustrate the proposed phases, which will lead to answering the main research question. How these questions will be answered will be further explained in the next section (section 3.2).

The sub-questions:

1. What is the current organizational structure of the waste management within the Hogeschool van Amsterdam?

2. What is the quantity, quality and the composition of the waste streams at the Hogeschool van Amsterdam?

3. What are the largest improvement potentials within the described waste management and waste streams of the Hogeschool van Amsterdam?

3.2. Methodology Approach

The sub-questions are used to guide the research towards answering the main research question. The first sub-question focuses on the evaluation of the current waste management on an organizational level. Its main goal being to describe the different stakeholders and the roles they play, as well as the organizational structure the HVA handles.

Sub-question 1:

1. What is the current organizational structure of the waste management within the Hogeschool van Amsterdam?

In order to get an understanding of the different involved stakeholders and actors active within the HVA, interviews were scheduled with student groups previously conducting research on the waste management of the HVA. Their findings on the involved stakeholders will form the basis for choosing more subjects to interview. The interviews will be conducted in an open conversation format, where a list of questions and topics will guide the conversation. This prepared list will be made available to the interviewees, so they are able to prepare themselves if necessary. Afterwards a loosely based transcript will be made and send to the interviewee for approval. The interviews will be supported by a survey send out to the users of the faculties. The goal of the survey is to provide insights into the material-based waste streams coming into faculties and on the behavior and motivation of the population that makes use of the facilities of the faculties. The survey questions will be designed to fulfill described goals as effectively as possible, by finding a balance between being thorough and not making the survey to long. The survey will be spread around by the contact person within the HVA, Joep de Hoog, and is meant for students and staff in order to get a full representation of the HVAs population. These two information inputs must lead to the desired all-inclusive overview. The results will be expressed in an organizational flowchart and stakeholder analysis.

Sub-question 2:

2. What is the quantity, quality and the composition of the waste streams at the Hogeschool van Amsterdam?

The goal of the second sub question is to understand the waste streams within a faculty. Precise knowledge on the waste streams can lead to possible hot spots of waste generation and to finding high reduction potentials. This is best done by creating an overview of the largest material-based waste streams. In order to create an overview of the waste streams, provided data on the disposed waste can be used, together with the waste input data from the survey. However, due to a low separation rate of waste at the moment, more detailed information is needed. A waste audit where for a certain period of time waste is collected and manually separated, is the most commonly used method of finding out the composition of residual waste streams. Due to the pandemic this is however not an option, therefore comparable information from case studies and experts will be used to make the necessary estimations. These experts and case studies will be found by going through the literature and finding sustainability representatives within comparable universities. The results will be represented in a Material Flow Accounting of the most important material-based waste

streams.

Sub-question 3:

3. What are the largest improvement potentials within the described waste management and waste streams of the Hogeschool van Amsterdam?

The provided information on the material-based streams will be evaluated to provide a basis for research on waste management improvements. The hot spots of certain material waste streams can be identified and the quantitative generation over time determined. These results will be important in answering the third sub-question. Namely, the quantity and hot spots of waste streams can show the areas that have the most potential towards environmental impact reduction. This information can subsequently lead to the most effective and efficient policy measures for a more sustainable waste management.

The above answered sub-questions will lead to the answering of the main research question. To determine fitting policy measures, the earlier mentioned interviewed experts and comparable case studies will be used. The experiences of the sustainable waste managements of HEIs will provide effective policy measures, the barriers involved and strategies for successful implementation. These best practices need to be fitted to the specific needs of the HVA, their waste management structure and waste composition.

4

Data collection on the current waste management

In this chapter all the necessary information will be collected to be able to answer the 3 sub-research questions in Chapter 5. In order to answer the first sub-research question information will be needed on the current organizational aspects of the waste management within the HVA. First the work of the student group Waste2Worth will be considered. Their work on the organization of the HVAs waste management will form a preliminary overview of the waste management. This overview will be aided by interviews conducted with people occupying influential positions within the waste management organization and a survey spread around the population that uses the faculties. To be able to answer the second sub-research question, the waste streams within the HVA need to be quantified. This is done by combining the information on the waste streams from different sources. For the third sub-research question information will be gathered about waste disposal methods and their relative environmental impacts.

4.1. Waste Organization

The structure of the waste management has been evaluated by an earlier research performed by a student research group. They performed their research on behalf of a course given at the HVA. In their research they made a Makigami of the waste management structure. A Makigami is a tool which is, among other things, suitable to help within transnational office environments. It can be used to look at any organization and through analysis find the structural wastes that are embedded in that organization. Examples of these wastes are for instance time-waste or economical-waste. A Makigami is mainly used by practitioners and not by academics, but that does not mean it is without its value for academic purposes. The analytic methods used are often used to evaluate organizational structures for academic purposes (Chiarini, Gabberi, 2020).

The Makigami as of the moment of the interview was unfortunately incomplete, however the mapping of the waste management was finished. The next steps of the Makigami would revolve mainly around time-savings. The group expected that the major time-savings would be achieved by further examining the work of the cleaning staff and the positioning of garbage bins within the faculties. The mapping of the waste management provided by

the group, introduced the first view upon the organization that is to be evaluated and improved. Figure 4.1 shows an redesigned version of the organizational flowchart (Eijck vd et al., 2020), the original flowchart can be found in Appendix E. This Flowchart will be used as a reference point to compare with the information from the to be conducted interviews interviews.

All the involved actors according to the group are listed on the left-side of the figure. The catering facilities range from coffee corners to supermarkets. The cleaning staff are employees from the corporation Hago and the waste collectors are from the firm Pantar Amsterdam, both stand alone companies hired for a specific purpose. The waste organization starts with the separation of the waste into different groups based on material, what material based groups are distinguished will be discussed in section 4.3. The initial separation is done by the students/employees, catering facilities and the cleaning staff. The HVA briefs the waste collectors and they manage the movement of the separated waste to the primary waste collection point, when the capacity of the primary collection point is met, the waste gets moved on to the secondary collection point. Before the waste gets deposited in the secondary collection point, the cleaners will do a quality check on the level of separation of the collected waste. If the waste is considered separated well enough it is added to the right material deposit within the secondary collection point. If the waste is considered to be insufficiently separated, a decision on the spot will be made whether or not the waste can be post-separated at that moment. If post-separation is considered to be possible the cleaners separate the waste at that moment, if not the waste is deposited into the residual waste. When the secondary waste containers are full the HVA management is notified and they notify the waste disposal company, in this case RENEWI. The paper and residual waste are disposed of more frequently because of hygienic reasons.

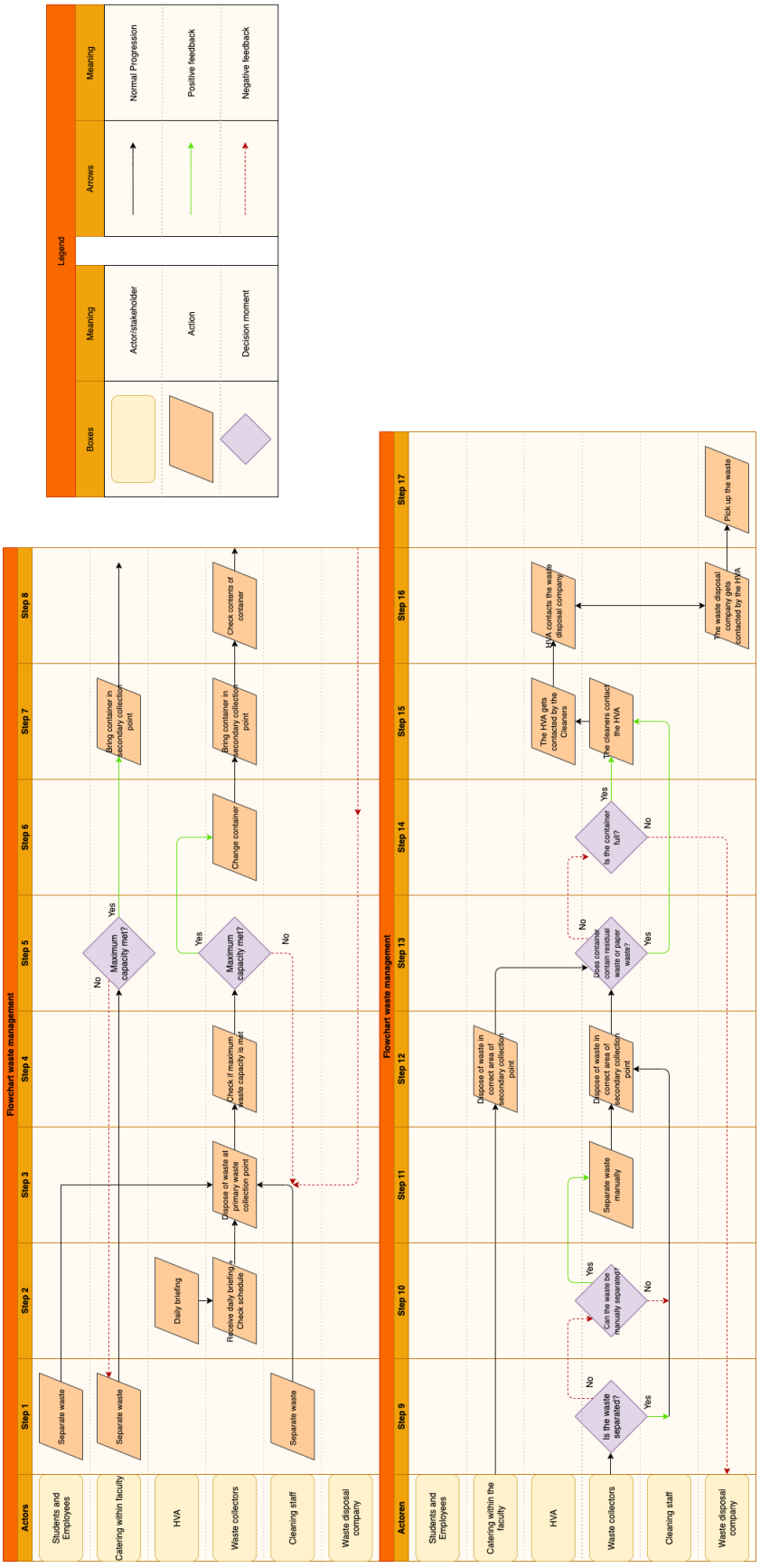


Figure 4.1: Waste management flowchart

4.2. Interviews

In the interviews section the interviews conducted will be reviewed. All the interviews were conducted via Zoom, an online communication platform, because direct face to face communication was not possible due to external factors. The interviewees were given a list of questions and subjects beforehand. The interviews were executed as an open conversation with the list of questions as a guideline to structure the conversation. An approved transcript of all the interviews can be found in A to D. All the interviews will first be discussed separately. It will be discussed who the interview was conducted with, why that person was chosen to interview, what was discussed in the interview and how it relates to the flowchart shown in figure 4.1.

4.2.1. Waste2Worth

Waste management as an organizational tool is integral to a good sustainability performance. As the social aspects discussed in chapter 2.3 show, the success of a sustainable waste management is highly depend on performance of all involved individuals and parties. They need to be continuously made aware of the to be performed actions. A well structured organization with the possibility of clear and open communication, can facilitate an environment in which this is possible. Such an organizational structure can dictate precise sequences of actions. Making the organization run more efficiently and taking complex decision making problems away from individuals or parties that are more likely to make mistakes. Therefore limiting the amount of mistakes that are made.

This is also something considered by a student group of the HVA that analysed the waste management of the HVA. They produced the preliminary Waste2Worth (W2W) report (Marella et al., 2019) which was looked at beforehand to structure the interview (A). The preliminary report was part of a larger research and therefore lacked some information and sets up research that was later disregarded. The main goal of the report was to investigate what the psychological or physical factors affect the separation and reduction of solid waste. The main actors they took into consideration were the users of the faculty and the waste disposal company RENEWI (Marella et al., 2019). The interview was held with group members Ellen McCarthy and Federica Marella, later an additional interview was held with a third group member James Ric-Hansen. The W2W group was recommended by the contact representative of the HVA because it was judged that there would be clear overlap between the produced work of the W2W group and the evaluation of the waste management of the HVA. A full transcript of the interview can be found in Appendix A.

Observations and Survey

In their research the W2W group undertook observation studies and surveys to create an understanding of how the available facilities were used by the users oft he faculties. In their observations they took the time to see how the users interacted with the several waste bins available and deduced from the interaction how well waste is separated. The Survey was used to determine the interest and willingness of the users to separate waste (Appendix A). The outcome of these observations and survey can help to better understand the inner workings and effectiveness of step 1 to 3 of the flowchart in figure 1.

One of the observations of the W2W group was that it wasn't always clear to the users of the faculty how the waste was supposed to be separated. It was observed that in most

cases when the waste was thrown in the wrong bin, it was due to the material of the object being ambiguous. It was observed that people first compare their waste to the small icons on each garbage can. When people were still unsure in which bin the waste was to be deposited, they would check the contents of the bins to make their decision, but if this did not give a conclusive answer, they would make a choice randomly. According to the group this happened so often that they could conclude that the recycling bins were ineffective in guiding the users toward correctly separating their waste (Marella et al., 2019). The placement of bins also played a large part in the effectiveness of the separation process. It was the W2W group's opinion that the ratio of residual waste bins in comparison to recycling bins was largely askew towards the residual waste bins. This resulted in the fact the recycling bins were less likely to be used. Because residual waste bins were more abundantly available, it relieved people of having to make a decision and devalued the urgency of recycling.

Moving on to the survey, the suspicion of the group that more people did not recycle than did recycle waste was confirmed. When asked how often people recycle their waste on a scale of never-sometimes-always, the mean was found to be on the negative side of sometimes (Marella et al., 2019). The results of the survey confirmed that the reason behind the low recycling rate is largely due to the poor distribution of recycling bins, 25% of the participants responded with an insufficient bin availability as their main reason not to separate. Additionally, to the question if the waste bins at the faculty encourages recycling 58% answered negatively. The survey also displayed something positive, namely the survey showed that most people are willing to recycle and see the importance of it concerning the environment. About 97% of the people either agreed or strongly agreed that recycling would benefit the environmental cause and almost 90% would support a sustainable waste management system (Marella et al., 2019).

Looking at the findings described by Schoot (2017), the main problem can be found in the fourth motivation, the lack of sufficient utilities (table 2.3). The W2W group recognizes that this problem is predominately solved by placing recycling bins instead of residual waste bins. However, the group also recognizes that this alone will not fully solve the low separation ratio. They stress the importance of affixing proper sustainability education. It needs to be explained how the recycling bins are to be used, which material has to be thrown into which bin. Additionally, they feel that an added stand-alone course about general sustainability subjects would benefit all students. This could influence their intrinsic views on sustainability expressed in step 1 to 3 of Schoot (2017) (table 2.3). It would also align with the outspoken ambitions of the HVA concerning their sustainability goals, says the group. If a stand-alone course is not among the possibilities, an integrated sustainability agenda into the curriculum is advised. One of the reasons the group gave is their view upon the general sustainability issue. Is because in their literature review they came upon a concept that can be explained as the Rebound effect (Hertwich, 2008). The moment people start to believe that through recycling the waste problem is solved, they start feeling less guilty in producing waste and will therefore produce more waste (Appendix A). Based on this concept, the group feels that if the HVA wants to move towards a more sustainable waste management system, the best way is to focus on waste reduction instead of recycling.

RENEWI

The second part of the research performed by the group that will be discussed, is their interaction with the waste disposal company RENEWI. The W2W group was able to interview one of RENEWIs employees. As RENEWI handles all the waste that leaves the HVA, it plays a considerable role in the sustainability level of the HVA's waste management. The following will predominately concern the steps 15 to 17 of the flowchart in figure 4.1.

The waste that is to be picked up by RENEWI is separated into the following material streams: paper/cardboard, Glass, Plastic, Organic Waste, Residual Waste. Thereafter each stream can be categorized into one of two possibilities. It is either a mono-stream, in which case it is considered a clean enough stream to be recycled, either by RENEWI themselves or by a third party specialized in recycling that waste stream. Or a waste stream is categorized as "unclean", then the waste stream is treated as residual waste and sent to an incinerator or landfill. Although these options are on the Ladder of Lansink and in the waste hierarchy, which puts circular options in order of circularity, see figure 2.1a, the group feels that these options are to be avoided when the goal is a sustainable and circular waste management (Appendix A).

RENEWI however, advertises incineration with energy generation as one of their circular and sustainable methods of waste disposal. While the circularity of incineration with energy generation, although undesirable, can be argumented for, the incineration of waste is not a sustainable energy source (Recupero, 2019). The group also found out that due to the high number of unclean streams most of the waste is directly send to the incinerator to be treated as residual waste. Plastic waste is not even checked anymore and is directly sent to the incinerator. They do this due to the high levels of contamination that are usually found in the plastic streams. The fact that REWEWI does not have the capacity and facilities to check all plastic waste and post-separate all the different kinds of plastic (HDPE, PP, PET, PS), is only one part of the problem (Appendix A. The problems created in step 1 to 3 of the flowchart of figure 4.1 prevent better recycling of the streams in these later steps.

The W2W group was willing to share their contacts and expressed that they felt RENEWI would be willing to share further information if necessary. More information can be found in section 4.2.3. Here a later interview will be discussed with Cor Gerritsen, employee of RENEWI. Topics that will be discussed are the interaction of RENEWI with the HVA and the manner of waste disposal by RENEWI.

4.2.2. Facility Coordinator, HVA

Jeroen Wagenaar has a key position within the organization of the waste management. As a Facility Coordinator he is responsible for all the waste that accumulates within the faculty and the disposal of this waste. This means he oversees the execution of the management from step 3 to step 16 of the flowchart in figure 4.1. In the eleven years that has been employed by the HVA he also has been responsible for the restructuring of the waste management. Through the years there have been multiple improvements considering the separation of waste. Due to the lack of a specific role assigned to the development of a waste separation plan, he took it onto himself to pioneer a system based on his own judgement. This interview was conducted to get an inside view of the reasoning behind the current system. A full transcript can be found in Appendix B

The waste management system
Wagenaar explains that within the faculty the first layer of personnel that comes into contact with the waste are the cleaners. They are supplied with a cart in which they store cleaning products and cleaning tools, and which have different compartments to store separate waste streams. The cleaners pick up the waste from the several waste bins spread across the faculty. Each classroom has a waste bin for residual waste. The only stream in the classroom that is separated from the residual waste is paper. In the public areas of the faculty these same waste bins are present only in a larger size (AppendixB. Wagenaar continues by explaining that when the storage on the cart is full the cleaners bring the waste to a large 60.000 Liter container which is connected to a pressing machine. When this container is filled up to three quarters of the whole, around 45.000 Liters, RENEWI is notified, and waste is moved to a secondary storage. According to Wagenaar the caterers within the faculty are responsible for their own waste separation and collection. They are however allowed to use the pressing machine containers. Wagenaar estimates that about 25% of all the waste is brought in by the students and faculty members. The other 75% is a result of directly bought materials and products by the faculty itself or the caterers.

The above described system fairly well resembles the structure given in figure 4.1. The only main differences seem to be that there are not two different groups for the cleaning (the cleaning staff) and waste collection (Pantar Amsterdam). There is also another contradiction compared with the information from W2W (section 4.2.1). Wagenaar expresses that the waste bins spread around the faculty only separate 2 waste streams, namely residual and paper, while W2W expressed there were more waste bins for separation. This difference may occur because not every faculty has the same management.

What is also missing in flow the flowchart (figure 4.1) is the main amount of waste which is created, namely the amount created by the faculty itself, which is part of the 75%. The faculty needs to buy a lot of material and products for the maintenance of the building itself or for the support of lectures. These maintenance products are items such as, batteries for automatic doors and fire alarms, lamps for hallways and classrooms and cleaning material for the cleaning staff. There are a total of 10 separated streams created. the streams are, Paper/Plastic/Tin (cans)/Fruit(GFT)/Chemical waste(batteries) /Styrofoam/Wood/Pallets/Inktoners/Filters (Appendix B, these streams could be relatively easy to regulate for the faculty. The second part of the 75% waste created by the faculty itself comes from the caterers. These are included in the flowchart (figure4.1), and mostly contain packaging plastics. Unfortunately, according to Wagenaar, these are not separated in to material based waste streams.

Obstructions
As expressed earlier, there are only a few possibilities for students and employees to separate their waste. Through the years there have been many initiatives, mostly by student groups, to introduce extra bins and educate the users of the faculty on the importance of waste separation and how to use the newly introduced waste bins (Appendix B. Unfortunately, although very noble, these initiatives always lack the ability to make long term changes, according to Wagenaar. When these initiatives start, the changes are usually promising but when the initial boost by promotion stops the promising effects fade away. The result of the continuously failing attempts to improve waste separation is that the purity of the streams is very low. Another observation by the cleaning staff Wagenaar was made aware, is that there is a large amount of waste that does not make it into the waste bins at

all. The cleaning staff is responsible to make the faculty ready for the next day and they usually only have a limited amount of time to do so. Therefore, they do not have the luxury to be concerned with the separation of waste, the addition of waste laying around only makes this more difficult. This problem reflects poorly on the effectiveness of step 1 (the separation of waste by the several parties) and steps 3 to 12 (the inner faculty transport and handling of waste) of the flowchart (figure 4.1).

From a material point of view it would be very interesting to have an extensive insight into the exact purchases. The purchases both of the caterers and of the maintenance. With this extensive insight one could project what kind of streams are to be expected at the exit side of the HVA. This information could not only help with shaping the waste management but also influence the purchases. With a strategic purchase management, the amount of separate streams could be limited. The caterers already keep an inventory list, with their purchases and sales. The maintenance however doesn't keep track of their purchases. Wagenaar expresses that this is due to the nature of the purchases. The purchases are usually for acute problems that arise.

4.2.3. Project manager Food and Drinks, HVA

The interview with Guido Meijer was initiated because of Meijers relations with the catering parties that are situated within the faculties of the HVA. As a Project manager Food and Drinks, he is in the key position in between the catering parties and the HVA. He looks at the needs of each individual faculty and provides suitable caterer option to fulfill those needs. Afterwards he will provide a service to the caterers and the HVA as he functions as contact person. Because of the nature of Meijers role within the HVA, this interview will mainly concern subjects outside of the flowchart (figure 4.1). Nonetheless the content of this interview reviews important structures that will help with the better understanding of waste management system. The contribution of waste generated by the caterers is considerable as can be concluded from the previous section. The information drawn from the interview with Meijers adds to the organizational structure which shows the importance of the holistic approach of the entire research. A full transcript of the interview can be found in Appendix C.

Catering management

Within a faculty there are 4 segments of catering. Each segment tends to its own specific purpose and is fulfilled in its own manner and by its own parties. All caterers operate independent from each other and the HVA. Before a caterer gets assigned to a location, they need to provide a valid business plan. Next the HVA and the caterer both express their needs and set up a plan how these needs can be met (Appendix C). The segments are displayed in table 4.1.

Within the search for new caterers CIRFOOD is the HVAs main partner. Cirfood is a caterer that specializes in the catering for restaurants, food stations for companies, business hub buildings and schools. Around 90% of all new partners are proposed by CIRFOOD first. Especially the Horeca and Banking partners are rotated frequently to diversify the offer (Appendix C). This is considered good practice from both the caterers and HVAs point of view. As expressed in section 4.2.2, the caterers are responsible for the initial separation and disposal of their waste, hereafter the HVA takes the waste and arranges the pick up of the waste by RENEWI. As Wagenaar also expressed (section 4.2.2), Meijer explains that although the caterers keep track of their purchases and sales, they do not link this to an

Table 4.1: Segments of caterers within the HVA

Caterer service	Function
Vending	All food and drink dispensing machines, serves small snacks and beverages, it is a caterer with no human interaction on the sales side
Banking	Supplies larger lunch arrangements, suited to specific wishes
Horeca	These are all the manned locations in a faculty, for instance small coffee shops and lunchrooms
Retail	These are manned or unmanned supermarkets of variable sizes

evaluation that benefits their waste management. Meijer attributes this to the sometimes difficult to allocate purchase-sale connection. For a lunchroom for instance a lot of different purchased items are used to create a single item that is to be sold (Appendix C). This is however unnecessary information when considering a Material flow approach. Analyzing purchases and linking them to waste generation in order to influence the purchasing strategy so the amount of waste streams and waste in general can be limited, is something that could be attempted without the allocation of materials purchased to products sold. Although this seems a promising strategy according to Meijer, he emphasized the fact that the caterers work autonomously after securing the contract. They are free to purchase and sell all goods within the agreed upon boundaries. These boundaries are largely dictated by the segment a caterer is part of. It would create unequal situations if certain caterers, across the four segments, were allowed to sell certain products while others would not.

A situation that illustrates this is when Join the Pipe and the HVA were working together to introduce water taps within the faculties to encourage the users to refill water bottles instead of buying new ones. In addition, a ban on the sale of water bottles by caterers within the faculty was discussed. Legally this turned out to be a difficult thing to enforce. Because of the difference between rules per segment, a lunchroom would be able to be prohibited from selling water bottles, while a supermarket would not. This would create an unfair market situation.

At the end of the interview Meijer wanted to clarify that a wide spread knowledge about the benefits of waste separation and sustainability in general, is important to create a support base among the users of the faculty. However, he does feel that the future lies not in the source separation of waste but in the post-separation of waste as a more efficient way to ensure optimal waste recycling. Meaning that collecting all waste as residual waste and separating them at a waste disposal plant. There are most certainly many arguments that support this statement. However as of now it can be concluded that the technology will still need to relay on some degree of source waste separation (Appendix C).

4.2.4. Account manager, RENEWI

After hearing much about the waste disposal company RENEWI and how they are working together with the HVA it was important to have a closer understanding of the system from their point of view. Therefore, an interview was conducted with Cor Gerritsen an account manager at RENEWI. This interview will once again be mostly about subjects outside of

the flowchart of figure 4.1, however it does show the relationship between the HVA and RENEWI, which plays an important role in the waste management as it once again enforces the importance of a strong organizational structure.

Besides being an account manager, Gerritsen is very involved with all subjects surrounding sustainability and circularity within RENEWI. In that role he tries to implement the principle of Zero Emission as much as possible to all projects he is involved in. In his own words this involves the following facets: the technology that supports the separation, cleaning and recycling of materials. Logistics, both internal logistics of the HVA and the logistics of REWEWI itself. Lastly a concept called VANG is mentioned, a Dutch acronym that translates to "from waste to raw material".

Contractual partnerships

Within the municipality of the city of Amsterdam, RENEWI has three separate locations they collect waste at. Two of those locations are equipped to collect residual waste and plastic and the last location has a digester to handle organic waste. An important benefit of two of the locations is that they have the availability to quay space, with gives the advantage of being able to receive waste transported by water routes which are plentiful available in Amsterdam. This saves time, energy and reduces traffic in the city. The residual waste that is collected at the facilities will later be send to an incinerator where they are used for the production of electricity. These incinerators produce electricity with an efficiency of 60%.

When RENEWI starts with a new customer they first sit down with that customer to break down there needs and wishes. RENEWI as a recycling company is open for the collection of all waste streams a customer wants to distinguish between. Streams RENEWI has no recycling abilities for, will be transported to partners specialized in the recycling of these specific materials. The wishes that are discussed include, but are not limited to, the logistics (Appendix D). Gerritsen continues by explaining that logistics concern predominately the pickup moments and the mode of transportation. As mentioned RENEWI has the ability to transport waste over water which could be a very efficient way of transportation. Customers will also have the option to pay for the use of electric vehicles over combustion vehicles (Appendix D). RENEWI also has the ability to help customers with the separation of waste. ECOsmart is a special program that helps large organizations with their internal waste management. Next to the logistics it is discussed what material streams will be collected and a what purity is required for each material stream. The purity comes into play when the waste is collected and send to one of RENEWIs locations, here the waste is checked on the agreed upon purity. As expressed by the W2W group (section 4.1), when a stream does not satisfy the purity requirements it is regarded as residual waste and handled as such from that point on. Gerritsen explains that all the subjects mentioned above, are transcribed in a contract. This means that when streams that are collected do not meet the required purity or cleanness, RENEWI has the legal right to dispose of it as they feel best suited without being obligated to report on it. As discussed in section 4.2.1 we know this happens more often than not. The nature of the contract results in the fact that this happens without the HVA having knowledge of this practice. This miscommunication makes it that the HVA is able to think their waste is being recycled while in truth, it gets incinerated as residual waste.

4.2.5. Survey

A survey was constructed as a method to get an understanding of the population of the HVA and their use of the faculty. An attitude and behavior survey is a method described by Zorpas, Lasaridi (2013) and Sharp et al. (2010) and a method tested by Martinho et al. (2018). Martinho et al. (2018) used surveys to understand the generation of waste and the anatomy behind the composition of waste streams that were generated. The survey was spread among students and faculty members of all the faculties that are part of the Amstelcampus. Due to the pandemic the faculties were all closed at that moment. The survey takers were therefore asked to fill in the questions as if they would make normal use of the faculties.

The survey was set up in four section. The first section had the purpose of setting up a user bio of the survey participant. The questions are about their relation to the HVA, student or employee and they were asked a few questions on their overall use of the faculty. Which faculty they predominately used, the frequency of use and for how long they usually resided for in the faculty per visit. These questions can later be used to identify which user characteristics are correlated to certain behaviors. The second section has two main objectives, firstly this section was used to create an inventory of the waste that the participant of the survey generally throws away within the faculty, this was done by asking what kind of materials are predominantly thrown away. The second objective was to determine what the motivations were behind separation behavior. It was asked if the participants separated their waste and what the reasons were behind their decision to separate or not. Section three focused more on the waste related to food and drinks. The assumption is that waste related to the consumption of food and drinks is a large fraction of the waste collected in the waste bins spread out over the faculty. It is therefore important to understand the material composition and quantity of the waste generated in this particular stream. Therefore, the questions are on the behavior with food and drinks and the additional waste it produces, with an emphasis on the products that are brought in from outside the faculty. The waste produced by foods and drinks acquired from within the faculty can be monitored by different methods, therefore there will be no additional questions on that fraction of waste. Since the primary function of the HVA is to educate. It is normal to evaluate the role education plays in their circularity ambitions. To improve the separation and reduction of waste, certain sustainability seminars could be organized, or sustainability could be given a more prominent role in the curriculum of all students. It is also an option to involve students in the strive towards circularity by involving them in the decision-making process. The fourth section asks the participants about their opinion on what role sustainability should play within the HVA as an educational institute. Are the participants of the survey well informed on the existence of this ambition? do they feel a need for extra communication about themes like circularity from the HVA? and which form would they prefer?

4.3. Material Flows

Besides the Organizational aspects of the waste management, it is important to consider the actual waste flows. It is important to understand in what quantities specific material streams are moving through the faculties, separated or not. Information on the quantities of specific materials within the waste streams can reveal high potential areas for sustainable improvements of the waste management as a whole. In this section the waste flows will be

evaluated. Unfortunately, the data collected by the HVA does not supply information on specific material-based streams. The goal of this section is to find reliable data sources that can later be used in the estimation of material-based waste streams within the HVA.

Material Based streams within the HVA
Since RENIWI has been the main waste disposal partner for the HVA, their collected data will be the main data that is to be considered. As part of RENEWIs service they collect and display all information on the collected waste in their RENEWI portal, which is made available for HVA management. Within the RENEWI Portal all the data is collected concerning the waste that is picked up at all the faculties of the HVA. This data consists of disposed waste in kilograms for a variety of material-based waste streams, the total costs, the type of containers used and avoided CO_2 emission per material-based waste stream. The data in the portal can be categorized per faculty and per material-based waste stream. For this research the information of the calendar year 2019 was chosen, since this was the last year the faculties were used to their full capacity before the pandemic. Table 4.2 shows the total waste generated by the complete HVA per material stream. Streams smaller than 0.1% of the total are left out due to insignificance.

Table 4.2: Quantity of waste generated by the HVA in 2019

	Mass [tons]	Percentage [%]
Flammable company waste	406,2	89,7
Motley paper	25,9	5,7
Reusable demolition waste	15,7	3,5
Scrap	2,6	0,6
Polystyrene	0,6	0,1
Batteries	0,5	0,1
Lighting equipment	0,4	0,1

looking at this list of waste streams it is important to consider on what level within the waste hierarchy (figure 2.1) these materials are dealt with. Scrap, Polystyrene, Batteries and lightning equipment are clean mono-material waste streams which are separately disposed of by most individual households in the Netherlands. Because their recycling process is already defined and their stream quantities are relatively low, they will be left out for the rest of the waste analysis. The third largest stream is Reusable demolition waste. The term alone says that waste is able to be reused. RENEWI describes the strategy for demolition waste in their sustainability policy presentation (RENEWI, 2020a), they explain how third parties will be used to prepare the waste for specific reuse purposes. The Second largest waste stream is Motley paper, a collection of most paper products that can be found in any office/university environment. This means the stream is a mixture of paper types like cardboard and paper, it will also most likely contain some contaminants. For true recycling the stream needs some further separation. In the Netherlands this is done by scrap paper companies (Houtum "v et al., 2020).

The by far largest stream with 89,7% of all the waste is the flammable company waste. Unfortunately this waste stream is very poorly defined and does not help in the further analysis of waste streams. It is made up out of all the residual waste streams collected within the faculty and is used for incineration with energy recovery. This stream originates

Table 4.3: Contents of the flammable company waste.

	Mass [kg]	Percentage [%]
Organic waste/Swill	3494,1	26,8
Paper	2881,2	22,1
Paper coffee cups	1391,9	10,7
Compostable disposables	1328,9	10,2
Foil (plastic)	1134,2	8,7
Textile	509,8	3,9
Residual waste	509,8	3,9
Plastic (others)	486,9	3,7
PET bottles	452,5	3,5
Carton	429,6	3,3
Metals	194,8	1,5
Drink cartons	103,1	0,8
Glas	57,3	0,4
Wood	45,9	0,4

from the catering services and the thrash cans spread around the faculties. The content of this waste stream is highly variable and consists of many material streams. In order to better understand the waste streams within the faculties this general waste stream of "Flammable company waste" needs to be further dissected. In 2019 RENEWI preformed an audit of collected residual waste, by separating the waste of a single faculty after collection.

The information of table 4.3 is a representation of a period of 200 days. The choice for 200 days is based on the total active days on the faculty in a year. This means that in a full year the total amount of waste collected for a single faculty is 13020 Kg. The amount of people responsible for that waste was estimated around 600 people, which consists out of staff and students. The results shown in table 4.3, will be used to further estimate the composition of the waste stream "flammable company waste". With this estimation a more precise representation of the material based waste streams can be created in Chapter 5.

4.4. Case Studies

In order to support the estimations of the material-based waste streams of the HVA, a small selection of case studies was looked at. The first case study is from the Delft University of Technology (TUD). This case study consists out of quantitative data collected by the waste services of the TUD. This case study will help with the legitimization of the quantities that are to be determined on the basis of the data in section 4.3. The next two case studies are of Universities in the United States, The University of South Carolina (USC) and Appalachian State University (ASU) in North Carolina. For these case studies the University's directors of sustainability were interviewed to get an understanding of how these Universities perceive and tackle the sustainability of their waste management.

Delft University of Technology

The Delft University of Technology (TUD) has recently started implementing policies improving its overall sustainability. Part of their improvements are stimulated by TUD founded Green Teams. Each faculty at the campus has been provided with the resources to start a student led Green Team of interested members to improve the sustainability of their own faculty. All the facular Green Teams have a single overarching University wide Green Team, Green TU, that is able to look at the full picture and connect and guide facular Green Teams where necessary.

The Logistics and Milieu Coordinator, Michiel Faber, has taken the responsibility upon himself to improve the waste management of the TUD as a whole. He did this with the help of RENEWI, the waste disposal partner of the TUD. RENEWIs Ecosmart team preformed a waste audit to determine the content of residual waste streams (Team, 2019). Based on the outcome RENEWI wrote a report explaining which material-based streams the TUD could best focus on. The report explained that the residual waste originating from different faculties consists of 83% recyclable materials, namely, Paper/carton 10%, Organic 30%, Plastic 0,17%, Coffee cups 13%, Drink cartons/metals 13%. The last 17% is considered as unrecyclable residual waste. As RENEWI does for the HVA, RENEWI also keeps the data of all collected waste streams of the TUD in their online portal, containing the waste masses, costs and recycling ratio of the collected waste. In table 4.4 the data from the waste audit and the portal are combined, the result is an estimation of the amount of waste generated. The waste streams are differentiated into 4 main waste streams, namely Residual waste + PMD, Paper, Organic waste and Cups and disposables. These are chosen due to their dominant presence in the HVA (table4.2 and 4.3. Since the data provided in the RENEWI portal concerned the waste streams of the University as a whole, a ratio of the two populations was used to make the data easier to compare in a later stage. The data provided for the HVA was for a population of 13020 people, for the population of the TUD the total population of 35451 people was used (including students/employees/PhD students). As the TUD has a relative similar culture, waste management partners and organization, data can later be compared with the estimated waste stream quantities within the HVA.

Interviews

Both interviews come forth from contacting the College and University Recycling Coalition (CURC). The CURC is a non-profit organization that supports professionals working toward a zero-waste society by connecting people in the field and organizing workshops and webinars. The interviews were conducted over a video-call, they were recorded and later loosely transcribed into a summary of the conversation. Approved versions of these transcripts can be found in Appendix F (Appalachian state University) and G (University of South Carolina).

Sustainability Director, Appalachian State University

As a sustainability Director of Appalachian state University (ASU) Jennifer Maxwell has played an integral role in the evolution of the current sustainability policies of the ASU. Since 2006 Maxwell has been involved in several sustainability programs on campus, including the Universities Zero Waste Commitment. Maxwell is also the chair on the board of the (CURC).

ASU is a University located in a small town called Boone. Due to the relative isolation of Boone, the inhabitants of Boone have historically been forced to learn how to be self-

Table 4.4: Dominant material based waste streams of the TUD

Main stream	specified stream	Mass [Tones]	Percentage [%]
Residual waste + PMD		**199,42**	**31,18**
	Residual waste	62,22	9,73
	Drink cartons /metals	47,58	7,44
	Plastic others	62,22	9,73
	Foil plastic	0,6	0,09
	Glass and Wood	26,8	4,19
Paper		**135,6**	**21,2**
	Paper/Carton	99	15,48
	Paper motley	36,6	5,72
Organic waste		**249,1**	**38,95**
	Food waste	114,2	17,87
	Garden Waste	134,8	21,08
Coffee Cups		**55,28**	**8,64**
Total		**431,5**	**100**

sufficient. A characteristic that is adopted into the University's culture. ASU has about 20.000 students of which around 7500 live on campus. The rest resides in the town. This puts the cultural influence of the town more on the foreground, but simultaneously limits the impact ASU has on its own waste streams.

The waste management of the ASU is focused on an upstream approach. This means the university specifically looks at sustainable purchasing as a method for waste reduction. The reduction, reuse and recycling of waste are central in ASUs policy to a more sustainable campus (Appalachian State University, 2021). They find it important their efforts go into these higher levels in the waste hierarchy, instead of gradually moving up the ladder. With the focus on waste reduction and therefore the purchasing side of the waste management, additional financial costs can create a disincentive for some institutes. The ASU however has accepted any additional costs as part of the necessary change. Part of the extra costs are absorbed by external funds from the state or generous foundations.

ASU splits their waste streams into three main material based waste streams. The first stream is the organic waste stream. This waste stream has been used for composting in the ASU's own composting facilities for the last 21 years. The compost won from the facility is later used in campus gardens, for roots therapy to support declining trees and on the ASU's farmland.

The second waste stream is the recycling waste stream. This waste stream consists out of Glass/Paper/Metals and plastics. This stream is picked up by the ASUs waste processing partner, Republic services. They are a company specialized in the separation and processing of waste. They separate the four mentioned materials with a combination of manual and mechanical methods and after the separation they sell the bulk material to third parties able to use it for the production of their own products. The ASUs relationship with Republic services exists out of an annually renewed contract with semi-annual evaluation meetings.

The last waste stream is one that needs the most attention, namely it is the residual waste that is landfilled. As expressed earlier, ASU is not interested in finding intermediate solutions like incineration with energy generation, but they strive towards a complete reduction of this stream. At the moment the ration between the recycling and landfill waste stream is 40% to 60% respectively.

The ASU feels that their role as an educational institute should also be reflected in their sustainability policies. One way of doing this is by incorporating sustainability subjects into the curriculum. Students are also encouraged to get involved with the several different sustainability projects going on at the campus, by making them available as internships or extracurricular activities. Additionally, all first-year students have to attend sustainability seminars to get familiar with the sustainability policies on campus. A second way the ASU involves students is by introducing student organs into their sustainability decision making procedures. Student organs like the Renewable Energy Initiative and a sustainability committee within the student's council have both come up with their own improvements towards a zero-waste campus and collected funds through their own channels to help fund sustainability programs on campus. The ASU has also employed students to work as sustainability liaisons. These liaisons have the responsibility over a residents' hall and the right implementation of sustainability policies within that hall.

The University believes that it is their responsibility to teach a correct way of understanding what sustainability entails. While they really believe in the push towards a zero-waste campus, they equally believe that the incremental change of a single student towards living a more sustainable live, can in the end support a more sustainable future.

Director of the Office of Sustainability, University of South Carolina

For the past 12 years Larry Cook has worked at the University of South Carolina (USC). He first began as the recycling and waste manager and later became the Director of the Office of Sustainability, where his main responsibilities were the implementations of sustainability policies on the campus. This interview was structured by following the structure of a beforehand supplied document written by the CURC. This document, College, University Recycling Coalition (2018), helps many universities all over the United states to improve on their own sustainability and was well known by Cook himself. The USC works with a list of 8 main priorities that gets updated annually. The Priorities are there to help guide the University towards its set goals. Recently, after insistence of Cook and a global change in the social climate, the USC added sustainability to their ranked list of priorities on the 7th place.

In their endeavor towards a more sustainable campus some goals on waste were set. Their goals are mostly based on the top of the waste hierarchy, reduce, reuse and as last measure recycle. All waste that is not able to be disposed of on any of those levels is now sent to a landfill. This is highly undesirable, but in the American market this is the most commonly used method of waste disposal. The readily available space gives a lot of opportunity for landfilling. Cook explains that while some landfills work with methane capture techniques it is still not a desirable method of disposal. However, he also expresses that a intermediate solution like waste incineration with energy generation, is in his view not an option either. Although it has its advantage over landfilling it still has it negative effects and therefore the USC chooses to strive towards the higher levels within the hierarchy.

A method to successfully reduce waste is the use of the Precautionary principle. The Precautionary principle requires people the think about the necessity of purchasing an item. In particularly new items that are probably already readily available. Cook gives the example of office supplies. Employees would often order a new stapler for instance. The precautionary principle teaches them to first check the campus storage, preventing an unnecessary new product. This principle can also be extended to events like Halloween. Were students often bought single use items for the festivities, with the precautionary principle they are encouraged to think ahead and find more durable options. This also extents to the USCs own purchasing policy. Cook emphasized that the University realizes that with the purchase of products they control a large portion of their waste output. Therefore, each and every supplier of goods is forced to think about a second life for the products they sell, and they need to elaborate on it in their campus contracts.

Besides the the control over the input of waste by purchasing, the output of waste needs to be well regulated. A well-regulated waste output starts with an effective separation of waste. The main two methods that are regarded in waste separation are post-separation, where all the waste is collected as a single waste stream and is thereafter separated. Or source-separation, where the waste is segregated by the first disposers on the basis of material while disposing of it. At the USC both methods are used due to undesirable secondary variables. Their preferred method is source-separation, this method when performed well saves effort on the separation which results in cost and time reduction. However, source-separation requires a certain availability of space for the necessary different waste bins needed for segregated collection. Also, the entire population that uses these waste bins needs to be aware of the correct use to prevent contamination of material-based streams. The USC has the problem that not all campus buildings have availability to the required space. They also experience contamination from the larger public that have excess to certain areas on campus for recreational use.

Cook initiated a program for post-separation on campus. This initiative works on the basis of manual separation into 8 different material streams, mixed paper, cardboard, plastic bottle 1 (PET), plastic bottle 2 (HDPE), metal scrap, glass, aluminum and organic waste. The manual waste separation is responsible for 500 tones of recycled waste on a annual basis, this is 12,5% of the total annual waste generation of the USC.

To ensure significant and ongoing improvements Cook executes a continual assessment. A five-year plan for the sustainability on campus is written and during that period data is collected on the areas where improvements are intended. Each year the data is used to evaluate the incremental improvements that are made, and adjustments are made where necessary. The USC is also subscribed to a inter-university ranking system called, Sustainability Tracking Assessment & Rating System (STARS). This platform gives universities the free voluntary opportunity to report their sustainability efforts and the progress that they make. Each university supplies its own input, and this forms the basis for their ranking on the platform. The purpose of the platform is to inspire universities to do better and gives the opportunity to learn from one another.

Cook realizes that as they are an education institute, they have the responsibility of not only being a sustainable organization but also create the awareness and spread knowledge

among the students on campus. Partly this is done by implementing policies that can be seen by many students and will stimulate curiosity amongst them. Cook gives an example of solar powered picknick tables or simple water filling stations, that students interact with on a daily basis. Another way to spread sustainability awareness amongst the students is to incorporate it into the curriculum. And although the University has multiple courses and programs that embrace sustainability, it is not a mandatory subject for a student. To compensate this, several additional student engagement programs are available. Here students get a beyond the classroom, hand on experience with sustainability. As an educational institute Cook strongly believes they have to help the future generation, by giving them the proper tools and information on sustainability.

4.5. Waste Disposal

In the previous sections the organizational structure and the collected waste have been evaluated. Something the HVA has a less direct influence on is the method of disposal. While this is technically outside of their own organizational structure, it highly influences the environmental impact of the entire waste management. Therefore it is important to include into the considerations as part of the holistic approach. The waste Hierarchy (figure 2.1) shows the several options for waste disposal. After the literature study and the interviews with the experts we know that landfilling and the incineration without or with energy generation is not preferable, as is discussed by Eriksson et al. (2005) in their paper on municipal waste management, and by Björklund, Finnveden (2005) in their paper on the global warming impact and total energy use of waste management strategies. In order to later discus the most effective policy measures it is important to understand where the most potential for improvement lies. Therefore the four main waste streams discussed in section 4.4, Residual and PMD, Organic, Paper and Disposable cups, will be evaluated on potential recycling techniques and the potential reduction of environmental impact of those recycling techniques.

Residual waste and PMD

Before the stream of residual waste and PMD can be processed, it first needs to be further separated. Moerenhout, Cuyvers (2014) has made an extensive report on the several available separation techniques used in the Netherlands. The separation techniques are shortly explained in table 4.5, naming the technique, shortly explaining the method and giving the separation characteristic. RENEWI has their own evaluation of their processing of residual waste and PMD (RENEWI, 2020b). Of their residual waste 5% is captured to be used as raw material, 73% is burned to produce energy and out of the 22% residue first the metals are collected, the rest is used as raw material for construction. Of the separately collected PMD 86% is captured to be used as raw material and the remaining 14% is used for energy production. RENEWI made a comparison between the environmental impact of PMD disposal as they do it and as it would be if it was disposed of as residual waste. The result is that 81% more materials are recovered and 1468 kg CO_2/ton waste is prevented.

The proper recycling, or reusing, of plastic products can greatly reduce the overall energy usage in the plastic life cycle as was concluded by Ross, Evans (2003) in their life-cycle assessment of plastic waste in Australia. Plastic is a material that is very well suited for recycling. If clean, the plastic waste can often be used in the same life cycle as a raw ma-

Table 4.5: Separation techniques

Separation technique	Method	Separation characteristic
Standard technique	Examples are a drum sieve and shaking sieve, the motion is used to separated waste of different sizes	Size
band magnets	Waste streams are transported underneath an electromagnet to subtract metallic material	Ferromagnetic
Shredding or Breaking	This method is usually used early on the separation process. The Small particles and uniformity help the further separation process.	-
Hydrocyclones, upflow columns	These methods are used for separation on micro scale, mainly sludge and sand fractions	Density
seive belt press	This method is linked to the hydrocyclones. It dehydrates with the use of filter cloth	Density
Wind shifters	This method uses gravity to separate light objects, like plastics, from heavier objects. The wind blows the light object up while the heavier objects fall	Weight
Eddy current	Waste is moved on a conveyor belt where at the end a magnet rotates. This creates a counter magnetic field which removes metallic objects	Ferromagnetic
Optical separation	With laser scanners a thin waste stream can be scanned, and waste can be ejected by compressed air	Optic
Aquamator	The waste is transported on a conveyor belt and hosed with an opposite water stream. The water pushes larger object back while smaller objects forward on the conveyor belt. By the regulating the flow, the size of separation can be adjusted	Size

terial. A barrier for proper plastic recycling is the several kinds of plastic wastes that are collected together. The main kinds of plastics are HDPE (polyetheen), PP (polypropeen), PET (Polyethylene terephalate), PS (Polystryreen). Within the recycling of plastic, a distinction can be made between high-quality and low-quality recycling. In a comparison of waste management scenarios in the Netherlands (Corsten et al., 2013), it is shown that the high-quality plastic recycling is far more preferable to low-quality plastic recycling. This is because the high-quality plastic can be used as raw material in the production of new plastic products, where with low-quality plastic recycling this is not the case. The recycling of high-quality leads to a large quantity of energy and emission prevention (Corsten et al., 2013). However the recycling of high-quality plastic requires the separation of the different plastic polymers by the first disposers of the plastic. Umincorp a company specialized in the separation of plastics, found method for the post separation of plastic polymers, namely

a technique called Magnetic Density Separation (MDS). MDS is a method where the combined plastic stream is cleaned and shredded and then put in a ferromagnetic fluid. The fluid is put in an electromagnetic field which creates a density gradient. Letting the liquid flow, it separates the different kinds of plastics. With this technique Umincorp promises a 99% purity of streams, 90% of plastic recovery, 75% cost reduction and a 90% reduction of CO_2 (Umincorp, 2019). RENEWI explains that they also separate their plastic waste into the two mentioned groups, high quality plastic and low quality plastic. The high quality plastic is turned into Regranulate which is qualitatively comparable to new raw material. The low quality plastic is turned into Agglomerate which is used for several big plastic products like, garden benches, terraces, planks, sheeting and children's play equipment (RENEWI, 2020b). RENEWI also remarks that it can be very useful and economically beneficial to separately collect plastic foil (LDPE plastic). Foils often take up much volume and are relatively clean. Clean foil can be directly used for the production of new plastic packaging products, which gives it a material recovery rate of 98% and reduces emissions by 1188 kg CO_2/ton waste (RENEWI, 2020b).

The refining of metal ores is one of the most impact full processes within the metal production cycle. Especially due to the ever degrading ore grade because of depleting sources (Norgate et al., 2007). Therefore the introduction of recycled metals into the metal production cycle can replace the metals ores and make the impactful refining of metal ores unnecessary. However the metals that are collected in waste still need to be separated into more specific streams. The separation can be accomplished by using the different material characteristics of metals. RENEWI first shreds and cleans all the metals and then sort the more valuable metals like, copper, aluminum and bronze. These sorted metal streams can immediately be used in a diverse set of metal production cycles. The recycling of metals captures 91% more raw materials and prevents 1876 kg CO_2/ ton waste, then it would have when treated as residual waste RENEWI (2020b).

At RENEWI, drink cartons are separated from the rest of PMD waste and it is used in the production of tissue products like toilet paper and carton boxes RENEWI (2020b). Research by Persico (2019) compares the environmental impact of three different disposal strategies for drink cartons in Italy. The first the is disposal of drink cartons by incineration as part of the residual waste. The second one is the use of drink cartons in a general paper waste recycling facility and the last is where drink cartons are recycled in a facility specialized in recycling drink cartons. Persico (2019) used an LCA to determine the relative impacts of these strategies, and could conclude that the specialized paper recycling facility had the best results, diving into the results it can be seen that the main emissions are due to the energy use in the facilities. She also compared the results with an LCA of a PET bottle and came to the conclusion that the use of PET bottles is more preferable to drink cartons for the distribution of liquid consumption in Italy.

Organic waste

Turner et al. (2016) concluded that the capture of organic waste is the most effective way to decrease the environmental impact of a waste management system. There have been found many ways to recycle or reuse organic waste. Chen et al. (2017) looked into the environmental impact of the use of organic municipal waste and supermarket food waste for

the production of caproic acid. The uses of caproic acid include the production of artificial flavors. Lozano-Miralles et al. (2018) concluded that the use of organic waste in the production of clay bricks could reduce the environmental impact by 15 to 20%. However, the most used application of organic waste is composting. Amicarelli et al. (2020) researched the composting of potato skins, a byproduct of a chips factory in Italy. They found that composting of the potato skins does not only have environmental benefits, but it can also result in economic and social benefits. The composting of 11,500 tons of potato skins produces 7,100 - 10,200 m^3 bioethanol which can substitute 3,700 - 5,300 ton of fossil fuel. The economic benefits for the potato factory are twofold, namely the income for the biofuel and reduced costs for waste disposal. Depending on the market this can result in an economic benefit of around 35 €/ton organic waste.

Where the main environmental benefits come from in the composting of organic waste, was research by Oliveira et al. (2017). They looked at a number of scenarios of different ratios between using composting plants, home composting and landfilling. The main benefit of home composting comes from the reduction of transportation. However, it did lead to more N_2O emissions and freshwater toxicity. Their main conclusion was however that the focus should be on the prevention of landfilling organic waste, since that produced the most negative effects. Composting also contributes to a better nutrient balance. However, Corsten et al. (2013) suggest that due to the low reductions in energy and greenhouse-gas emissions of composting, anaerobic digestion is a better option. Fermentation in anaerobic digestion produces a lot of energy which can replace energy generation from conventional fossil fuel electricity production.

RENEWI makes a distinction in the kind of organic waste in their organic waste disposal. The first stream is called GFT waste, which consists out of discarded vegetables, fruit and garden waste. The second stream is called Swill, this stream consists out of cooked or otherwise prepared food waste often found in kitchen areas. For the GFT RENEWI uses composting as a disposal method. RENEWI has a composting facilty that uses aeration techniques to increase the yield of the plant. The resulting compost can be used for agricultural purposes. About 82% of the organic waste that is composted at RENEWI is produced into raw materials like compost. The other 18% is used for the production of green energy. If these results are compared with normal residual waste disposal. There is an added 77% raw material capture and a reduction of 501 kg CO_2/ ton waste is realized. As can be seen from these numbers, a 100% of the organic waste is disposed of sustainably. The Swill is disposed of with the help of a digester. The digester produces a biogas that can be used as a sustainable energy source. The residue of the digester is used as a fertilizer. In this process 94% of the waste is captured as raw material and 6% of the waste is used for energy generation. When compared with residual waste incineration a gain of 89% raw material capture is obtained and a reduction of 328 kg CO_2/ton waste is achieved.

Paper and compostable cups

In the Netherlands paper is already a material which is separated quite well (Corsten et al., 2013). RENEWI makes the distinction between confidential paper waste and normal paper/cardboard waste. The advantage of confidential paper waste is that this usually is a higher quality waste stream. Therefore, REWEWI collects this waste separately and because of that they can recycle most of it into new office grade paper. Of this waste stream

84% is used as raw material and the remaining 16% is used for the generation of green energy. When compared with residual waste incineration, the recycling of confidential paper results in 79% more raw material capture and a reduction of 194 kg CO_2/ton.

The normal paper/cardboard waste stream is first further separated into quality determined streams. Three methods are used. Namely, manual separation, sieving processes, and air-stream techniques. The papers gets chopped to smaller pieces and are processed into carton boxes, newspapers and tissue products. This stream is, in percentage terms, a little bit less successful then the confidential paper stream. Namely, 79% and 8% are used for, respectively, raw material and green energy production (RENEWI, 2020b). The percentile gain in comparison to the incineration of residual waste is that an added 74% of raw materials are captured and a reduction of 148 kg CO_2/ ton waste is realized. RENEWI also has a very efficient recycling process for the recycling of disposable cups. Disposable cups are made of 95% paper and 5% PE. The PE is separated from the paper. Whereafter the paper is used to produce toilet rolls. Approximately 70 cups are used for one roll of toilet paper. The PE is presented to the plastic industry. This means the cups are 100% recycled.

5

Results

In the results all the information gathered from the previous chapter will be deeper analyzed and the research questions will be answered. To answer the first sub-question the information gathered from the interviews will be used to suggest a new and improved flowchart that better represents the current situation of the waste management. What follows is an explanation of the survey results. Which part of will be used, together with the improved flowchart and interviews, to make a power-interest grid of the involved actors and stakeholders. In this grid the relative power and interest of all the actors and stakeholders are shown.

The second sub-question on the quantity, quality and composition of the waste streams within the HVA, will be answered with the help of the waste data collected in section 4.3. The found data will be used to make an estimation of the material based waste streams, thereafter a short comparison with the data of the TUD (table 4.4) will be made. By combining the estimated waste streams with results on the organization behind the waste management, a Material Flow Accounting of the four main waste streams will be presented to give a better understanding of the waste streams movement within the faculties.

Sub-question 3 on the improvement potentials within the HVA, will make use of all the previous collected information. The organizational flowchart, data on the use of facilities from the survey, the data on material-based flows and information gathered on waste disposal emissions and opportunities.

Lastly the main research question will be answered by giving examples of possible improvement strategies based on the expert information and literature review.

5.1. Waste management organization

This section consists of three parts. First a new adjusted flowchart will be presented based on the earlier presented flowchart of the W2W student group (figure 4.1 and the interviews with representatives within the HVAs waste management. Next the results of the survey will be discussed and lastly an insight into the relations between the actors and stakeholders will be given in a power-interest grid. This section will subsequently serve as an answer to sub-question 1 (section 3.2).

Adjusted waste management flowchart

After conducting the interviews, a realistic rendition of the waste management can be made. In this section that will be done by showing the results of the interviews in an adjusted version of the flowchart of figure 4.1. A few important distinctions can be made between the original flowchart in figure 4.1 and the situation as described in the interviews. In the original flowchart a distinction was made between a group called the cleaners and a group named the waste collectors. However, from the interview with Jeroen Wagenaar (Appendix B) it can be concluded that these two groups are really just the one group of cleaners. This is an important change because, while it makes the management structure less complicated, it also leads to a less effective separation of waste. In addition to emptying the bins and cleaning the building, they don't have any time to check the contents of the bins or separate the waste scattered in the building. Another problem, as expressed by Wagenaar (Appendix B), the waste generated by the caterers is not separated. Wagenaar also explained that the waste deriving from the faculty itself is being separated into 10 material-based streams. All the above-mentioned actors are allowed to use the first waste collection point. The relation between collection point 1 and collection point 2 as described in the flowchart of figure 4.1 differs from the information gathered by interviewing Wagenaar. The cleaners are responsible to keep track of the available capacity at collection point 1. What follows is a quicker response compared to the flowchart of figure 4.1, namely the HVA contacts RENEWI in an earlier stage.

These differences are shown in a Revised flowchart of the waste management, figure 5.1. In the revision, important actors and steps are added to make the waste management more complete. These include steps and actors that are outside of the influence of the HVA itself. Although the HVA has no direct control over them, they are crucial to the circularity of the waste management due to the holistic nature of the problem, therefore it is important to include them in the evaluation of the waste management.

In all, the revised flowchart representation of the HVAs waste management is shorter and less convoluted. The simplified relation between the first and second collection point is the main reason behind this modification. The use of thicker and thinner lines illustrates the quantity of certain streams and decisions. This flowchart also differentiates between residual waste streams and separated waste streams to give a better understanding of where problems for the sustainability performance occur. The waste coming from the faculty management is categorized as separated and the caterers create an unseparated residual waste stream. Concerning the waste streams coming from the students and the employees, some contradicting information is gathered. The survey (section 4.2.5) and the W2W group (section 4.2.1) explain that people want to separate but that the unclear and small amount of recycling bins lead to very contaminated streams. On the other hand it is also expressed that paper and plastic streams are separated (Appendix B). And although it is highly debatable if these streams are pure enough for recycling by RENEWI, the benefit of the doubt is given in this flowchart by categorizing the stream as separated.

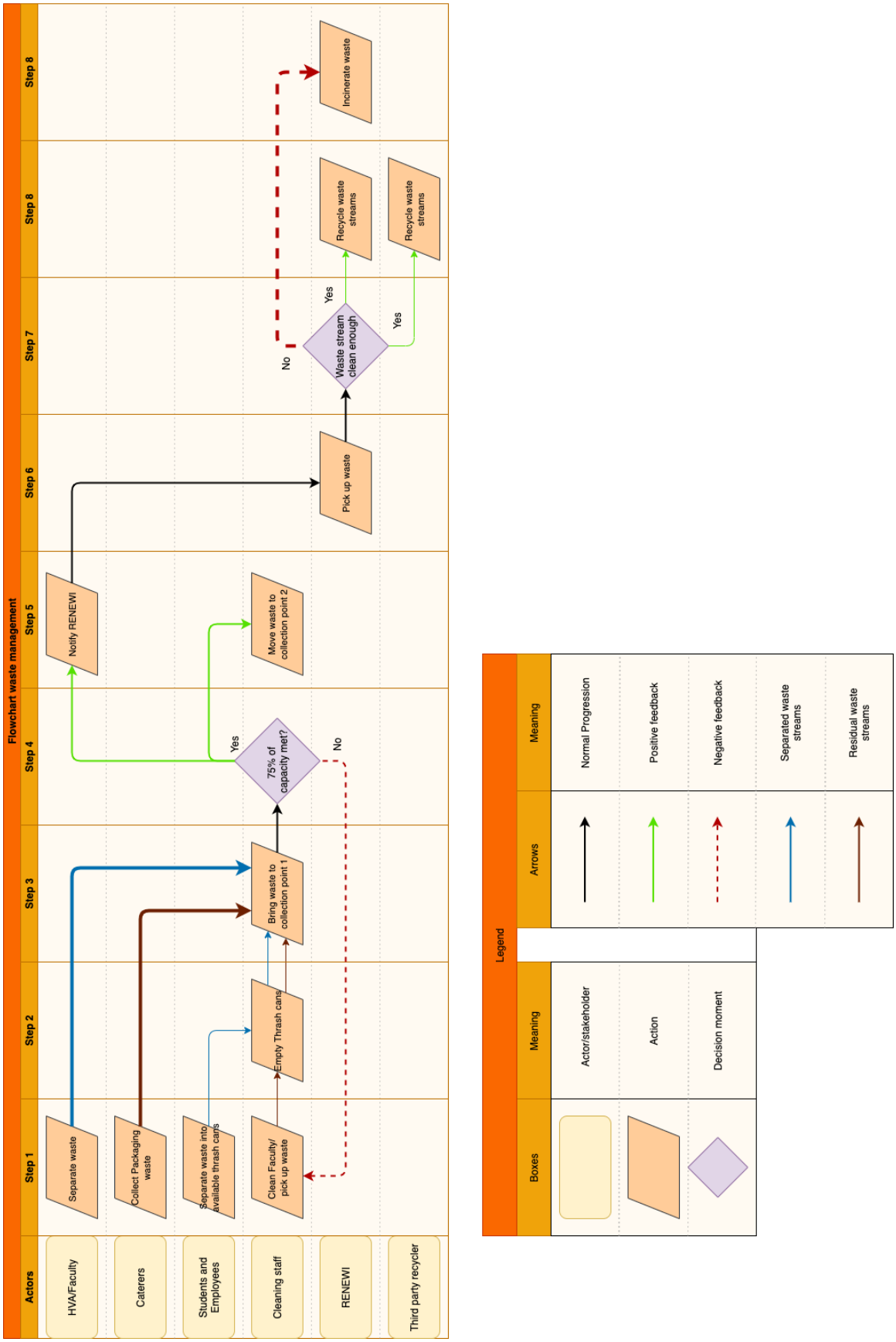


Figure 5.1: Adjusted waste management flowchart

Survey

Unfortunately, the survey was not filled in by a very diverse group. Over 90% of the people that filled in the survey were employees of the HVA (figure 5.2), which gives a skewed view of the reality. This needs to be taken into account when analysing the results. The results of the first section on the quantitative use of the faculties are less useful due to the skewed participants of the survey. The questions on how and how often the buildings are used does not represent reality. The employees represent a small and special faction of the users in that sense. They make more standardized hours and use more specific designated areas to work in.

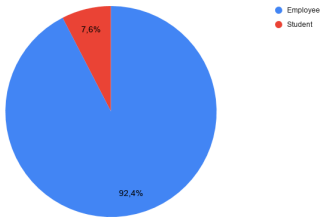


Figure 5.2: Participants relation percentage

The second section of questions about the separation of waste within the faculty tells us the main materials thrown away by the employees, 93,8% of the employees say they throw away organic waste, 92,3% paper/carton waste and 76,9% plastics waste. When throwing away these materials a large majority express that they either 'Often' or 'Always' separate their waste (figure 5.3). The most supported reason by participants to separate waste is because they value the environment (figure 5.4a).

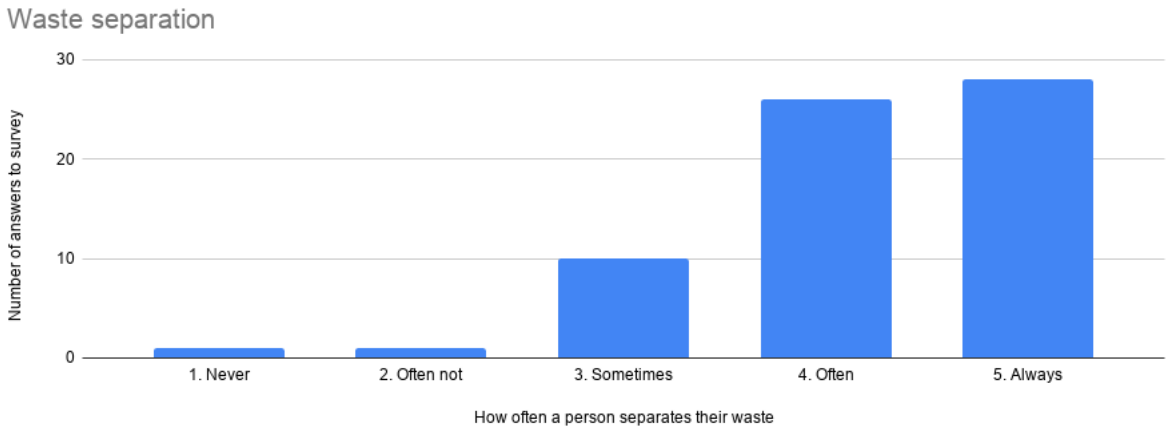
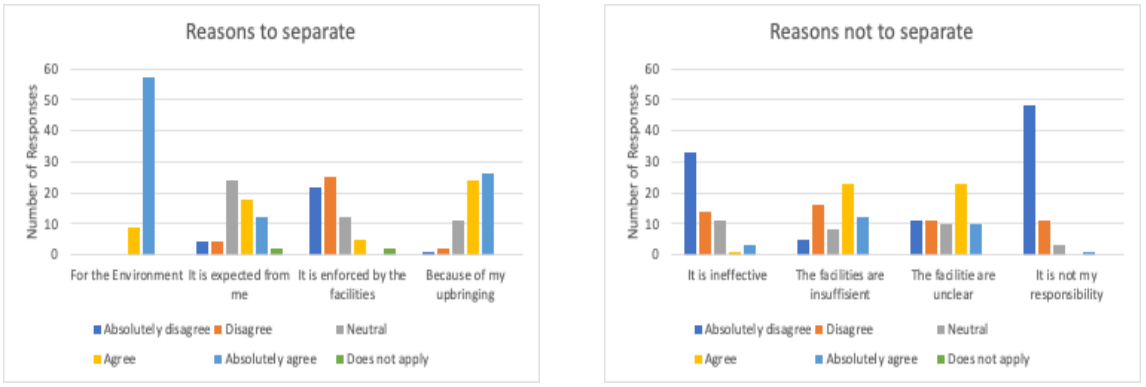


Figure 5.3: Waste separation

When asked what a reason would be not to separate waste, the absence of the right facilities showed to be a problem for a minimal majority (figure 5.4b). This concern is also expressed in a comment of one of the participants who specifically asks for more separate trash cans, "I would like to see more separate trash cans. The faculty only has paper and plastic". Another participant adds to this statement by voicing the concern that people have little faith in the current system, "There is a feeling among teachers that behind the scenes all the thrash ends up in a single container, which demotivates employees to separate their waste. Plastic can only be separated in the teachers' room, while most plastic originates in classrooms. These are two easy to solve problems which can have a large impact!". The lack of trust and sufficient facilities seems like a missed opportunity since the answers of figure 5.4b also underline that the participants see the value of waste separation and feel the responsibility to do so. It could be argued that since employees are older and therefore often more mature towards the shared responsibility of taking care of the environment.

These results do not represent the complete population of users. However, as mentioned before, Schoot (2017) finds very similar results. Therefore, the above-mentioned results can be considered as reliable.



(a) Reasons to separate

(b) Reasons not to separate

Figure 5.4: Motivations behind the separation of waste

The third section results are less reliable than those of the second section. The difference in lifestyle and therefore diet varies significantly between students and employees of the HVA. Of the employees almost 70% either always or often brings food from home. This has a specific influence on the sort of waste they bring into the faculty. The survey now portrays that the main waste that is brought in by its users is mostly organic. However, when considering the voices within this survey it is not certain that this is fully representative of reality. The times that the employees do not bring food from home, over 50% gets food from the facilities within the faculty. It is reasonable to expect that students will probably be less likely to use the caterers within the faculty as they are more expensive and have a less diverse offer than nearby supermarkets. For the fourth section the answers of the students would have given good insight in their own wishes for a curriculum with circularity topics. However, the answers now represent the insight of the professors' (figure 5.5).

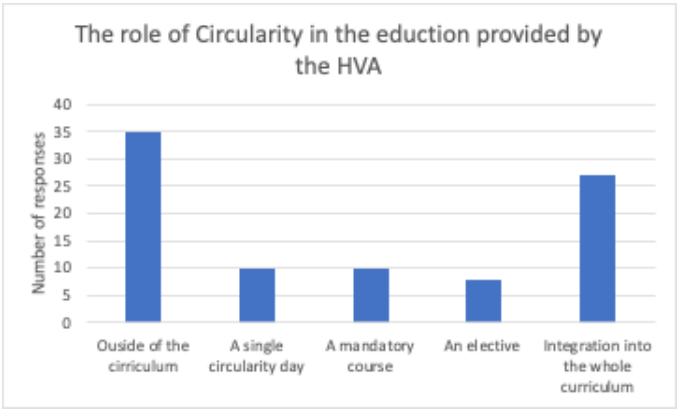


Figure 5.5: Role of circularity in the provided education

The opinion that the HVA should spend more attention on circularity topics is carried by 80% of the participants. The table of figure 5.5 shows which methods are most desired by the teachers. Laying the focus on measures that are 'Outside of the curriculum' and simultaneously 'Integrating it into the whole curriculum' are the most favorable measures. But the most unifying trend in the answers is that multiple measures are needed. Namely, most participants filled in multiple answers. Which leads to the conclusion that the best method

would be to create a holistic approach, integrating circularity into multiple facets of the HVAs practices. This is perhaps best expressed by an open answer of one participant, "It needs to be in our system, our ethos".

Power-interest grid

To illustrate where the power for change lies and which actors are most likely to push for sustainable changes, a power interest-grid was made. Figure 5.6 contains a graph with two axes which shows the relative power and interest of each individual actor compared to the other actors. Therefore, it must not be regarded as an absolute value of how much power or interest an actor has.

Logically the HVA/faculty is the most powerful actor, as they have the end responsibil-

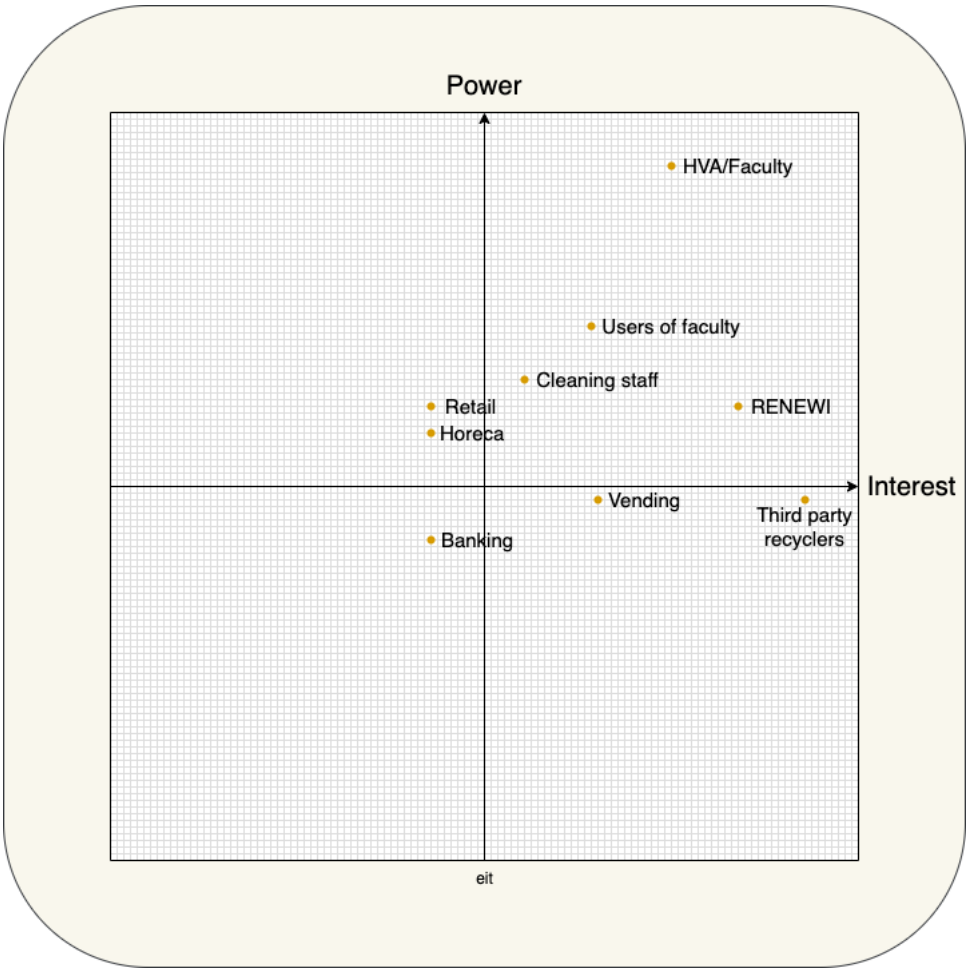


Figure 5.6: Power-interest grid

ity, they decide what policy changes will occur and which won't. Their interest level will eventually determine the amount of change that will occur. At the moment the HVA has an outspoken ambition to move towards a more sustainable waste management, however their current policy is focused on research and determining which steps are the right steps. Therefore, it can concluded that their interest is growing but not yet at a peak. From the survey and the interviews, it can be concluded that among the users of the faculty the interest in sustainability is present. They also have a considerable responsibility and power

over the final effectiveness of a more sustainable waste management. If their interest translates into an effort to reduce, reuse and recycle waste the effectiveness of any policy will be greatly improved. They can however not do this alone, as they do not have the direct power to evoke policy changes.

RENEWI's power lies in the recycling of the collected waste, although this a great responsibility and will, for a large part, determine the success of sustainability policies that are implemented by the HVA, RENEWI has very little actual power within the decision making of the HVA. They can only advise the HVA in order to improve the separation of waste and in determining what material-based streams are to be collected. RENEWI's entire business model is built around the reuse and recycling of waste into new raw materials. Therefore, their interest level is estimated to be one of the highest respectively.

The only actor with a higher estimated interest level is the third party recycling companies. Usually, they are small specialized companies that recycle one specific material based stream. The culture within those companies is usually build around sustainability principles. Since they are contacts of RENEWI and not of the HVA itself they are a step further away from influence within the HVA.

The influence and power of the cleaning staff is similar to those of the users of the faculty. Since they are employees of the HVA they can be instructed very specifically how to perform their duties in a sustainable manner. However, their cooperation is crucial. The effectiveness of how they carry out their duties directly influences the success of a policy. Therefore, they can best be included in the decision making of relevant topics. Their interest will however most likely not be in the sustainability aspects of policy but more towards the impact on their work.

The four different kinds of caterers all have their own interest and power level. They all work with pre-existing contracts. In these contracts their rights and responsibilities are clearly stated. The larger the company the better they will be able to negotiate favorable terms within their contract. The retailers, as big supermarket concerns, are the largest companies. Therefore, they can exercise the most influence on the contracts and thus are estimated to have the most power of the caterers. The Horeca is the largest in presence at the faculties, therefore they have the largest influence on the effectiveness of sustainability policies, the same way the cleaners have. They relatively generate the most waste and therefore bear a similar responsibility as the users and cleaners, namely, to separate part of the packaging waste. Thus far their lack of waste separation has shown that they have a low interest level either way. This means that they are probably easily persuaded to start separating their waste. However, forcing them to find sustainable sources for their produce is likely a bit more difficult, they are profit driven and are not willing to risk to much profit in the name of sustainability. The Vending concerns have shown a sustainability interest in their use of recyclable/compostable cups. Their true influence and power within the HVA is however limited since they are not involved in the separation and or recycling stages of the management. Banking has the lowest influence, these are mostly temporary partners which deliver a prepared lunch or dinner on an irregular or even single time basis. Their interest within the sustainability ambitions of the HVA is therefore also limited. Banking caterers might have high sustainability standards of their own or are willing to reshape their service with the goal of securing more work from the HVA. This is however hard to determine due to the irregular nature of the banking service.

5.2. Material based waste streams

In this section the collected data on the waste streams within the HVA (section 4.3, will be used to make an as accurate estimation of the reality as possible. To check whether the concluded numbers are near to what can be expected, a short comparison will be made with the data from the TUD, presented in section 4.4. The final estimations will also be used to make Material Flow Accounting to create a better insight into the movements and origins of the material-based waste streams.

Material flow Accounting

Based on the information of table 4.2 and table 4.3 the waste is characterized into four main streams, 'Residual waste + PMD', 'Paper', 'Organic waste' and 'Cups and disposables'. These are the dominant streams within the faculties of the HVA, therefore these streams will predominately be looked at when further discussing the waste streams apparent in the HVA. The density of these four streams have also been established by measurements preformed in the waste audit performed by RENEWI. These densities are of course representations of the specific ratio of contents found in the analysis and are therefore an estimation of what the density could be. Focusing on these four main waste streams, means the considered waste is derived from only two streams of the original waste streams in table 4.2, namely 'Flammable company waste' and 'Motley paper'. Some rounding losses occur due to the implementation of the percentages of table 4.3, which results in a total waste stream of 431,5 Tons/year.

Table 5.1: Dominant material based waste streams

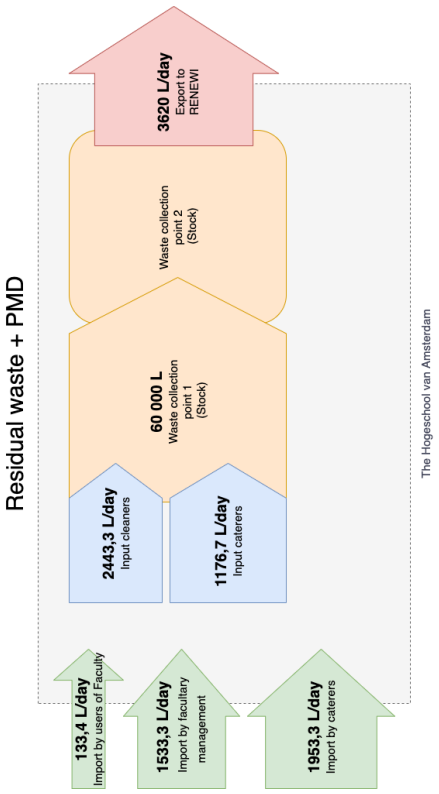
Main stream	specified stream	Mass [Tons]	Percentage [%]	Density [Kg/m^3]
Residual waste + PMD		**108,6**	**25,17**	**150**
	Residual waste	15,8	3,66	
	Drink cartons	3,2	0,74	
	PET bottles	14,2	3,29	
	Plastic others	15,0	3,48	
	Foil plastic	35,3	8,18	
	G/W/M/T	25,1	5,82	
Paper		**129,1**	**29,92**	**120**
	Paper	89,8	20,81	
	Carton	13,4	3,11	
	Paper motley	25,9	6,00	
Organic waste		**108,9**	**25,24**	**1000**
Cups and disposables		**84,9**	**19,67**	**100**
	Coffee Cups	43,5	10,08	
	Compostable disposables	41,4	9,59	
Total		**431,5**	100	

Table 5.1 shows that the non-recyclable residual waste is combined with the recyclable stream Plastic/Metal/Drink cartons (PMD), this is following the trend of the municipality

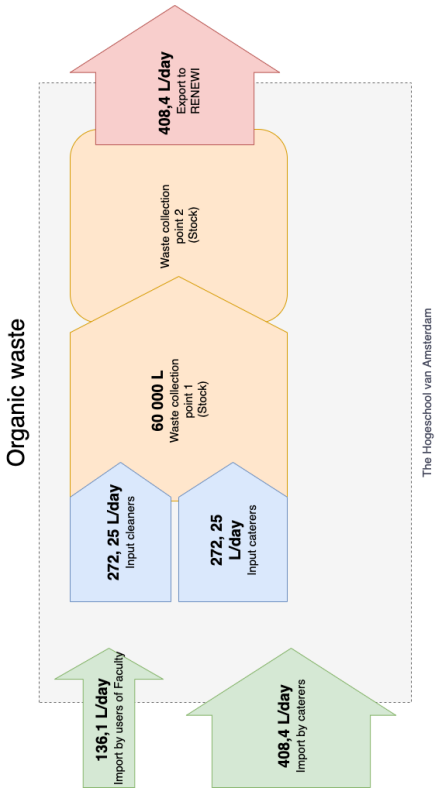
of Amsterdam. The municipality has stopped with the collection of separated PMD waste due to too high contamination levels making the separated waste streams invaluable. They have therefore changed their approach to post-separation, together with their partner AE-Bamsterdam they have the goal to prepare as much waste as possible to be redistributed as raw material (Zoelen van, 2020). The 'Residual waste + PMD' waste stream will result into multiple streams after post separation. Potentially the largest is plastics, depending on the separation technique the stream can be separated into several specific plastic types. The second largest stream might be the Glass/Wood/Metal/Textile stream (G/W/M/T). However, due to the relatively high density of these materials, the total volume might be relatively low compared to other material streams. Looking back at table 4.3 it can be deduced that the G/W/M/T stream contents is distributed in percentage terms as follows, 7,1%/5,7%/24,1%/63,1% relatively. PET bottles and drink cartons are two relatively smaller streams and can be considered as more mainstream recyclable waste streams. In the end there is still a fairly significant inseparable stream that will most likely end up in either a incinerator or landfill. The eventual quantity of the stream will depend on the effectiveness of the post separation technology. Out of the 'Flammable company waste' around a 100 tons of paper waste can be collected. Together with the already collected motley waste this becomes the largest material stream of the HVA. The Organic waste is also a significantly large stream, the total mass equals that of the residual + PMD waste stream. Organic waste is different to the other streams because of the effect time has on its storage opportunity. In figure 4.1 it can be seen that the organic waste has a shorter storage time, to prevent large nuisance due to rotting. The Cups and disposables stream is, with a small quantity difference, the smallest waste stream. What stands out is that the ratio between coffee cups and Compostable disposables is close to 1. Depending on the kind of coffee cups are used, the stream does need further separation for recycling.

To verify that the results of table 5.1 are realistic, they are compared with the data of TUD on their waste management. Some of the specified waste streams in table 4.4 are slightly different from the ones in table 5.1. These small differences are due to nuances in the way the data was collected. When further comparing the data from the HVA and the TUD, it can be seen that most material-based waste streams are relatively similar. Overall, the TUD generates about 50% more waste compared to the HVA. Most of this additional waste can be attributed to the addition of garden waste collected by the TUD and the large amount of Residual waste that is collected, in total 366 tons. This waste segment originates directly from users using the waste bins. The difference in this segment can be explained by a more extensive use of the faculties due to the difference in educational level. Overall, it can be said that after the comparison of the HVAs and TUD data on waste output, the estimation on the HVA waste streams can be accepted.

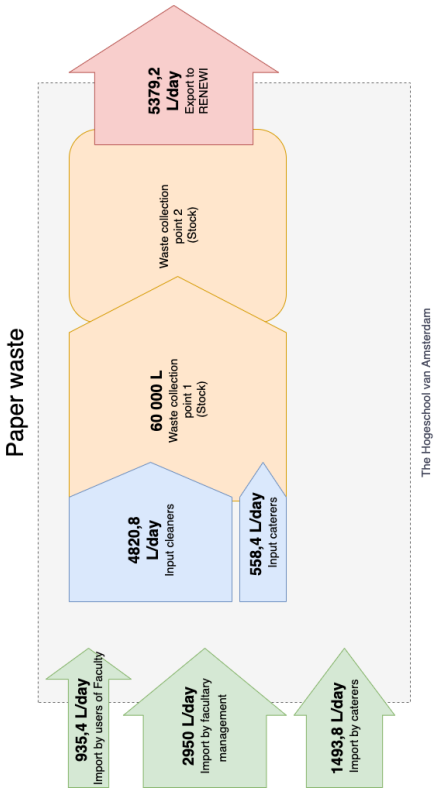
Based on the flowchart in figure 5.1 and the data in table 5.1, Material Flow Accountings (MFA) were produced to further evaluate the material based waste streams within the faculties. Figure 5.7 shows the four main waste streams, where they originate from and how the collection quantifiably is distributed between what the cleaners collect and what is collected by the caterers. It also shows where the waste ends up. This is the same for all the waste streams at the moment, as all the collected waste is picked up by RENEWI. With the density information from table 5.1 and knowing the effective days in a year (200 days/year),



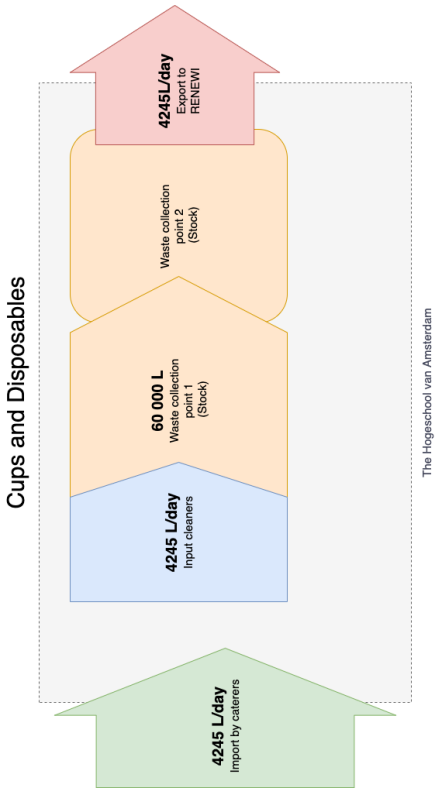
(a) Material Flow accounting of the Residual waste + PMD waste stream of the HVA



(b) Material Flow accounting of the Organic waste stream of the HVA



(c) Material Flow accounting of the Paper waste stream of the HVA



(d) Material Flow accounting of the Cups and Disposables waste stream of the HVA

Figure 5.7: Material flow Accounting for the four main waste streams

the volume of waste per day is calculated and used in figure 5.7. The reason behind the use of this unit flow, is to estimate the interval in which each material-based stream needs to be picked up by RENEWI.

As can be noticed, the first and second waste collection point function as a stock in the MFA. The first waste collection point has a maximum capacity of 60 000 Litre as is discussed by Wagenaar (section 4.2.2). It is unclear what the maximum capacity of the second collection point is, but since the frequency of pickup is partly determined by the speed of waste generation (section 4.2.2) the capacity can be thought of as sufficient. The output of each MFA shows an average export to RENEWI per day, however, in reality RENEWI will not schedule a pickup every day. Wagenaar explained that when 75% of the full capacity of the first collection point is reached, the waste is moved to collection point 2 and RENEWI gets notified. This means that, assuming every waste stream gets its own 60 000 Liter container, the pickup frequencies of 'Residual waste + PMD', 'Paper waste', 'Organic waste' and 'Cups and disposables', are respectively, 13 days, 9 days, 83 days, 10 days.

The division in import sources of the waste streams are estimated with the help of the information gathered in the interviews and the concluded data from table 5.1. For the residual and PMD waste stream, it can be deduced that most of the drink cartons and PET bottles are directly purchased by the caterers. The Plastic foil is a byproduct of the caterers' purchases, as plastic foil is used as a packaging material. It is deduced from the interview with Wagenaar (Appendix B), that the Glass/Wood/Metal and Textile are mostly products required by the faculty management. Because the contents of the residual waste is uncertain (table 5.1), it is difficult to pin down its origin. Therefore the rule of 75%/25% is used. This means that 75% originates from the faculty itself (caterers and faculty management) and 25% originates from the users of the faculty (Appendix B). Of all the above-mentioned waste streams all except the plastic foil end up in the trash cans spread around the faculty. This means that the cleaners are responsible for most of the waste's movement to collection point 1. The plastic foil is directly moved by the caterers after unpacking their purchases. The Paper stream exists out of three main streams, namely Paper, Motley Paper, and carton. It is reasoned that the Motley Paper originates from the faculty management, this combination of several types of paper products are most likely the paper products collected by the several different maintenance and educational purposes. The carton can, for the largest part, be allocated to the packaging of the caterers' purchases just as the plastic foil was. The paper stream was divided over the three groups, it was however decided that the faculty management is responsible for most of the paper import, therefore they carry the largest percentage of this waste stream. For the movement of the waste to collection point 1 the same principle as for the residual and PMD waste stream is in effect. Most streams are thrown away in trash cans after use and are therefore moved by the cleaners, except for the carton which is moved by the caterers directly to collection point 1 after unpacking their purchases. The Organic waste originates from 2 of the three groups. The caterers purchase food and drinks for sale and the users will bring in food themselves. The percentile division was decided by the earlier mentioned 75%/25% rule. Here all waste is thrown away in trash cans after use. Considering that there is some spillage by the caterers, it means they are also held responsible for the movement of organic waste to the collection point 1. The cups and disposables are entirely brought in by the caterers. They are made available by the vending parties. After use they are thrown away in the trash cans around the faculties and thereafter pickup by the cleaners to be moved to the collection point 1.

5.3. Improvement potential

Now that the organizational structures and material-based waste streams are known, subquestion 3 on the potential for improvement can be answered. First the emission reduction potentials per material waste stream will be displayed. This helps to understand where the largest environmental benefits potentially lay. The largest potential for improvement is also dependents on the quantity of the waste streams. The more waste there is within a material-based stream, the more environmental benefits can be achieved. Lastly it is important to consider the organizational structure to understand where weaknesses of specific waste streams occur.

Potential environmental benefits of waste

Section 4.5 gives an extensive review of the sustainable disposal options of the four characterized waste streams, 'Residual waste and PMD', 'Organic waste', 'Paper' and 'disposable cups'. Per material-based stream a potential reduction in CO_2 and a material recovery rate is given by the RENEWI. RENEWI made some distinctions that have previously not been made in the material flow assessment. Namely the distinction in 'organic waste GFT' and 'organic waste Swill', the difference between 'confidential paper' and 'paper/cardboard' and they separately recycle foil plastic. Table 5.2 shows the total potential emission reduction per waste stream.

Table 5.2: Possible emission reduction per material based waste stream according to RENEWI

Material based stream	Mass [Tons /year]	Material recovery rate [%]	Reduced emissions [kg CO_2/ton waste]	Potential emission reduction [kg CO_2 /year]
PMD	38,45	86	1468	56.444,6
Foil	35,8	98	1188	42.530,4
Confidential Paper	44,9	84	194	8710,6
Paper/ Cardboard	84,2	79	148	12.461,6
Organic waste (GFT)	95,85	90	501	48.020,85
Organic waste swill	54,45	94	328	17.859,6
Disposable cups	84,9	100	-	-

The PMD waste stream displayed in table 5.2 consists of the mass of a specific fraction of the Residual waste and PMD stream found in table 5.1, namely, drink carton, PET bottles, Plastic others and metal. The foil fraction of the residual waste and PMD stream is considered separately. The glass, wood and textile are left out of consideration due to little applicable information found and the relatively small quantities. The distinction between confidential paper and paper/cardboard made estimation on mass distribution necessary. The mass of the confidential paper was estimated to be 44,9 ton. The reasoning behind it was that the confidential paper would originate from the faculty management and only

from the paper fraction and not the paper motley fraction. The paper/ cardboard stream is the remainder of the total paper waste stream found in table 5.1. The difference between the mass amount of the two organic waste streams, GFT and Swill, comes down to where the waste is collected. RENEWI states that the main difference between Swill and GFT is that Swill is usually collected as kitchen waste. In practice this means that the organic Swill waste will be collected by the caterers and a different organic waste stream is created by the cleaners, who collect the organic waste from the bins around the faculty. Looking at figure 5.7b, it can be seen that these streams are equally divided. An addition is made to the GFT stream, namely the compostable disposables. This leaves the disposable cups of which, unfortunately, no specific data on emission reduction was found.
Taking a look at the potential emission reduction given in table 5.2, it can be concluded that the recycling of PMD has the most potential for reduced emissions. However, this is all dependent on the effectiveness of the separation methods. The literature explains that the best method of separation is debatable. Both source-separation and post separation have barriers and benefits. A successful separation method makes sure that the waste is accurately separated, to maximize the amount of separated waste streams and assure they are as uncontaminated as possible.

The separation of high quality paper from lower quality paper also benefits the emission reduction. The confidential paper, due to its higher quality, can be recycled more effectively, providing a higher reduction of emissions over the whole cycle.

While there are many methods of sustainable disposal of organic waste, composting or digestion seem to be the most environmentally beneficial. The composting of organic waste seems to be the better usage of organic waste when both methods are compared with incineration, however the reduction of CO_2 merely shows the primary benefits compared to incineration. The production of compost and biofuel both have secondary benefits themselves. This is however somewhat out of the HVAs control. Their contract with RENEWI limits their influence on the method of disposal. However the power-interest grid (figure 5.6 shows that the HVA does have the last say, and with the right motivation they can exercise their power to require their partners to work more sustainable.

Because the separation of waste is an important aspect influencing the success of a sustainable waste management. The organization of the waste management cannot be overlooked. The literature and interviews with experts teach that mono material waste streams result in the highest recycling rate and highest environmental benefits. However there is no consensus on the best method to achieve the necessary separation. A combination of source- and post-separation seems to best solution. Therefore a selective part of the waste needs to be separated in the faculties. As is described above and shown in table 5.2. The Flowchart in figure 5.1 and the results of the survey indicate that the separation at the faculties is insufficient. A significant part of the unseparated fraction originates from the caterers. Based on the fact that this is one of the waste streams where the input can be well regulated and inventoried, means there is potential for improvement. The interview with the W2W group (Appendix A) and the survey additionally expressed that the recycling bins were insufficiently placed and used. This together with the worries expressed about the time schedule and the workload of the cleaning staff, making them unable to separate collected waste, shows that the waste is not yet efficiently separated within the faculties. This indicates more areas of potential improvements. Previously it is mentioned that often a

large fraction of emission is due to the transport, it is worth looking in to the minimization of this burden. The way the first and the second collection point are organized insinuates that the waste is only picked up when the capacity is met. With more separated waste streams and an inventoried input, more knowledge is available to determine more efficient schemes for the pickups of the waste.

5.4. Improvements to waste management of the HVA

This section will go into the most effective policy measures and planning strategies the HVA can implement to improve the sustainability of their waste management. To come to this answer, it was first determined what the organizational structure of the HVAs waste management was. Thereafter an estimation was made on the quantity and composition of the HVAs waste streams. With the help of literature on environmental impacts of waste disposal methods, the two mentioned evaluations were used to determine the highest potential improvement areas. Based on these potential improvement areas the literature and the expert information from interviews was used to produce fitting and logical policy implementations. The proposed policy implementations are categorized into three sections. Focusing on the separation of waste inside of the faculties, on the prevention of waste and on the regulation of purchasing and waste output.

Improving on the separation of waste

The separation of waste is important for a sustainable disposal of the waste, the cleaner the waste, the less impurities it has, the more efficiently it can be recycled. While source separation seems the cheapest and easiest way to separate waste, many researchers found that source separation always lacked the required purity. Several reasons were given. The USC had difficulties with the required space for enough recycling bins (Appendix G). The ASU had difficulties with populations beyond their influence which contaminated their waste streams (Appendix F). Zhang et al. (2011) found that even after instructing the population, the waste streams were still too contaminated to recycle effectively and that it was therefore better to post separate. This being said, source separation is still the cheaper option if performed well. Therefore, it is advised to do selective waste separation. Focusing on the waste streams that benefit the most of separate collection. Since PMD and residual waste are already collected together by the municipality of Amsterdam, this waste stream is a logical choice. Companies like RENEWI, AEBamsterdam and Umincorp are able to produce high separation rates out of these mixed material streams, finding an effective partner is therefore possible and advised. A good partner is however not only good at the post-separation and recycling process, but also provides clear feedback on the received waste. The interview with the W2W group showed that due to a lack of communication on the quality of the collected waste, streams perceived by the HVA to be recyclable were in fact disposed of as residual waste (Appendix A).

The next two streams are both paper based. However, making a distinction between high- and low-quality paper can be very beneficial for the recycling process. The high-quality paper can remain in its own paper production cycle and therefore has a higher energy value. Environmentally seen this is an energy value that can best be captured. Organic waste is not yet captured either at the HVA. Because organic waste has the highest impact when landfilled and has a high potential when used for compost or biofuel production, it will have a large benefit on the sustainability of the waste management when captured.

The last waste stream that is advised to separate are disposable cups. Research has shown that when collected separately and uncontaminated, this stream can be a 100% recycled.

The necessity of source-separation at the faculties of the HVA asks for a waste separation strategy. This strategy needs to be implored to make sure the required purity for the waste streams is achieved. First and foremost, this means that there need to be more recycling bins available and it needs to be clear how they are to be used. From the literature (Martinho et al., 2018) and the survey it can be concluded that when presented with the opportunity people are willing to separate their waste. However, a lack of understanding prevents them from correctly separating their waste. In order to create an overall understanding on how waste is to be separated, a sustainability awareness needs to be created among the users of the faculty. Creating awareness means the population needs to be confronted with the subject on a regular basis. In creating the required awareness, the HVA can best use the fact that is an educational institute to its advantage (Appendix G) The ASU advises to start the year off with sustainability seminars to introduce the first years to the sustainability policies active on campus (Appendix F). This lets them know form the start how to sustainably use the facilities within the faculty. To increase the effect of the introductory seminars, the population needs to be reminded of the active policies throughout the year. This can be done by making the policies visible. Like making the recycling bins a notable color or introducing water tap points, something the HVA already has experience with according to Meijer (Appendix C). Another good way of exposing students with sustainability is to offer sustainability subject inside and outside of the curriculum. The HVA has already used student project groups to help in the research for more sustainable practices within the HVA. Examples are Uiterwijk (2018) researching waste separation, Daalhuizen et al. (2020) looking into the best waste bins for waste separation Marella et al. (2019) whom are interviewed in section 4.2.1 (Appendix A. According to Cook (Appendix G) however, it is best left outside of the curriculum, because the effect will be more fruitful if students chose for it themselves and it is not forced upon them. However, looking at the survey it can be concluded that a large number of staff members feel it should be part of the curriculum. More specifically it can be said that the survey shows that the members of staff want sustainability incorporated in all the facets of the HVA. This is something that was also concluded by Zhang et al. (2011). Their experience with the use of student involvement in the implementation of sustainability policies was seen as a considerable boost to the sustainability of the waste management. They used "Environmental Champions" to support the environmental officer in the implementation of policies. The use of students here made it easier to reach a larger population. The ASU used student liaisons as sustainability representatives within the student housing facilities, in order to ensure the correct implementation of the active policies. The ASU also actively encouraged student committees to involve themselves in decision making processes and to come up with sustainability initiatives (Appendix F). The TUD has a similar attitude. Namely, they have introduced green teams for every faculty each responsible for their own sustainable initiatives, not limited to the waste management. Similarly, the ASU had the Renewable Energy Council and the Sustainability Committee within the student council. These are all examples of student interactions that greatly benefited the sustainability awareness on their respective HEIs. Not only did it make students more involved in the policies and activities, it also taught them about having a sustainable live style, something very valuable for later in live.

Prevention before recycling

All studies and research agree that the prevention of waste is an even more important tool then the proper recycling of waste Waste Framework Directive (2008). An important strategy in enforcing waste prevention according to the USC is the precautionary principle (Appendix G). This teaches to first find alternative solutions before purchasing something new, reducing unnecessary purchases and therefore reducing waste on the long term. Examples on the USC of the precautionary principle are office inventory regulation for the staff members and the exclusion of one time use products for social activities. Following the precautionary principle led to an overall waste reduction at the USC, which shows it to be an effective tool.

For Organic waste the best method of prevention is simply not throwing out food waste. Food waste is a problem especially in restaurants and other dining venues, like for instance the catering facilities in HEIs. First of all, a well planned purchasing strategy can limit the amount of access food, therefore preventing food waste. This not only has environmental benefits but also economic benefits for the caterer themselves. This however will not result in the elimination of all food waste. To further reduce food waste, food that is edible but not marketable anymore can be gifted to charities, who distribute it among the less fortunate (Schneider, 2013).

The prevention of paper waste is something Smyth et al. (2010) have looked into. One of their techniques might be an effective method for the HVA. Namely the double printing on paper and the re-utilizing of paper where possible. A simple but effective method. The use of disposable cups is easiest prevented by introducing reusable cups. Smyth et al. (2010) found that the sale of reusable cups had one downside, it asked the population to make an initial financial investment. While a fraction of the population was willing to make the investment, it did form a barrier for the residuary fraction of the population. Research showed them that rewarding the population with a small financial incentive increased the reuse of disposable cups or the purchase of reusable cups. For a considerable result a price difference of 0,10€per hot beverage creates the desired effect (Smyth et al., 2010).

Regulating the input and output of waste

From the interviews it became clear that there is little regulation on the purchasing within the different waste generators of the HVA (Appendix B, Appendix C). A strong control over and accurate knowledge about what comes into the faculties, can help limit and control the waste streams that come out of the faculties. This is why the ASU uses an upstream approach, wherein they contractually force in-house partners and suppliers to buy sustainable (Appendix B). As part of the precautionary principle the USC uses a portal for faculty purchases. Not only does this prevent unnecessary purchases, but it also inventories the purchases made. Using such an ordering platform can also drastically reduce costs (Zhang et al., 2011). With an overview of all the purchases from the faculty staff and the different caterers within the faculties, a prediction can be made of the waste output.

Comparing this estimation with a quantity, quality and composition check of the outgoing waste, a better understanding of the waste movement in and out of the faculty can be established. This better understanding can be used as feedback of the waste management and help to improve on the situation (Gallardo et al., 2016). When preforming waste audits it is important to consider and take measurements at different locations within the faculty and at different times of the week and year (Smyth et al., 2010), this produces a more detailed understanding which can be used to specificly target problem areas. The data on

the waste output can also help to reduce the number of pickups that are necessary. As can be seen in the section 5.2, different waste streams will meet their storage capacity at different times. With precise data on waste generation, the pickups can be efficiently scheduled limiting emissions from transportation (Zhang et al., 2011), and expenses (Appendix F).

Many HEIs have, or are planning on building, a composting facility for the composting of their own organic waste. Some reasons are that er isn't any composting facility available nearby Smyth et al. (2010), others use it as an educational tool or because they can use the compost themselves (Appendix F. Since the HVA has no direct use for compost and there are composting or digestion facilities available outside of the HVA, it is not advised to build an expensive composting facility themselves. It is however important to find reliable waste disposal partners. It is financially beneficial to find a single waste disposal company that meets all the demands. However, the collected data can also be used to single out specific waste streams that have a specific recycling procedure and find smaller partners that perhaps can create higher valued products with specific waste streams.

In general, it is advised to create a large data structure of all the inputs and outputs of waste. There are multiple techniques to measure waste and waste prevention (Zorpas, Lasaridi, 2013). It is also important to periodically use the data to evaluate what is going wrong and what adjustment can be made (Appendix G). The use of an annual survey among the population is also advised to better understand how the population interacts and understands the policy measures implemented Zhang et al. (2011). All literature and exerts also advice to learn from others, looking at how HEIs or other large institutions improve their overall sustainability. Joining a group like the College and University recycling Coalition (Appendix F) or subscribing to something like the Sustainability Tracking Assessment & Rating System (Appendix G) can greatly benefit the HVAs network. Also, the communication on sustainability between HVA departments needs to be clear and open. A holistic problem like the sustainability of a waste management can only be improved when all the actors and stakeholder work together.

6

Conclusions and Recommendations

In this chapter the main conclusions from the previous chapter will be summed up. They will consist out of the main improvements the HVA can focus on to successfully and effectively improve their waste management. These will be followed a short discussion with the personal opinion of the author and by some recommendations for further research to further improve the waste management.

6.1. Conclusion

The improvement of waste management is not something that can be solved by looking at it from one perspective. The holistic nature of this problem makes it very interesting and at the same time very complicated to solve. Not one single solution can be considered to be the holy grail and it will require the cooperation of all the involved actors. Therefore, widely spreading awareness on sustainability is something any large institute should take very serious. This is an aspect that requires constant action, especially within HEIs since their population gradually changes every 4 to 5 years. As a HEI it is also important to realize the educational role it has. Not only living up to being a sustainable organization but also preparing students for a sustainable life after their education. This is what makes the incorporation of students in sustainable activities and decision making so important. It is therefore highly advised to initiate a student council committee that is solely occupied with the sustainability of the HVA. To reach the broader population of students it would also be wise to organize sustainability events, like introductory seminars, or make sure sustainability policies are visible and recognizable.

Since the caterers and the faculty, itself bring in the most amount of waste by their purchasing. It would be wise to collect all that data to make a comprehensive inventory of all products that come into the faculties. With this purchasing data it can be estimated what the waste composition could look like. With extensive waste audits these estimations can be checked and when discrepancies are found, the use of data analysis and material flow analysis can show the sources of barriers for the separation of waste. In order to make the tracking of waste work properly a close relationship with the in-house caterers is necessary. They need to give insight into their administration. A strong data collection system can not only help waste tracing, but it can also help with the communication to departments within the HVA and to partners outside of the HVA. This means waste pick-ups can be planned

more efficiently, which in turn reduces transportation cost and emissions. Another purpose of waste tracing is possibly uncovering new unexpected waste streams. Uncovering specific material-based waste streams can stimulate the search for specific waste recycling partners. Perhaps certain materials can be utilized better with different recycling methods. A good waste disposal partner with a large network can play an important role in the maximization of recycling and the minimization of environmental impact. It is therefore important to work with reliable and knowledgeable partners.

Since the separation techniques used in specialized separation facilities have made it possible to separate waste with high purity. It has become unnecessary to separate all material-based waste streams. After estimating and analysing the current waste streams of the HVA it was concluded that the focus of separation should be on a few waste streams only, presented in table 6.1

Table 6.1: The separation streams for the HVA

Residual waste together with Plastic, Metals and Drink cartons
Edible Organic waste
Inedible Organic waste
High quality paper
Low quality paper
Disposable cups

Multiple sources have expressed concerns about the barriers surrounding the separation of to many separate waste streams. Barriers such as the required space for facilities and the lack of understanding among large populations lead to too contaminated waste streams. Since the waste disposal industry has shown its capability to post-separate the residual waste stream collected together with PMD. It is advised to collect these materials together. However, in other waste streams there are subtle distinctions that can be made. Organic waste can best be collected separately because this stream has high environmental costs when landfilled and it is difficult to post separate unless done manually. It is also best to save edible organic products from the waste and distribute to help organizations, saving its primary value. Paper is a relatively common material to pre-separate. It also helps to separate the higher quality paper from the lower to preserve the higher value of the quality paper for the recycling process. The last stream that must be collected separately are the disposable cups, they form a waste stream that can be recycled 100% if collected separately and uncontaminated.

6.2. Recommendations

Following most literature, the next step of research would normally be to perform pilots or something of the sort. Like is described in for instance in the ILSE project (De Langhe et al., 2013). Another approach could lead to the use of ranked indicators to valuate the options in a Analytical Hierarchy Process Handfield et al. (2002).

But in order to preform test pilots and rank indicators or perform any short of validation technique, first a data collection system will have to be introduced. An all-encompassing data collection system is something that could greatly benefit the HVAs ambitions. The

purpose of collected data is to increase understanding of the waste flows and test the effects policy measures have. Therefore, it is important to create a data collection system that supplies data steadily, is easy in use and integrate it into the HVAs structure. For future research it would therefore be beneficial to create an online interactive data collection environment. An environment where purchases from caterers and faculty staff can be inventoried and directly linked to material specific waste generation, including a tested time-delay were necessary, to account for the time the product stays in use. As a precautionary measure it could also be linked to storage within the HVA to prevent unnecessary purchases. It can also be designed to receive waste audit data and directly perform waste analyses. Such an environment would require an extensive database on the packaging material purchases arrive in, an understanding of the purpose and use of the purchase and knowledge on the inventory of the HVA. When performed well it could significantly increase the ease in which waste data is collected which will improve the amount of data that is collected.

Discussion

After all the research that was done, I greatly appreciate the fact that the sustainability of a waste management is an everlasting work of art that is never really finished. But in order to approach the requested sustainability two main things need to be established.

The first is a purposeful spread of information, to make every individual aware of the goals that are set. As can be said of so many things, the success of a sustainable waste management is determined by its weakest link. Unfortunately, there are always individuals that are unwilling or misinformed. The problem can also be induced by a larger group with momentary lapses of motivation or lapses of discipline. That is what in my opinion makes a sustainable waste management such a difficult thing to obtain. The introduction of student run management bodies or sustainability committees will benefit the involvement of students overall, but it will most likely be met with ups and downs.

The second thing that needs to be established in my opinion is also discussed as recommendation. Namely, the introduction of an all-encompassing data collection structure or program. Not only the students need to be constantly reminded of the set goals, but also the management departments. This is best done by periodically evaluating the progress and tweaking the system where necessary. The data that can be collected is of utmost importance for creating the understanding that is necessary. In the long term it can also help to realistically plan the track an institute as the HVA wants to be on.

Waste management in general is something that is far from interest for a lot of people. When people do not know or understand something they tend to not care about it. Therefore, I find it hopeful and inspiring to see an institute as the HVA pursue a sustainable waste management. They have the reach and podium to affect a lot of young people and teach them and get them interested in sustainability subjects. Hopefully this will set up a new generation that will be responsible with the limited resources that are available to us.

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A

Interview Waste2Worth

The interview with the Waste2Worth group was initiated by Jibbe Knuit (myself), he was brought into contact with the group by Joep de Hoog after reading their Waste2Worth initial research report. The information found in the report is a good source of preliminary information. However some of the mentioned subjects were not fully developed later on in the report and could use further clarification.

The interview was conducted on Zoom and was with two of the group members, Ellen McCarthy and Federica Marella. The interview was prepared by Jibbe Knuit by making and sharing questions. The questions were separated into segments related to the chapters of the report. This shared question list was used as a guide to lead the interview as an open discussion. The following will be a loosely based transcript of the interview and is agreed upon by the interviewees.

Transcript

The transcript is divided into seven main sections which were discussed during the interview. The sections loosely follow the structure of the Waste2Worth report. The last section however is an addition made later on. This part of the interview was conducted later with a third member of the group, James Ric-Hansen.

Opening

In the report there has been a distinction between three forms of research questions, namely a Design Challenge description, Design Sprint Goal and a Research question. These three definitions served approximately towards the same purpose. Therefore, it was not entirely clear why the choice for this approach and distinctions was made and how this was reflected in the results/conclusion.

W2W explained that the report was part of a larger project, this meant that the report and its results were just preliminary. A lot of the instances where the report mentioned that further research would be needed in a later stadium or implementation would be attempted later, were either done after the report was completed or not returned to because the project moved into a different direction.

Research Methods
Here it is firstly explained that out of observations it was noticed that facilities within a faculty greatly influence human behaviour regarding waste separation/management. Based on this their methods were constructed to further explore faculty driven measurements towards circular waste management. The following methods were used to collect information, a literature review, survey, interviews. The information material flows were visualized, and stakeholders were mapped. They elaborated that the stakeholder mapping was realized by using ethnographic information that was earlier collected, combined with an interview with a RENEWI representative. It was also stated that further information collection was needed to fully understand the stakeholder's role. When asked if they did go through a further analysis to better explain the relation between the stakeholders, they answered that they had wanted to but that the project had taken a different direction. More interviews with representatives and a possible Power-interest grid would have made the relations more tangible and was theorized to benefit the understanding of what measurements would possible.

Literature review
The literature review resulted in several positive and negative effects that influence the motivation behind separating waste. The concept that because people know their waste is being recycled, they will feel less guilty about their waste and therefore produce more was introduced. This can be explained as an example of the rebound effect, which was not known by the W2W group. This concept however was a reason for the group to acknowledge the importance of reuse and reduce over recycling. Recycling is therefore considered not to be the sole solution. It was discussed that the faculty plays a big role in the motivation and education of individuals by for instance using measures such as, choice editing and services over products.

Observations
The observations were done by going to faculties and sitting down to observe how users of the faculty were using the bins. One of the recurring observations was concerning the cutlery provided in the faculties canteen. The users of the faculty had problems with identifying what material the cutlery was made of and therefore which bin they belonged in. This cutlery was made of organically degradable material. It was often mistaken for plastic or paper and there were faculties that didn't have bins that could receive the cutlery. The discussion led to the responsibility of the faculty to purchase responsibly and keep the recyclability in mind. The W2W group felt that extreme measures would be possible when justified. Extreme measures could ensure an even bigger control over the waste composition and therefore ensure pure and clean waste streams. Also, the control over the waste could lead to a total reduction of waste. The group also strongly felt that any kind of measure implemented by a faculty should always be accompanied by an educational component. The students need to be aware of the separate bins that are used and how they individually influence circular waste management. Research showed that these educational institutes are well respected and trusted by the students in these regards, the W2W group felt this power should be used by the university. This is especially the case for the UvA and HvA as they have publicly announced their ambition to become more circular. This makes their circular position a philosophy of the institute and users of the institute should be aware of this.

A problem arises when the measurements are taken university wide as each campus or faculty can have their own suppliers. Therefore, it is more difficult to make the measures uniform for the whole university if you want to control the input of materials.

Survey
The survey was conducted to gather more information on the behaviour of the users of the facilities and specifically their behaviour towards sustainability. The survey was filled in by 104 students of both the HvA and UvA. A difference of measured between students of the HvA and the UvA in their involvement in the recycling practices. The students of the UvA were generally more involved. The W2W group credited this to the difference in form of education. A theoretical education (UvA) was regarded to be more accommodating than the more practical education (HvA), in preparing and involving students in practices that are less tangible as sustainability and waste separation towards circularity are.

As of now there is no form of information distribution about the waste management taken up into the educational curriculum. According to earlier statements this should be implemented. The precise manner is not yet determined. But explanations could be planned in introduction weeks of the study programs. Or if the university would allow it, a somewhat broader course could be introduced into all the curriculums to form a general sustainability basis for all the students. A minimum amount of ECT's could even be awarded.

One of the students also mentioned that to his own opinion the situation of the university of Utrecht was much better. The W2W group considered exploring this, but unfortunately they didn't see an opportunity to come back to this path.

RENEWI's interview
An interview was conducted with a representative of RENEWI. The representative was very open and helpful in the research. His main motivations of open conversation were fed by the will to keep the contract with the educational institutes.

Out the of the interview several mechanics were made clear. RENEWI collect the waste of the institutes and differentiates their waste streams into, Paper/cardboard, Glass, Plastic, Organic waste, Residual waste. These are always categorized into two possibilities. It is either a monostream, which means that it is "clean" and can directly be send to a site specialized in recycling that stream. Or the stream in considered "unclean" and is treated as residual waste which is send to an incinerator or landfill. To the surprise of the group the incineration of waste was considered as a circular method since energy was won by the process. At the facility of RENEWI some sorting is possible. But it is limited to small practices. Glass can for instance be sorted by colour, but plastics cannot be divided into specific types of plastic. Plastics are generally a big problem for RENEWI, this has to do with the high contamination of the waste stream. Many different types of plastic are collected together and RENEWI is not able to separate them in a later stage. This results in the fact that almost no plastic is actually recycled.

RENEWI also suggested to take the disposal of paper cups on. They have a technique where they can soak the plastic lining of the cups off. Afterwards the paper residue is used to make toilet paper. The circularity of this ultimately linear chain is debatable, but it is arguably better than the alternative. The alternative, how they are disposed of now, is that the producer of the cups recollects them under the pretence that they are recycled. In reality this is however not the case. The cups that are made out of organic degradable material

are not suitable to be made into a compost due to the numbers they are supplied in. The paper cups lined with plastic are not recycled either. The W2W group believe that the institutes don't change this because at the moment it seemed like a good method of disposal and weren't aware of the problems.

Unfortunately, Ellen and Federica weren't the main people involved with RENEWI interview and will therefore redirect me to a college of theirs, James Ric-Hansen. They also referred me to the website PlasticfulFood.com were the remainder of their research is posted. Also, they will see if they can share the contact of Jasper Bok a faculty manager that helped them with their research and can possibly help me in the future.

James Ric-Hansen
This part of the interview is an addition to the before conducted interview. The addition was initiated to further discuss the interview between the Waste2Worth group and the RENEWI representative Richard Batenburg. James was the group member that had was mainly involved with the RENEWI contact and had agreed to have an interview with me to help me further understand RENEWI's role in the waste management of the HvA/UvA.

The interview started off with James expressing the willingness of RENEWI to help students. They, in the form of Richard Batenburg, were open for an interview and follow up meetings if necessary. James expressed that this was most likely because the HvA and UvA combined are one of their biggest clients and that their openness would contribute to cementing that connection. James has agreed to share his contacts within RENEWI because he feels that because they are willing it would be best for me to contact RENEWI directly.

The Role that RENEWI plays is more as a transport company. They are less involved in the treatment of waste. The faculties separate the waste, RENEWI picks it up, checks the purity of the waste and sends it to the specific waste treatment facility. They are more interested in the logistical problem sets that result in making the least possible trips. In the first stage the waste is brought to is a sorting centre were the purity checks are done and all the waste is sorted to be brought to the right treatment facility. The purity check determines if the waste is considered as residual waste and is send to the waste incinerator or if the waste is considered a mono-stream and is send to a recycling facility. However, this sorting centre is a small part of the whole process. RENEWI has communicated that all plastic is automatically send to the incinerator because of purity and cleanliness problems. The paper-stream on the other hand satisfies all the requirements and is therefore handled as a mono-stream. RENEWI also collects all the paper and biodegradable coffee cups used by the faculties. The have the techniques to recycle these into, among other things, paper towels for restroom use.

RENEWI also participates in activities to educate people in how the separation and processing of waste is done. This aids in people's understanding and therefore involvement in waste management. They believe in the responsibility of the individual within the waste management.

B

Interview Jeroen Wagenaar

Dit interview is geïnitieerd door Jibbe Knuit (ikzelf), hij is in contact gebracht met Jeroen Wagenaar via het contactpersoon Joep de Hoog, na overleg over mogelijke gesprekspartners die het onderzoek verder zouden kunnen helpen. Jeroen Wagenaar is hierbij gekozen vanwege zijn werkzaamheden en verantwoordelijkheden binnen de faculteit. De vragen zullen voornamelijk gefocust zijn op de behandeling van verschillende afvalstromen binnen de Amstelcampus. Het interview is afgenomen op 29-04-2020 via het medium Zoom. Vooraf aan het interview zijn er door Jibbe Knuit vragen voorbereid en gedeeld met Jeroen Wagenaar, zodat hij zichzelf indien noodzakelijk kon voorbereiden op de gespreksonderwerpen. Deze vragen zijn vervolgens gebruikt als richtlijnen voor een open discussie

Jeroen Wagenaar
Als facilitair coördinator is hij de afgelopen 11 jaar onder andere verantwoordelijk geweest voor het vormgeven van de logistiek achter het afvalbeleid. Door de jaren heen zijn er verschillende stappen gezet om het scheiden van afval, en dus ook het uiteindelijke recyclen, te verbeteren. Bij het gebrek aan een specifieke functie of rol om dit te begeleiden, heeft hij aangegeven dat er veel zelf gepionierd is op dit gebied. Zo is er stap voor stap gekeken naar de benodigdheden voor bijvoorbeeld opslagplaatsen en verzamelpunten. Met RENEWI is er hierin overlegt over de gewenste vorm waarin het afval afgeleverd wordt. Handelingen binnen faculteit

Binnen de faculteit zijn de eerste die in contact komen met het afval de mensen die het afval ophalen uit de prullenbakken, de schoonmakers. De schoonmakers rijden rond met karretjes die voorzien van onder andere schoonmaakmiddelen, schoonmaak gereedschappen en ruimte om verschillende afvalstromen te verzamelen. Zij verzamelen het afval uit de prullenbakken tijdens hun schoonmaakactiviteiten en brengen deze naar de grote container. Deze container is 60.000 liter bak en is gekoppeld aan een persmachine. Wanneer de container voor driekwart gevuld is wordt er contact opgenomen met RENEWI zodat ze op tijd zijn met het legen van de container.

De prullenbakken staan verdeeld over de faculteit. Elk lokaal heeft een kleine prullenbak die dagelijks wordt geleegd. Dit zijn prullenbakken waar alle diverse stromen afval in één bak verzameld worden, behalve papier/karton deze worden wel gescheiden ingeza-

meld. Door de faculteit heen in openbare ruimtes staan deze zelfde prullenbakken (voor algemeen afval en papier/karton) alleen dan in een grotere uitvoering. De zuiverheid van deze stromen kan beschouwd worden als erg laag. In het verleden zijn er verschillende testen en pilots uitgevoerd, vaak opgezet door studenten, waarin meerdere afvalbakken gebruikt werden die allen een verschillende stroom afval moesten verzamelen. Jeroen Wagenaar zijn hiermee is dat er in het begin zeker goede resultaten geboekt worden, maar dat het op de lange termijn toch altijd weer verwaterd. Dit heeft volgens hem voornamelijk te maken met de intensiteit waarmee er in het begin gepromoot wordt. De intense promotie zorgt ervoor dat gebruikers van de faculteit goed meewerken. Echter wanneer de promotie wegvalt, valt ook de medewerking weg. Een andere observatie is dat het afval ook niet altijd in een prullenbak terecht komt. Vooral in de namiddag en avond is er een opstapeling van afval dat niet wordt weggegooid en dus in de openbare ruimte blijft liggen. De genoemde dagdelen zijn de grootste probleemtijden omdat er in deze periode door veel mensen gegeten wordt in de openbare ruimte en bij eten altijd veel afval geproduceerd wordt.

Voor de genoemde schoonmakers is het verzamelen van afval eigenlijk een nevenactiviteit. Hun voornamelijkste taak is het schoonmaken van de faculteit, daarbij hoort natuurlijk ook het ophalen van het afval, maar ze zijn niet verantwoordelijk voor het scheiden van afvalstromen. Het precies scheiden van afval zou te veel tijd in beslag nemen. De toch al beperkte tijd dient gebruikt te worden om de faculteit schoon te maken voor de start van de volgende dag.

Het afval dat wordt meegenomen door de gebruikers van de faculteit, wordt door Jeroen Wagenaar geschat op een kwart van al het afval dat verzameld wordt. De andere driekwart aan afval komt voort uit producten die ingekocht worden door de faculteit zelf en inkopen van de verschillende cateraars. De cateraars scheiden de verschillende stromen afval niet en hebben de mogelijkheid om hun afval te deponeren in de eerdergenoemde containers. Binnen de faculteit moeten er ook veel materialen ingekocht worden. Materialen die ervoor zorgen dat het gebruik van alle faciliteiten altijd door kan gaan, zoals batterijen voor rookmelders en deurvergrendelingen of lampen. Maar ook materialen die voor verschillende lesmethode gebruikt wordt. Al deze verschillende benodigdheden zorgen voor de volgende gescheiden stromen: Karton /Plastic /Blik /Fruit /Chemisch /Piepschuim /Hout /Pallets /Toners /Filters. Hierbij moet aangemerkt worden dat de stroom Fruit (of GFT) een probleem in de opslag creëert doordat het muizen en ander ongedierte aantrekt. De inkoop van deze producten zou een goed overzicht kunnen geven over de kwantiteit van de stromen. Wanneer de inkoop bekend is kan er namelijk veel worden gezegd over wat er aan afval wordt verzameld. Echter is het inkoopbeleid van de faculteit zo georganiseerd dat er voornamelijk op de acute vraag naar materialen wordt ingekocht via onder andere leveranciers als Conrad, dit leidt ertoe dat er geen uitgebreid overzicht is van alle inkopen. De catering houdt daarentegen wel goed bij wat de inkoop en verkoop is van producten maar daar heeft het faculteitsbestuur geen inzicht in en omdat er niet gescheiden wordt door de verschillende cateringspartijen is die informatie tot op heden ook niet interessant. Op de vraag of de cateringspartijen meer zouden kunnen doen op het gebied van afvalbeleid, ook met het oog op inkoopbeleid om afvalstromen te minimaliseren, ziet Jeroen Wagenaar mogelijkheden.

C

Interview Guido Meijer

Dit interview is geïnitieerd door Jibbe Knuit (ikzelf), hij is in contact gebracht met Guido Meijer via het contactpersoon Joep de Hoog, na overleg over mogelijke gesprekspartners die zijn onderzoek verder zouden kunnen helpen. Guido Meijer was hierbij gekozen vanwege zijn werkzaamheden en verantwoordelijkheden binnen de faculteit. De vragen zullen voornamelijk over verschillende cateraars gaan die er binnen de faculteiten van de HvA aanwezig zijn en hun omgang met afval.

Het interview is afgenomen op 30-04-2020 via het medium Zoom. Vooraf aan het interview zijn er door Jibbe Knuit vragen voorbereid en gedeeld met Jeroen Wagenaar, zodat hij zichzelf indien noodzakelijk kon voorbereiden op de gespreksonderwerpen. Deze vragen zijn vervolgens gebruikt als richtlijnen voor een open discussie.

Guido Meijer.

Guido Meijer is werkzaam bij de HvA als projectmanager Eten en Drinken. Hierbij is het zijn taak om tussenpersoon zijn tussen de hogeschool en de verschillende cateraars die aanwezig zijn in de faculteiten. Per faculteit wordt er door hem gekeken wat de behoeftes zijn en zoekt daarbij in overleg een passende cateraar. Een belangrijk onderdeel hiervan is het contact behouden met gebruikers en deze goed weten over te brengen met de betrokken partijen.

Catering op faculteiten van de Amstelcampus.

Binnen faculteiten zijn er verschillende vormen van catering mogelijk. Deze worden zoals gezegd ook per faculteit gekozen naar de wensen en benodigdheden van een faculteit. Deze verschillende vormen zijn onderverdeeld in 4 segmenten. Vending is alle automaten die op een faculteit aanwezig zijn, hier gaat het om zowel koffie als zoete/zoute snacks. Banking is een cateringsegment die over lunch arrangementen gaat, hier gaat het over op maat verzorgde bestellingen. Onder Horeca vallen alle bemande locaties op een faculteit, bijvoorbeeld koffiehoekjes en lunchrooms. Als laatste zijn er ook Retail locaties op faculteiten aanwezig. Dit zijn supermarkten van verschillende grote. De cateraars zijn allen eigen baas in hun respectievelijke onderneming. Vanuit de hogeschool is er daarom beperkte invloed op het beleid wat er gevoerd wordt. Er wordt voor het accepteren van een cateraar op een locatie wel overlegd over wat de verwachting zijn van beide partijen en hoe de behoefte van

de faculteit het best gevuld kan worden.

De grootste partij in deze onderhandelingen is de cateraar CIRFOOD. Tussen de 85% en 90% van alle cateraars wordt door CIRFOOD geregeld, ze leveren veel eigen business met personeel maar zoeken waar nodig ook naar specialisten voor de Horeca en Banking opdrachten. De specialisten wisselen vaak om een divers aanbod te behouden, elke specialist moet vooraf ook met een eigen beleidsplan komen en krijgt mede op basis een contract voor een bepaalde tijd.

De cateraars halen een groot gedeelte van het afval binnen dat door de faculteit verzameld moet worden. Elke cateraar is er ook voor verantwoordelijk om zijn eigen afval te scheiden in de door de faculteit gekozen stromen. De faculteit verzorgt vervolgens de verdere verwerking van het afval. Welke stromen er gescheiden worden verschild per faculteit. Elke cateraar houdt zijn eigen inkoop en verkoop bij, hoewel de link hiertussen ingewikkeld kan zijn door uiteenlopend gebruik van de verkochte producten, kan dit wel veel waardevolle informatie geven over het potentiële afval dat ingekocht wordt. Momenteel wordt er nog niets gedaan met het bijhouden van verpakkingsafval dat ingekocht wordt en de potentiële optie op basis daarvan bewuster in te kopen om afval te minimaliseren. Een faculteit kan hier ook moeilijk invloed op uitoefenen, omdat het dus gaat om autonome partijen.

Een voorbeeld hiervan is het gebruik en verkoop van plastic flesjes. De hogeschool is bezig met een initiatief waarbij er watertappunten van Join the Pipe in faculteiten geplaatst worden. Dit om het hervullen van, duurzame, plastic flesjes te stimuleren. De verkoop van plastic flesjes is echter lastig te verbieden omdat er binnen de verschillende segmenten van cateraars andere regels gelden. Dit kan ertoe leiden dat de ene cateraar wel plastic flesjes zou kunnen verkopen terwijl een andere in dezelfde faculteit geplaatste cateraar dit niet mag. Dit zou tot oneerlijke concurrentie kunnen leiden. Ook is het gedrag van de gebruiker erg belangrijk. Uiteindelijk is hun gebruik van de faciliteiten leidend in of beleid werkt of niet. Daarnaast is de veiligheid van het eten en drinken uiteindelijk een nog belangrijkere richtlijn dan de duurzaamheid van de verpakking.

De koffieautomaten en de bijhorende koffie bekertjes die geleverd worden door het bedrijf MAAS, leiden uit vorige interviews tot wat onduidelijkheid. Sommige bronnen zeiden dat de koffie bekertjes na gebruik terug gestuurd worden naar de leverancier voor verwerking. Andere bronnen vertelde mij dat deze ook naar RENEWI gestuurd werden. Guido Meijer geeft hier een definitief uitsluitsel over, de koffie bekertjes worden ook opgehaald door RENEWI. Wat RENEWI er vervolgens mee doet in de verwerking is nog wel onduidelijk, of deze apart verwerkt worden op een duurzame manier of niet? Guido Meijer geeft ook aan zelf de toekomst te zien in het post-scheiden in plaats van scheiden bij de bron. Dit heeft te maken met de technologische vorderingen die gemaakt worden enerzijds en de moeilijkheden die komen kijken bij het volledig scheiden van stromen bij de bron anderzijds. Ook stipt hij nog aan dat het duurzaam inkopen van producten vaak ook nog ingewikkelder is dan op het eerste oog lijkt. Als voorbeeld het gebruik van biologisch afbreekbare producten. Hoewel het aan de invoer kant vaak duurzaam genoemd kan worden door het gebruik van hergebruikte producten, is de verwerking na gebruik van de producten vaak moeilijk volledig duurzaam uit te voeren.

D

Interview Cor Gerritsen

Dit interview is geïnitieerd door Jibbe Knuit (ikzelf), hij is in contact gebracht met Cor Gerritsen via het contact persoon Joep de Hoog, na overleg over mogelijke gesprekspartners die zijn onderzoek verder zouden kunnen helpen. Cor Gerritsen was hierbij gekozen vanwege zijn werkzaamheden bij de betrokken partij RENEWI. De vragen zullen voornamelijk gefocust zijn de rol en werkzaamheden van RENEWI met betrekking tot het afvalmanagement van de Amstelcampus van de Hogeschool van Amsterdam (HvA).

Het interview is afgenomen op 27-05-2020 via het medium Zoom, later voortgezet via de telefoon door technische problemen.

Cor Gerritsen
Cor Gerritsen is Accountmanager bij RENEWI en verzorgt hierbij voornamelijk de zaken van grote klanten met betrekking tot circulariteit en duurzaamheid. Er worden hierin veel ideeën gegeven door derde partijen en klanten vanuit de juiste bedoelingen, maar het is zijn rol om realistisch te kijken naar de mogelijkheden en in overleg tot een uitvoerbare aanpak te komen. Hij is erg betrokken in het principe van Zero emissie waarbij hij het belang van de volgende velden aankaart, Techniek, Logistiek (intern/extern), van afval naar grondstof (VANG). Ook benadrukt hij aan dat er per stad of partij gekeken moet worden wat de beste methodes zijn. Verschillende steden hebben namelijk verschillende wensen en mogelijkheden, daarom wil hij samen met de klant kijken naar hoe de toekomst eruit moet komen te zien en hoe dat toekomstbeeld bereikt kan worden.

De rol van RENEWI
RENEWI beschikt over drie locaties in Amsterdam. Deze locaties bevinden zich in Westpoort en beschikken over kade faciliteiten waardoor watertransport een goede optie is. Twee van de locaties gaan over vast afval bestaande uit twee categorieën, restafval en recyclables. De derde locatie bevat een vergister die het organische afval verwerkt naar biogas die vervolgens wordt doorgestuurd naar energiepartners. De frequentie waarmee RENEWI langsgaat bij de faculteiten van de HvA is afhankelijk van de containers die er op een specifieke faculteit geplaatst zijn. Er zijn containers met verschillende grootte, met of zonder pers functie. Een kleinere rolcontainer zal 2 á 3 keer per week geleegd moeten worden. Terwijl de grotere pers containers van 6000 liter slechts eens per de 10 á 14 dagen geleegd hoeft te worden.

De frequentie van ophalen wordt deels ook bepaald door de HvA, zij zijn ervoor verantwoordelijk om tijdig RENEWI op de hoogte te stellen van volle containers. Voor de methode van ophalen wordt ook geluisterd en overlegd met de klant. Zoals genoemd hebben de locaties van RENEWI de beschikking over kade faciliteiten, wat ervoor zorgt dat wanneer een klant hier ook over zou beschikken watertransport overwogen kan worden. Momenteel worden voor wegverkeer voornamelijk euro 6 of 5 diesel trucks gebruikt. Met het oog op de Zero emissie doelstellingen komen er in kwartaal 3 dit jaar (2020) voor het eerst elektrische trucks. Deze kunnen dan naar de wens van de klant en hun ambitie voor duurzaamheid, gebruikt worden in plaats van de diesel trucks. De keuze ligt bij de klant omdat het gebruik van de elektrische trucks wel meer kosten met zich mee zal brengen.

Wanneer het afval bij de locaties in de Westpoort aankomt wordt het gecontroleerd door acceptanten op zuiverheid en hoe schoon het afval is. Dit bepaald of een gescheiden stroom gerecycled kan worden of dat het als restafval behandeld wordt. De eisen voor de staat van het afval dat geleverd wordt staan vastgesteld in een contract dat vooraf aan de samenwerking opgesteld wordt. Mocht de klant moeite hebben met het halen van de afgesproken zuiverheid van de verschillende afvalstromen, dan biedt RENEWI de mogelijkheid tot ondersteuning door hun ECOsmart team. ECOsmart helpt bij de logistieke inrichting van het afval huishouden en regelt voorlichtingen om de bronscheiding zo goed mogelijk uitgevoerd te krijgen. Wanneer het aangeleverde afval is gecontroleerd, wordt het op de gepaste manier verwerkt. Reststromen worden gebruikt voor energieproductie met 60% efficiëntie. Grote stromen als hout en steen kunnen door RENEWI zelf gerecycled worden naar producten die afgenomen kunnen worden als nieuwe bouwsteen. Voor veel kleinere of specifieke stromen worden derde partijen gebruikt die gespecialiseerd zijn in het recyclen van de stroom. Dit zijn ook stromen die samen met de klant besproken kunnen worden. Zo verzameld RENEWI niet alleen de meer gestandaardiseerde stromen afval, maar halen ze ook specifiek stromen op en zoeken daar specialistische verwerkers voor.

E

Makigami

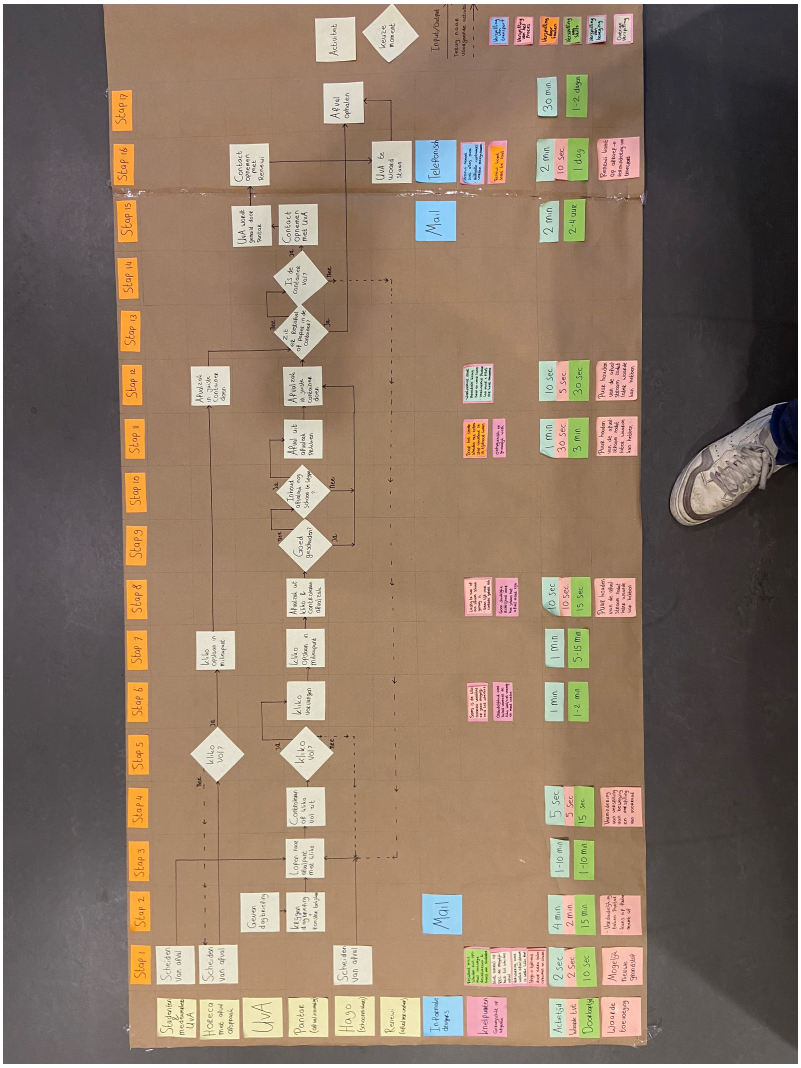

Figure E.1: Orginal makigami (Eijck vd et al., 2020)

F

Interview Jennifer Maxwell

This interview was conducted on the 10th of May 2021. The interview was initiated by Jibbe Knuit with the purpose of learning more about the sustainability management on the Appalachian State University in North Carolina (from now on mentioned as the University). The contact was established through the College and University Recycling Coalition (CURC) The interview was held as an open conversation. This is a loosely based transcript of the conversation approved by Jennifer Maxwell.

Jennifer Maxwell

Jennifer has been with Appalachian State University since 2006 and she leads many of the campus sustainability programs including the University Zero Waste Commitment, the Mountaineer Food Hub and Free Store, Green Suite (collection of programs designed to engage the campus community in efforts to incorporate more sustainable practices into their workplace and personal lives), Sustainable Purchasing and the Sustainable Film Series. She is the Chair of the Collegiate Recycler's Coalition of North and South Carolina and also serves as Chair for the Board of Directors of the College and University Recycling Coalition (CURC), a national organization that represents a vibrant community of waste reduction, recycling, and sustainability professionals in higher education. She studied and received her BS in Sustainable Technology in 2001 and MA in Higher Education - University Leadership in 2017, both from Appalachian.

Appalachian State University

Since 2012 the University has made a formal commitment to a zero-waste campus. Their approach can best be described as an up stream thinking approach, where the emphasis lies on the prevention and reduction of waste streams. In their Climate action Plan (Appalachian State University, 2021) their complete vision for a climate neutral campus is fully explained. Building on the Geographical location and their socially imbedded relationship with nature that is derived from that, the University finds it important that the students attending Appalachian State are confronted with sustainability on a daily basis. Another historical cultural advantage is that due to the relative isolation of the small town of Boone, in which the University is located, the inhabitants were forced to learn how to be self-sufficient. The end goal, a behavior modification towards a more sustainable lifestyle, is achieved with a method which is twofold. Namely, there is part that is integrated into

the curriculum and part that is offered as extra activities around the campus. Every student attending Appalachian State starts off with seminars on sustainability to inform them on the rules on campus. Students are also able to follow internships with on campus institutes, also students often come up with or help in the implementation of sustainability policies. Great examples are the Renewable Energy Initiative (REI) and the Student Government. The REI is a student led group supported by staff of the University and the Student Government has a sustainability committee who often requests help from the sustainability department and other available facilities to implement their own policies. One of their initiatives was to move away from plastic to paper bags, which have better recycling and composting possibilities. Students are also employed by the University as a sustainability liaison for residents' halls, as liaisons they are responsible for the correct compliance of implemented sustainability policies.

Concerning the waste management, the easier things to focus on are the composting of organic waste and the use of color-coding waste bins to separate waste into material-based waste streams. The majority of the waste is generated in the dining and housing areas. Within the color-coding scheme blue bins are used for Glass/Paper/Plastics/Metals and referred to as the recycling stream, separate green bins are used for the organic waste and black bins are used for all the residual waste which is landfilled. For the last 21 year the organic waste has been sent to the composting facility located on campus. The compost created is later used for other on campus areas. There are several campus gardens and Pollinating gardens which are fed with the compost, in some cases the compost is also used for tree root therapy to support declining trees. Compost is also brought to the 300-acre farmland the University has available. Besides its educational purpose, the farmland also provides food for the local community off and on campus. Their well-maintained relationship between the farmland and the dining department benefits the prevention of organic waste. The recycling waste stream is picked up by a Republic Services, a contractor specialized in the separation of waste. They separate the waste into usable material-based waste streams and send them in bulk to third parties that will use the material as raw material for production. Republic Services makes use of a state-of-the-art separation facility where most of the separation is done mechanically. Only where the facility lacks, some manual separation is performed. The contract with the contractor is fairly flexible, where the contract is renewed every year for the next year. Every semester an evaluation moment is scheduled, where feedback is delivered on, for instance, the contamination rates of the recycling stream. The recycling stream to residual stream ratio is around 40% to 60% respectively. The 60% residual waste is sent to a landfill. At the moment there is no better use for it. In the Netherlands incineration with energy capture is a more often used method for unrecyclable waste disposal. Maxwell however argues that both landfilling and incineration have substantial negative effects and that based on that the focus should not be in creating incineration facilities, but in the further reduction, reuse and recycling of waste. As the policy of the University itself states.

The upstream approach, meaning the focus on sustainable purchasing often leads to additional costs. Maxwell explains that those extra costs are something the University has accepted as being part of the necessary change. Some of these extra costs are absorbed by external funds. Funds made available by the state and funds from foundations funded by donations. Also, the REI has a sustainability fund that collects money for sustainability projects within the University, previously they helped fund a project concerning the

Composting facility. With these additional funds the economic side is balanced as well as possible, but it does force choices within purchasing decisions and certain policy implementations. Economic incentives are also implemented to motivate students to make sustainable decisions. A refuse the bag initiative was started where students were able to donate a small amount of money to a charity of their choice, if they refused a bag at an on-campus market and the bookstore. Maxwell stresses that it must not be forgotten that the influence the University is limited to its reach. The fact is that, of the 20.000 students attending Appalachian State University, only 7500 live on campus. The remaining students live in the city Boone and will therefore generate an uncontrolled waste segment. In addition, the non-student population of Boone often uses campus areas, like the gardens, for recreational activities and add to the uncontrolled waste segment. The goal of the University is to spread awareness to all its users, explaining what sustainability entails and how one could induce sustainability into their own day to day life. Forcing people to change unwillingly will not result into a sustaining change in behavior. Therefore, the focus lies on small incremental changes, letting people make decisions for themselves. The small incremental changes will lead to a large result in the end.

G

Interview Larry Cook

This interview was conducted on the 29th of April 2021. The interview was initiated by Jibbe Knuit with the purpose of learning more about the sustainability management on the University of South Carolina (from now on mentioned as the University). The contact was established through the College and University Recycling Coalition (CURC), a group that represents colleges and universities with the ambition of a more sustainable and circular waste management. The interview was held as an open conversation, while being structured by a beforehand supplied document (College, University Recycling Coalition, 2018), containing an overview of the policy strategies collected by the CURC. This is a loosely based transcript of the conversation approved by Larry Cook.

Larry Cook

The past 12 years Larry Cook has been working at the University of South Carolina. He started as the Recycling and waste manager. His responsibilities where the coordination and promotion of the University's Recycling & Environmental Services efforts. He also developed and implemented processes and participated in project management. He provided conflict resolution and work management expertise in escalated problematic situations, all with the improvement of the sustainability of the campuses in mind. From July 2019 onward he became the Director of the Office of Sustainability, giving him responsibility towards the implementation of sustainability policies. The CURC, our intermediary, is a non-profit organization that supports professionals working toward a zero-waste society. The start of the organization can be traced back to the 1990's as it was part of the National Recycling Coalition. In 2009 it branched off and became the CURC. Now it consists out of over 900 recycling and sustainability professionals. They provide help to universities and colleges in the United States and Canada by connecting people withing the sustainability world. They also provide webinars and workshops of case studies to explain certain methods and strategies with the main focus on reduction, reuse and recycling.

Sustainability within the University of South Carolina

The policy implementation of the University of South Carolina is predominately based on their predetermined policy list. This list contains 8 priorities which the university tries to improve over a certain period of time. Historically sustainability has never been on this list, but recently due to the changing social climate and the persistence of the sustainability

department, sustainability has been put on the list which shows the positive change the University wants to externalize. Sustainability is the number 7 of the ranked priority list, but Larry Cook has the ambition to make the subject an even more important priority in the coming years. The sustainability priority is expressed further into a few goals.

The waste Hierarchy

The first goal expresses the importance of the waste hierarchy. The University tries to put their emphasis on the reduction, reuse and as last measure recycling of waste. The lower stages of the waste hierarchy are preferably excluded entirely from their waste cycle. In the United States the main way to eliminate waste is landfilling. Where waste incineration has the benefit of energy generation, to prevent energy generation by fossil fuels, landfilling has no further benefits. However, due to the low population density, there is plenty of available space within the state. Therefore, this is the most used method for waste disposal. Some landfilling area's limit their emissions by including methane capture installations. Waste incineration also comes with strict contractual guarantees, which limits the freedom of the University. Because both landfilling and incineration have clear negative effects to the environment it is the Universities ambition to disregard both options and therefore lay their focus the higher option within the waste hierarchy.

One of the policies to reduce the waste generated is the use of the Precautionary principle. This principle requires people to think about the necessity of purchasing something new. Often things are already available and therefore it is unnecessary to purchase a new item. One can consider office supplies which are often made available by the university. It also motivates people to first consider secondhand products, students are therefore facilitated in the exchange in, for instance, secondhand furniture or other secondhand utilities. The Precautionary principle is also applicable to events. Halloween is an example where many single use items are purchased, like costumes and decorations. Therefore, these events create a lot of unnecessary waste which can easily be prevented with the right spread of awareness.

An important part of reducing waste is sustainable purchasing. Cook emphasized that the University realizes that with the purchase of products they control a large portion of their waste output. Therefore, they have a policy which forces the University and its suppliers to think about second life possibilities of their products. Practically this means that when contracts are being made with specific suppliers a sustainability section must be included, explaining how the supplier will ensure a sustainable product and waste minimalization. Sometimes it is unclear which products are more sustainable than others. Cook brings up the use of electronic hand driers or paper towels in bathrooms. He expresses that these are often difficult decision to be made since the sustainable answer is not straight forward. Cook explains that LCAs can be a useful tool to support the decision-making process. The LCAs used are mostly already existing LCAs, but it can occur that specific LCAs will be performed to weigh specific options. It is not unheard of that these specific LCAs are performed by students as an educational assignment.

A secondary issue to the purchasing policy is the economic aspect. Sustainability policies are stigmatized as more expensive and can therefore seem undesirable. Truthfully, sustainability projects often have a high upfront cost. However, when analyzed further, the initial investment is often paid back over time. An example is the investment into renewable energy. The costs to install solar panels or wind turbines are quite high, but the

reduction in electricity costs will slowly pay off those initial investments. A second side of the economic aspects is the creation of economic incentives to motivate people in choosing more sustainable options. Cook gives the example of the University of Kentucky, where a sustainability tax is implemented on all products sold at the campus. The tax compensates extra costs of a more expensive sustainable products and subsidizes sustainability projects on the campus.

Waste management

The second goal which was explained by Cook, considers the recycling step in the hierarchy. The University as a whole wants to recycle as much waste as possible. In order to do so, all the collected waste needs to be separated as effectively as possible. The two main approaches to consider here are pre-separation and post-separation. The University chose a mix of the two out of necessity. To use a pre-separation approach a sufficient amount of space needs to be available for the different wastebins required. The use of either approach is dependent on the local environment. At some areas there is sufficient space available for multiple wastebins. However, not all areas have this luxury, some of the areas on campus do not have the required space available, therefore the waste is collected as a single waste stream. There are also areas that are open for the larger public, meaning there is limited control over the proper instruction for effective waste separation, which leads to contaminated waste streams. All these factors lead to a situation where both pre- and post-separation are necessary. In order to generate separated material-based waste streams from the single waste and contaminated streams, the University has founded an institution that manually separates the waste into 8 different streams. The streams created are, mixed paper, cardboard, plastic bottle 1 (PET), plastic bottles 2 (HDPE), metal scrap, glass, aluminum and organic waste. Every year an average of 4000 tons of waste is generated by the University, a total of 1500 tons of the waste is recycled of which 500 tons is manually separated. The manual separation institute does not only separate the waste, but it also provides ample job opportunities for fulltime and parttime employees with some advancement possibilities. After the waste is separated the material-based streams are sent to recycling processing facilities. Of the organic waste 700 tons is recovered for people in need and other 300 tons are sent to a composting facility.

Continual assessment

In order to keep track of advancements and stay critical while looking for further improvements the ZWTK advices universities to implement a continual assessment. The University does this by making a 5-year plan which the general policy towards sustainability the. Every year an evaluation moment is scheduled. During the evaluation the incremental improvements will be examined by going through collected data. Based on the yearly update session adjustments can be made where necessary. In addition to the internal assessment of their sustainability progress, the University is subscribed to the STARS program. The Sustainability Tracking, Assessment & Rating System, is a transparent self-reporting framework for collages and universities across the United States to measure their sustainability performance. Here the University can show its sustainability progress and compare it to other universities. It helps motivate progress and gives the University the opportunity to learn from others.

Creating awareness

Cook realizes that as they are an education institute, they have the responsibility of not only being a sustainable organization but also create the awareness and spread knowledge among the students on campus. Partly this is done by implementing policies that can be seen by many students and will stimulate curiosity amongst students. Cook gives an example of solar powered picknick tables or simple water filling stations, that students interact with on a daily basis. Another way to spread sustainability awareness amongst the students is to incorporate it into the curriculum. And although the University has multiple courses and programs that embrace sustainability, it is not a mandatory subject for a student. To compensate this, several additional student engagement programs are available. Here students get a beyond the classroom, hand on experience with sustainability. As an educational institute Cook strongly believes they have to help the future generation, by giving them the proper tools and information on sustainability.