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# Value of Waste Flow Monitoring Service for House Managers in Municipal Solid Waste (MSW) management

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# Abstract

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Aalto University Department of Built Environment Engineering is developing a Waste Flow Monitoring Service. It provides better information about the amount and costs of the waste produced by real estates. Waste tracking indicators and their visualization have been examined but the value and feasibility of the service for House Managers have not been examined yet. It generated a need for this thesis. Target of the thesis is to clarify how Waste Flow Monitoring Service could create value for House Managers in municipal solid waste management and what kind of development needs the service have.

The theoretical background discusses on municipal solid waste management principles from waste producers' point of view. In the thesis waste producer means property owners, inhabitants and House Managers representing the properties. The benefits of smart waste processes on municipal solid waste management are considered in the thesis. Smart waste leads discussion to a business value creation. One way to create business value is to increase the service supply. New technologies in waste management allow new service experiences to customers through digital platforms. In order to develop services that fulfil customer needs and expectations, services have to be developed in a holistic way. Service Design is a new discipline supporting on that.

The research is based on semi-structured interview process but it's carried out in a way that differs from usual semi-structured interview. In the interview the Waste Flow Monitoring Service was demonstrated to give a practical context to the discussion. The thesis uses a case study research where researcher tests the demonstration screenshots presented and their applicability to House Managers.

As a result, the value proposal of Waste Flow Monitoring Service was recognized. The Waste Flow Monitoring Service allows House Managers to follow weight and costs of produced waste per real estate. Waste Flow Monitoring Service enables weight based billing model where each property is charged according to amount of the waste they produce. As results of the thesis primary use cases for the service were identified and development ideas for the service were gathered. Results can be used for further researches and development work.

**Keywords**
municipal solid waste, smart waste, value, service design

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# 1 Introduction

Waste management is a basic function of every society. It has evolved along the development and growth of society. Nowadays smart waste processes have an important role in evolving waste management. Internet of things (IoT) technology and new applications provide new possibilities to optimize waste management.

Municipal solid waste (MSW) is a waste that comes from households. Garden waste or street sweepings are considered as MSW as well and also the contents of litter containers. (VTT, 2012, 18.) Property owners, inhabitants and companies produce MSW. They pay to waste management companies for waste collection and handling. (Serkkola & Korhonen & Suomi, 2016, 2-3.) At the moment there isn't much literature available of waste management from MSW producers' perspective. It seems that the role of waste producer has not been researched thoroughly.

Details of waste behavior per property are not available. Waste Management Companies do know how much waste trucks are bringing from certain area, but they don't know how much waste one property has exactly produced. According to study "Monitoring indicators for Source Segregation in Municipal Solid Waste Management" (Serkkola & Korhonen & Suomi, 2016) "Waste producers, property owners and managers representing residents or businesses are becoming increasingly interested in feedback on the waste they have produced and on its costs. They are willing to use their judgment to choose and adjust containers and emptying schedules that are suitable for the property." It indicates that there is a clear need to launch a service that provides feedback to waste producers about their waste behavior.

European Union is pushing the member countries to develop their practices in municipal solid waste management. EU requires member states to recycle 50% of their municipal solid waste by 2020. According to European Environmental Agency, between 2001 and 2010 the MSW recycling rate in Finland was about 35 %. In order to fulfill the target, Finland has to significantly increase the recycling level in MSW. (European Environmental Agency, Finland, 2013, 6.) When looking at the waste recovery rates, situation looks much better. One of the EU targets is to reduce the amount of MSW in landfills. In 2014 Finland delivered only 17% of MSW to landfills because of the waste incineration plants. Finland is one of the top countries who are pretty much in line with EU target in terms of landfills utilization for MSW. (Uusiouutiset, 2015.) However, low recycling rate and high energy recovery rate lead to an assumption that lot of recyclable items end up to the waste incineration plants.

House Managers represent residents in housing cooperatives. They look after real estate's waste management. Together with housing cooperative they select right kind of bins for the waste collection room and they follow up real estate's waste management bills. House Managers are interested in more efficient waste management and the solutions that might bring cost savings to housing cooperatives.

Aalto University Department of Built Environment Engineering is developing a Waste Flow Monitoring Service for municipal solid waste management. Waste Flow Monitoring Service is a web service which gets the data of collected waste per property and creates reports to interested people. Waste tracking indicators and their visualization have been examined but the value and feasibility of the service for House Managers have not been examined yet. It generated need for the thesis. Target of the thesis is to clarify how Waste Flow Monitoring Service could create value for House Managers in municipal solid waste management and how the service's feasibility could be improved.

### 1.1 Background

Background organization for Aalto University's research project is ARVI program for Material Value Chains. Program was launched by Click Innovation Ltd which is an open innovation cluster owned by 30 companies and 17 universities and research institutions. ARVI program is creating an innovation platform which increases Finnish material and recovery industry's capability to extend their businesses in global markets. (Click Innovation, 2016.)

Waste Management has several stakeholders. As illustrated in the Figure1, national level authorities, who are led by ministries, are steering regional level authorities. National level authorities also monitor the data on municipal solid waste. In Finland authorities allocate the operational power to regional waste management companies. The actual waste collection is done by local waste management companies who have contracts with regional waste management companies. Waste producers are property owners, inhabitants or companies who produce waste. They pay to waste management companies for waste collection and handling. House Managers represent residents in housing cooperatives and companies. (Serkkola & Korhonen & Suomi, 2016, 2-3.)

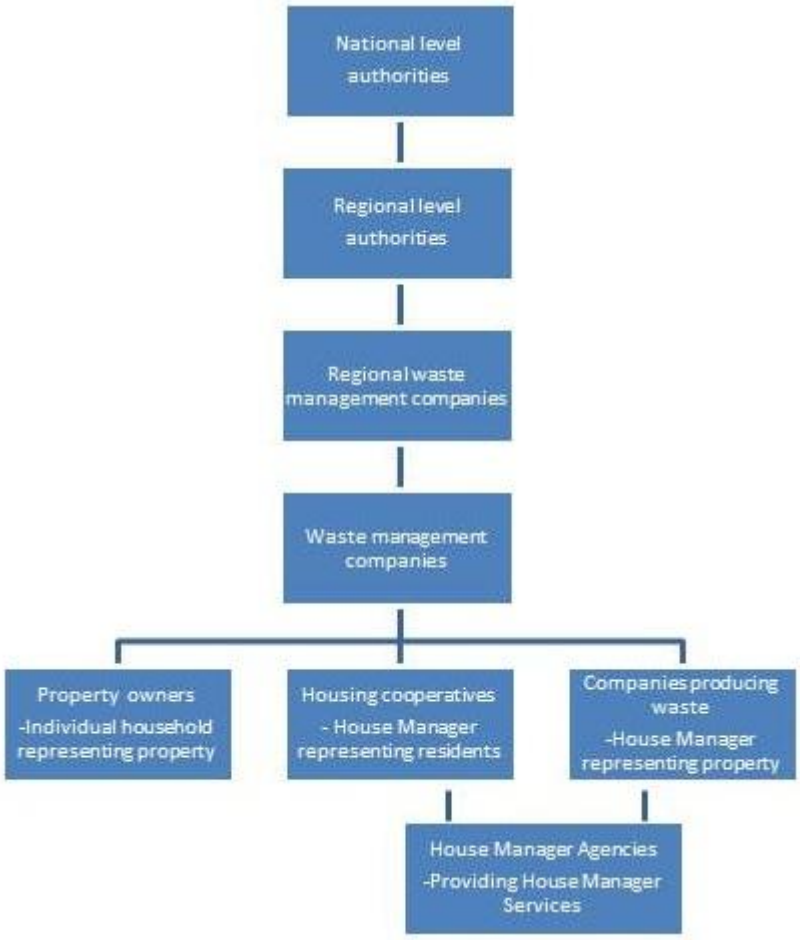


Figure 1: Stakeholders in waste management (Serkkola & Korhonen & Suomi, 2016, 2).

Regional waste management companies are aware how much waste one local waste management company is bringing to them because they need to be prepared from capacity point of view. However, as Figure 2 presents below, currently it is not known how much waste one property produces.

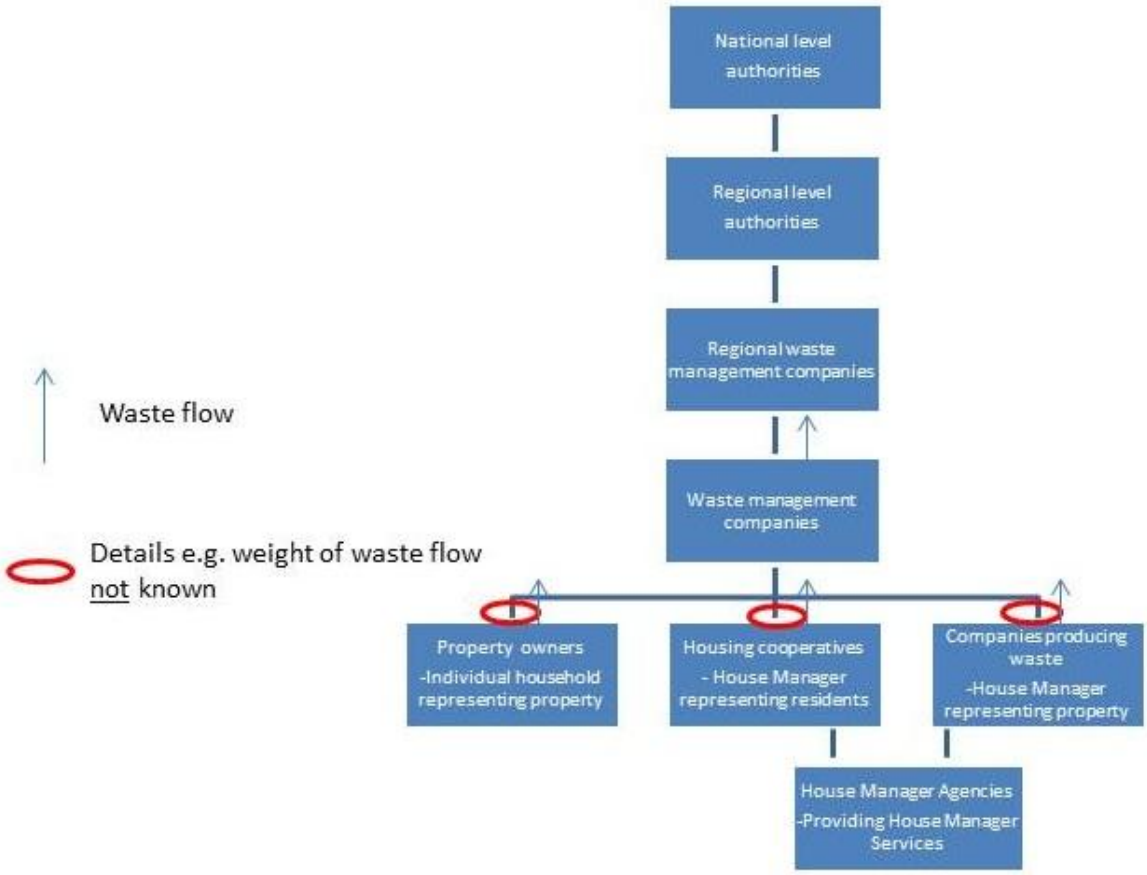


Figure 2: Waste flow (Serkkola & Korhonen & Suomi, 2016, 2)

Housing cooperation meetings can deal with reports of electricity consumption and water consumption. Exact results of waste production per housing cooperative are not available at the moment. Waste Flow Monitoring Service can provide such a report. Service has been introduced to some potential users but their feedback has not been collected.

The aim of this thesis is to collect the feedback and analyse development needs for the service. The value of Waste Flow Monitoring Service can be determined based on the feedback of potential users. It is very important to clarify the real user need and understand users' operating model. Otherwise there is a risk that final solution is not acceptable by users.

### 1.2 Scope

Scope of the thesis is to clarify Waste Flow Monitoring Service's value and feasibility for House Managers in municipality waste management (Figure 1). Prototype of the service already exists, which provides a baseline for the research. Empirical part of the thesis does not cover only the users who have already seen the service, but also new users to whom the service is introduced at first time. Service is demonstrated to potential users

and their feedback is collected. Target group in the research is House Managers. They represent residents in housing cooperatives. Individual households would have been interesting target group as well but if was left out from the research to avoid too wide research. Development ideas for the service are generated as a result of the thesis. Implementation ideas are introduced in general level.

### 1.3 Objectives and research questions

Objective of the thesis is to clarify how Waste Flow Monitoring Service could bring more added values to House Managers. The thesis clarifies what are the benefits for House Managers and housing cooperatives if they start to use Waste Flow Monitoring Service and how do House Managers see its feasibility with other stakeholders. The thesis clarifies potential use cases from House Managers perspective. Aalto University receives House Managers feedback for the service via the thesis. They can use the results for further research and development activities.

The main research questions are:

1) *What is the value proposal of Waste Flow Monitoring Service?*
    - *Do House Managers benefit of the service?*
    - *Who else benefits of the service?*

2) *What are the primary use cases for the service?*
    - *Who are the stakeholders of the service and for what purposes they use the service?*

3) *How the Waste Flow Monitor can serve more efficiently?*
    - *What kind of improvement ideas can be found?*

## 1.4 Structure

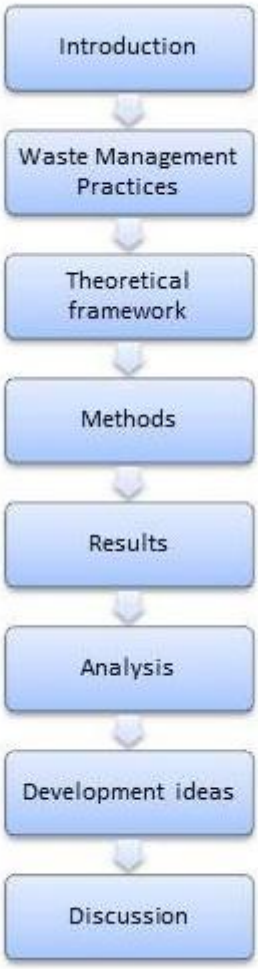


Figure 3:Thesis structure.

Thesis structure consists of eight parts. First part explains the background, scope, objectives and structure of the thesis. Second part introduces waste management practices. Third part concentrates in theoretical framework and discusses about the topic from smart waste processes, business value creation and service design perspective. The thesis approaches the topic from value and feasibility point of view. Fourth part is about methods. It describes methodology used in the thesis. The chapter introduces how data collection was done and what kinds of demonstration screenshots were used. Fifth part introduces results of the research by introducing interview results. Sixth part provides analysis of the results and builds up main conclusions. It also explains interrelations and connections within the results. Results generated development ideas that are introduced in seventh part. Last part is discussion part where generalization of the research is done and opinions about research process are shared.

# 2 Waste Management Practices

Waste Management practices are defined by authorities. Each stakeholder has its own responsibility. Municipality has to take care that waste is collected and households have to take care that recyclable materials are separated from household waste. House Managers look after real estate's waste management, thus they work closely with Waste Management companies.

## 2.1 Evolving municipal solid waste management

European Union Waste Framework Directive (2008/98/EC) sets requirements to waste management and recycling. According to directive member states have to adopt waste management plans where recycling target of certain waste materials from households is 50%. In practice it means that Finland has to recycle 50% of its municipal waste by 2020. (European Commission, 2008.)

According to study done by European Environmental Agency (2013, 6), Finland has not been able to increase the yearly recycling rate of municipal solid waste between 2001 and 2010. During that period MSW recycling in Finland was about 35 %. Compared to other European countries figures in Finland are low. E.g. in Belgium the MSW recycling rate has increased from 50 % to 58% between 2001 and 2010. It seems that in Belgium increase comes mainly from material recycling. (European Environment Agency, Belgium, 2013, 9). Sweden has been able to increase the MSW recycling rate from 40% to 50% between 2001 and 2010 (European Environment Agency, Sweden 2013, 6). Germany is a great example fulfilling the target. Total level of MSW recycling in Germany increased from 48% to 64 % between 2001 and 2008. (European Environment Agency, Germany, 2013, 6.) However, what is common in Finland and Germany, in both countries the trend in the end of measurement period seemed to be decreasing; in Germany last two years show that total recycling has decreased from 64 % to 62 %. In Finland total recycling decreased from 36% to 33% during 2009-2010. If the trend remains the same in Finland also in this decade, significant effort is required before the year 2020. (European Environment Agency, Finland, 2013, 6 & European Environment Agency, Germany, 2013, 6,8,15). Finland is not alone with the challenge. In Spain the MSW recycling rate was only just over 20% in 2001. They were able to reach 30% and have been able to stay in that level till the 2010 (European Environment Agency, Spain, 2013, 7).

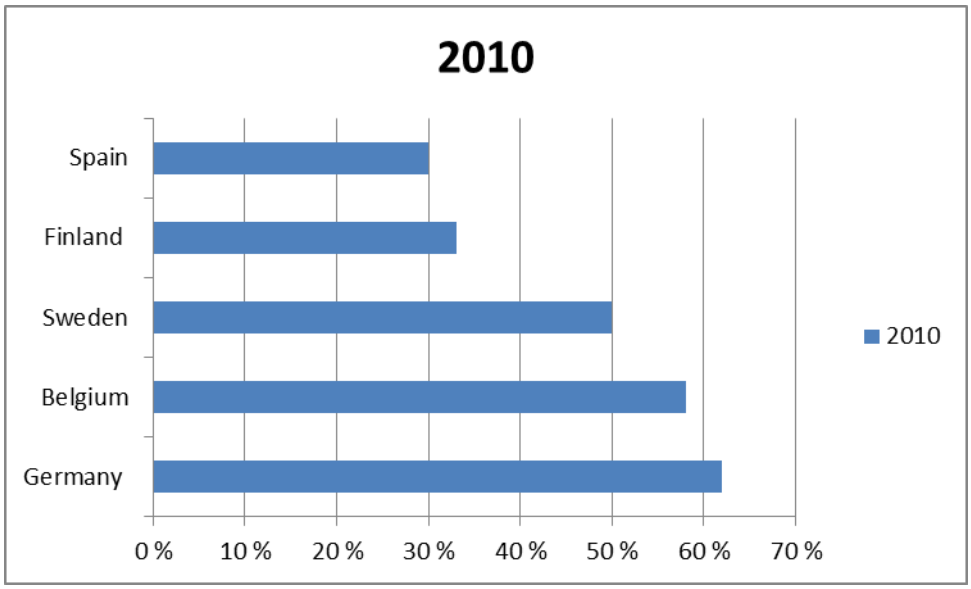


Figure 4: Recycling rate of solid municipal waste in 2010 (European Environment Agency, country specific reports, 2013).

In 2015 European Commission made revised legislative proposal on waste. The new proposal is even more ambitious and looks much further to the future. Revised proposal sets a common EU target for recycling 65% of municipal waste by 2030 (European Commission, 2015).

Recycling rate figures mentioned above do not give impressive perception of MSW management in Finland. But it is good to keep in mind that the figures talk only about recycling rate. The recovery rate of MSW has increased heavily in Finland because of waste incineration plants. Basically the recovery rate comes from material recovery and energy recovery. In 2013 the recovery rate of municipal waste increased up to 75% mostly because of energy recovery. In EU there are many countries using landfills for almost all their municipal solid waste. Finland is one of the top countries aiming to get rid of landfills for municipal waste. (Statistics Finland, 2014.) By doing that Finland is in line with the EU target for using landfills only for 10% of MSW. In 2014 Finland delivered only 17% of MSW to landfills. (Uusiouutiset, 2015.)

European Union Waste Framework Directive (2008/98/EC) has been a driver for Finnish waste legislation renewal. Finnish Waste Act was renewed in 2012 and it strongly concentrates reducing the amount of waste and increasing recyclability. (Ministry of Environment, 2009.) Finnish Government approved the National Waste Plan for 2016 on April 2008. It replaced the Waste Plan for 2005 and it will remain in force until December 2016. Renewed waste plan sets eight objectives. The waste prevention and recycling have to increase. Material efficiency and management of hazardous substances are promoted.

Waste management shall reduce the harmful climatic impacts as well as harmful impacts for the environment and health. Waste management organizations shall be clarified and expertise in waste sector is built up. Waste transports and frontiers shall be well-managed. (Ministry of environment, 2009.)

Renewed waste plan includes also general objectives for the waste policy. According to general objectives the amount of generated waste shall be decreased. Recycling and re-use of the waste shall be promoted as well as biological recovery of waste. In the cases where recycling is not possible the waste shall be used as energy. Waste treatment and disposal shall not cause any negative impacts. (Ministry of environment, 2009.)

Low recycling rate and high energy recovery rate indicate that lot of recyclable items are ending up to the waste incineration plants. Instead of burning recyclable items into energy, they could be reused or refined as a raw material for industry needs. Future recycling objectives have an impact to all stakeholders in waste management. Stakeholders are property owners and House Managers representing the properties, waste collection companies and waste treatment companies. Government and local authorities have to make actions to support better recyclability and stakeholders have to co-operate more efficiently to achieve the target. In order to fulfil the ambitious goals the whole waste management chain has to evolve and act more efficient way. One part of efficiency comes from customer value creation. We have to look at the beginning of the chain, to property owners and inhabitants who produce municipal solid waste. If waste management companies can provide more value to customers via services, it may increase recyclability and reduce amounts of waste.

### 2.1.1 Customer's responsibility in MSW management

Finnish Waste Act (646/2011) defines that municipalities have to either arrange waste collection or to make sure that inhabitants have possibility to arrange the waste management by themselves. In both cases arranging means that tender is put out to waste management companies to take care of operational waste collection. When one is selected, municipality or inhabitants make the contract with waste management company. Waste is collected regularly according to contract. (Finlex, 2016.)

In Finland each property has a waste bin or waste collection room including separate bins for different kind of waste. If there are at least four households in a residential house, there has to be separate waste bins for biowaste, paper, cardboard-paperboard, glass, metal and combustible waste. Smaller residencies and one-family detached houses who

do not have that kind of obligation are advised to take paper, cardboard, paperboard carton, glass and metal to recycling points that are available at many places in the cities. (City of Oulu, 2016.)

Authorities have given the state that recyclable materials must be separated from household waste. Usually recycling instructions are available at the waste collection rooms. Municipalities provide also separate collection points for hazardous waste and electronic waste. Small electronic waste and batteries can be delivered to stores that sell electronics and batteries. Waste collection room is meant only for household waste and e.g. pieces of furniture have to be disposed by delivering them to a charity or to some other collection point, or by selling them at flea market. Inhabitants are not allowed to bring waste from anywhere else, e.g. from work, to housing cooperative's waste collection room. (Infopankki, 2016.)

### 2.1.2 House Manager's responsibility in MSW management

The Finnish Real Estate Management Federation defines Real Estate management in a following way: "Real estate management is an expert service which ensures that everyday life in residences goes well, living costs can be anticipated and repair projects go according to plan." In Finland real estate management looks after the homes of 2.7 million people and services are provided by 700 companies. In Finland Real Estate employs 2,500 House Managers. (Isannointiliitto.fi, 2016.)

Among other duties that House Managers have, they look after real estate's waste management. House Managers work closely with waste management companies. Together with housing cooperative, House Manager selects the right kind of bins for the waste collection room. Property can own the bins or rent them from waste management company. Bins' size and amount have to correspond to the amount of inhabitants and waste collection interval. House Manager ensures that waste collection room provides required functionalities both for households and waste collectors. If collection interval requires temporary change, House Manager contacts the waste management company. House Manager approves the waste management bills on behalf of the housing cooperative and makes sure that waste management costs are visible in the annual closing of account report.

### 2.1.3 MSW management costs

Municipal solid waste costs consist of municipal waste charges and waste tax. Property holder is charged for a waste collection according to waste tariff approved by the municipality. The waste charge is in line with complexity of waste handling and usability. Usually

mixed waste is charged more heavily than recycled and reusable waste. Waste tax is required according to Waste Tax Act (1126/2010). It is based on nature preserving. In practice it means that all the waste that can be used by the help of technology is taxable. Also the cases where waste's commercial usability can be improved by taxes, waste is considered as a subject to tax. (Environment.fi, 2016.)

Waste Management companies in Finland prefer municipal solid waste billing model where property owners have regular waste collection cycle and they pay the agreed charge of every waste collection event. The charge consists of transportation fees and waste handling costs. In addition customers pay rent for waste bins if they don't own the bins by themselves. Waste collection follows the agreed cycle which is estimated based on the sample. The same cycle is followed as long as property owner or House Manager wants to change it.

# 3 Theoretical framework

The thesis theory part examines municipal solid waste management (MSW) principles from waste producers' point of view. Waste producers are property owners and inhabitants represented by House Manager.

Smart waste enables improved efficiency in waste management. Theory part explains what the smart waste means and how it can improve waste management. The markets of smart waste collection technologies are expected to grow in the future.

Business value creation is a key element when innovating something new. Theory part clarifies business value fundamentals and points out how to maintain current value but also how to find new opportunities. Customer value is just a one part of business value. However, there is potential to create more added values to the whole waste management chain by improving customer processes.

Service Design is a new holistic discipline that guides service development. It talks about clear service propositions that people would really understand service's primary reason. It also reminds that users experience the service as a whole, despite of the fact that there might be several touchpoints behind the service. Service should be designed keeping in mind service experience and relationships between customer and service provider.

## 3.1 Smart waste

Smart waste plays an important role in the evolving waste management. Market forecasts indicate that integration of IT capabilities, automation and data analytics will grow their role in municipal solid waste management value chain. According to Navigant Research, Mackinnon & Woods (2014, 13,58,60-62) say that the most promising growth in 2014-2023 is expected to smart collection technologies. Drivers for the growth are operational efficiency and cost reduction.

Smart waste aims to achieve improved efficiency in waste management operations. Efficiency can be improved by reducing the amount of time and energy required to provide waste management services. The other target of smart waste management is to reduce the amount of waste created. Educating consumers how to reduce waste is important from municipalities' point of view, because they are paying for the landfills and waste removal services. The aim is to produce households more information about their waste

behaviour. Right kind of applications would bring asset and material tracking available to consumers. (LinkLabs. 2015.)

### 3.1.1 Waste weighing

A team of researchers at Aalto University has examined how to fulfil the target to reduce the amount of waste created. In their study the smart waste infrastructure is built to enable real-time tracking and reporting of waste quantities (Figure 5). The infrastructure uses measurement technology to weigh the bins. Real-time weight data is sent to the cloud. Each bin has RFID tag which speeds up the weighing process. Terminal in the vehicle uses near field communication (NFC) technology and gets automatically all the basic data of the bin and its location. Truck driver needs to fill in only the weigh information. Smart waste infrastructure can be built on top of the existing waste management system. New vehicle measurement system can be retrofitted and smart waste infrastructure can utilize also the data available in the legacy systems. (Terefe et.al. 2016, 1.)

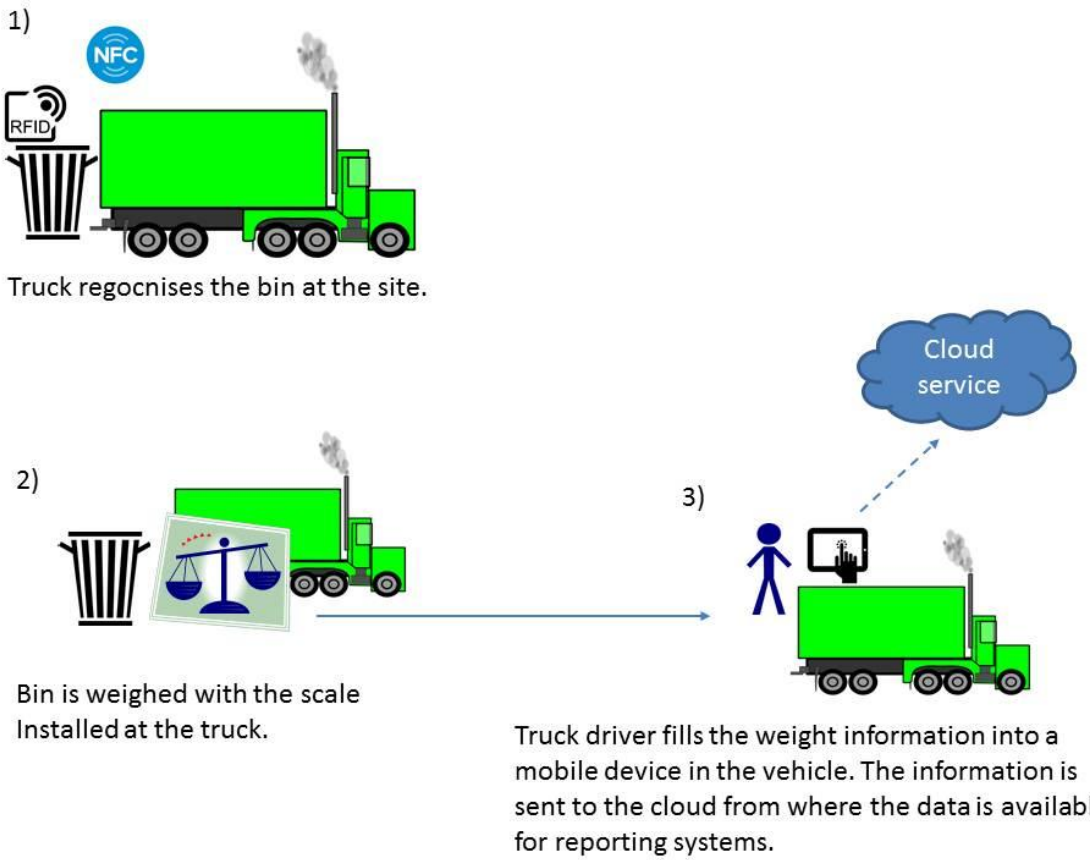


Figure 5: Weighing process (Based on Terefe et.al. 2016, 1).

Lisa Dahlén and Anders Lagerkvist in Luleå University (2010, 23-24) examined the weight-based billing model in Sweden. In the weight-based billing model vehicles have a

scale to weigh the waste bins and property owner pays per kilogram of waste. Based on their study municipalities who pay based on the weight of produced waste has 20% less household waste per capita. In their study Dahlén and Lagerkvist listed both the reported strengths and weaknesses in weight based billing systems. One of the reported strengths was increasing sorting of recyclables. It was also noticed that weight-based billing is quite well accepted system by the households and it encourages households for composting. However, even though weight-based-billing system provides fair allocation of costs to the users and ensures costs transparency, it increases investment and operational costs. It was also reported that some users move their waste to neighbouring communities to decrease their own waste costs. In worst cases it has also encouraged to illegal waste dumping. Still, according to study the overall weight-based-billing was seen in a positive light among local authorities.

Waste charging model which is flat rate based does not encourage households to reduce the amount of waste. The fee does not change if household generates less waste. It does not change even then if household generates extra amount of waste, as long as extra waste does not require additional pick-up from waste management company. Already 15 years ago Linderhof et. al. (2001, 370) examined case Oostzaan in the Netherlands. They found out that weight-based pricing has a strong effect on the amount of waste ending up for collection. However, they admitted that success of the study may have been partly explained by the political affiliation of Oostzaan because target group seemed to be more environmental conscious than average.

Smart waste practices have been examined at least past 15 years but for some reason smart waste management infrastructure is not widely in use at global scale. Main barrier for smart waste collection is costs that investing to smart waste requires. Some countries have challenges to provide even basic waste management so they might not be interested in investing smart waste. (Mackinnon & Woods, 2014, 18.) Countries that have basic waste management in order might not be interested to invest smart waste for other reasons. Economic crisis in several countries after 2008 might be one reason. However, investing to smart waste should be seen as a long term investment which brings cost-savings in a long run.

### 3.1.2 Waste Flow Monitoring Service for MSW

Authorities monitor the data regarding regional and national municipal solid waste. Existing reports show the amount of waste produced in regional and national level. All the data is based on same original data hosted in the same database. It can produce different kind

of reports to various parties of supply chain. However, reports are based on regional and national level data. Reports are not able to show how much waste is produced locally per one house or housing cooperative. (Serkkola & Korhonen & Suomi, 2016, 3.)

So far producers' waste amounts are estimated based on the samples and waste collection cycle is decided based on that. Evolving waste management focuses on the root sources of waste production. It generates a need for site-specific tracking system which is able to do real-time monitoring. That kind of smart waste management can produce essential feedback not only to waste producers but also to transport and waste management companies. Real-time information of waste amounts and materials support decision-making concerning waste management. Exact information of produced waste enables more efficient waste treatment and utilization. (Terefe et.al. 2016, 1-2.)

Cox et.al. (2010, 208) have examined household waste prevention methods in UK. Based on their study monitoring and evaluation are important elements through which household waste generation can be influenced. They say in their research that "Reliable and robust monitoring and evaluation of household waste prevention interventions is essential, to enable policy makers, local authorities and practitioners to:

- collect robust and high quality data
- ensure robust decisions are made about where to prioritize resources
- ensure that waste prevention initiatives are being effective and delivering behaviour change. "

Aalto University Department of Built Environment Engineering has examined waste-tracking and its indicators in waste production, collection and treatment. Examination has generated Waste Flow Monitoring server which gets the data of collected waste and creates reports to interested people. Vehicle that collects the waste has a scale and it weighs the waste bin before it is emptied. Truck driver has a mobile terminal in the vehicle and he or she sends the weight data to the database (figure 5). Waste Flow Monitoring server generates reports based on the data received from the vehicles. Waste Flow Monitor is a web-based tool that can be used from computer or from mobile device. It is easy to use and it provides e.g. yearly, monthly and weekly view of produced waste per site. Figure 6 below illustrates site-specific mixed waste amount per week in 2013.

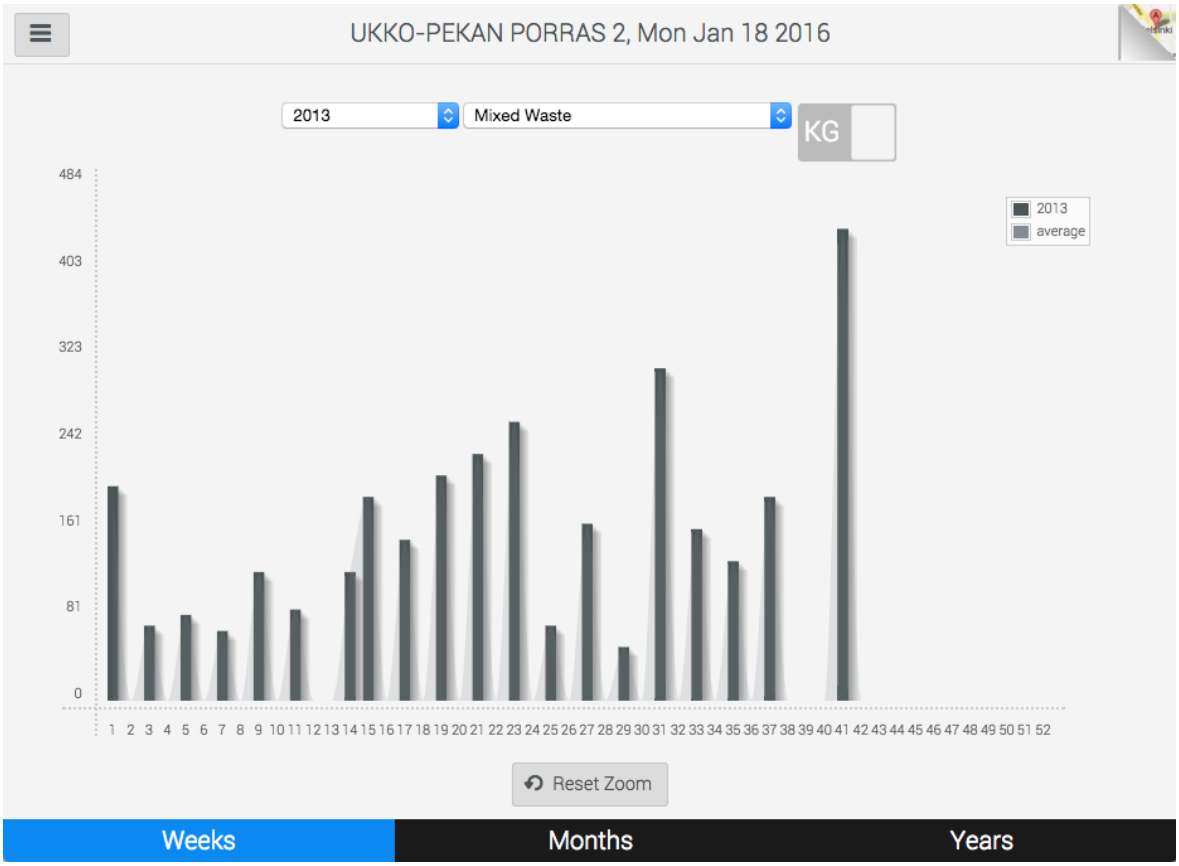


Figure 6: Site-specific waste amount per week in 2013.

### 3.2 Business and customer value

Business value consists of several parts. Those can be e.g. economic value, environment value and customer value. Thus the customer value is just a one part of business value. Business environment in municipal solid waste management consists of several actors. Waste producers generate the waste and they pay to waste management companies for the waste collection and treatment. Those two activities are main services in the waste management sector. What comes to waste management in generally speaking, many European countries have been successful focusing on improved service level. It is assumed that waste management market continue to increase because of the increased service supply and role of technology providers. (VTT, 2012, 13.)

New technologies bring more value to waste management business. Conceptually value means a fair return for something that has been exchanged. It can be monetary value or utility value and in some cases importance value. Definition of the value depends of the context. Value can be gained by the customers, by the firm, or by some other facet of value. When value concept has been defined precisely in the context it is used, the next step is to define how to create value. Very often we hear people talking that new products and services create more value. However, product or service itself does not guarantee the

value. It is actually the function of the product or service that creates value. The function might save customer's money, make customer's process more efficient or it can make customer happy in some other way. Once company understands the value in customer level it can start to think ways of value creation. (Soman & N-Marandi, 2010, 29-31.)

In the Implement Consulting Group's 'Viewpoints on Change' material Morten Hejlesen (2012, 5) describes four dimensions of customer value creation. As a first dimension Hejlesen thinks that customer value comes from emotional benefits. How the customer feels the service. Does it make him/her delighted? The other dimension is functional benefits. How efficient the service is? How about excellence of the service? Does it really support customer with the topic it is meant to? Third dimension is social benefits. Does customer achieve a certain status in his society when using the service? Fourth dimension covers altruistic benefits. It is about fulfilling customer's willingness to have an influence for a big picture. E.g. Is customer able to control climate change by using the service?

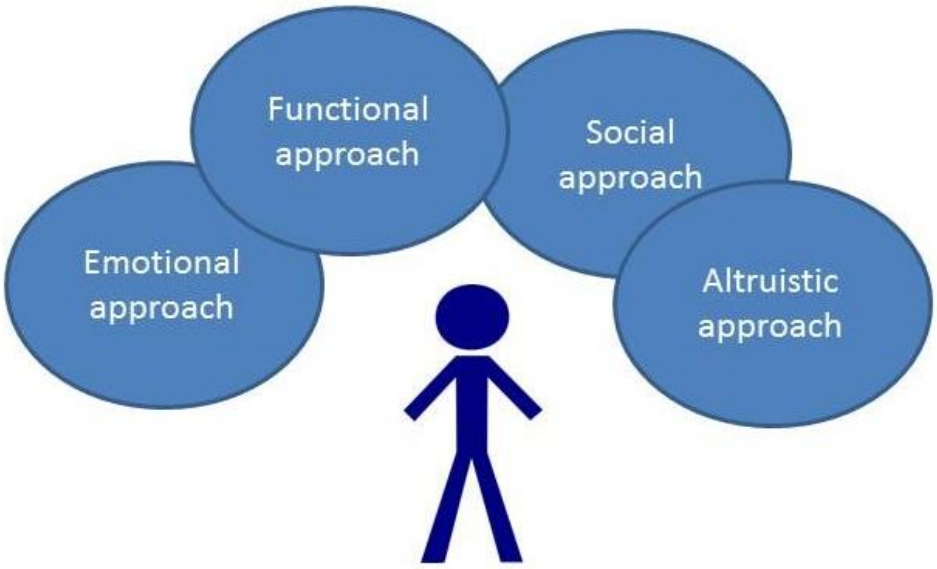


Figure 7: Four dimensions of customer value creation (Implement Consulting Group, 2012, 5).

### 3.2.1 Value chain

Value chain consists of activities which are required that a service can be delivered to customers. Value chain covers the whole life cycle of the service. It also includes after-use activities for the service. (Kaplinsky & Morris, 2001, 4.)

Companies have to evaluate their value chain components to optimize productivity and being competitive in the markets which changes dynamically. Business value thinking has become even more important than it used to be. It has to be understood what business value is, what it was in the history and what it might be in the future. Companies have to think about business values from several perspectives. One perspective is differentiation, how to be unique and how to deliver positive experience for customers in every circumstances. The other perspective is simplification, how to simplify products and make repeatable business model. Third one is execution, how to prioritize execution as a core capability. (Bhatia, 2012, 5.)

Customer value should be in the centre of every business but sometimes it seems not to be. Investors are expecting short-term optimization and following that path they put a risk to customer satisfaction in long term. Customer value creation gives benefits but it also causes costs. It is good to keep in mind that customer is the one who evaluate the value and might see the value in a different light than service producer originally thought. Value creation potential and risks in the value proposition have to be considered carefully. (Implement Consulting Group, 2012, 3.)

Basically waste management value chain starts from the entities that produce waste and ends to the companies who take care of the waste disposal. The chain itself looks simple but there are many stakeholders in between providing e.g. technologies and material recovery to improve the efficiency (Mackinnon & Woods, 2014, 12).


Figure 8: Waste management value chain (Mackinnon & Woods, 2014, 12).

Mackinnon and Woods (2014, 13) mention that one of the stakeholder groups in the chain is technology vendors and solution providers who offer e.g. control technologies for municipal solid waste management. Usually they operate as a subcontractor behind the waste management company and do not have direct relationship to end customers.

### 3.2.2 Managing value and new opportunities

In the past it was much easier to tie long-term relationships with customers and believe in customers' loyalty. Customers were relying on their previous good experiences and on the image the brand had created. Nowadays customers get a lot of information of products and services via different channels. Social media has a very big impact. If consumer reads many critical reviews of the new service, it is most likely that the reviews affect his or her purchasing decision more than previous good experience with the brand. (Simonson & Rosen, 2014, 77-79.)

On these days when customers' loyalty is not something that can be taken for granted, companies should see their great potential. If customers are not happy to the value provided by competitor the company should not hesitate to show their better solution to the customers. Also, if company did not provide that good service in the past, nowadays it is easier to get a better second chance. Customers' past experiences do not impact so much in the market anymore. If customers get the idea of how good the new service is they might decline the past bad experience. (Simonson & Rosen, 2014, 82-84.)

### 3.2.3 Future of value creation

Future of the trends shows that tools that provide access to absolute values are emerging. Simonson and Rosen (2014, 175-176) think that consumers, who feel that they are in the dark in terms of some essential information, start to demand the information, and eventually it spreads to a larger group of population. Their hypothesis fits to a waste management service. Environmentally conscious persons might feel that they don't know enough of their waste behaviour and its consequences. They start to demand more information about the waste they produce and they might start to doubt the costs they pay. Especially, if their recycling behaviour is much more efficient than recycling behaviour of neighbour's property that pays exactly the same amount of money of waste collection. Waste Flow Monitoring Service provides transparency and fairness in terms of costs. At the moment it shows waste amount and costs in weekly, monthly and yearly level per property. In the future system might evolve into the direction where measurement is done per household to bring even more added value. According to Simonson and Rosen (2014, 190-191) we are entering in to a new era where we should track what customers really want and not to focus too much on brand image and traditional marketing. Once we know what customer really wants we are able to provide absolute value.

Article in the Harvard Business Review (2013) formulates the future of value creation like this: "Value creation in the future will be based on economies of creativity: mass customi-

zation and the high value of bringing a new product or service improvement to market; the ability to find a solution to a vexing customer problem; or, the way a new product or service is sold and delivered." Article encourages accepting that creativity is a core component of value and continuous innovation is the way to sustain it. Management has to oversee ecosystems so that solutions meet customer needs and all this have to happen near real time. Article convinces that in the future machines will take over every routine work and that's how creative value is added. Value needs to be an obsession for those whose job is to think how to create value. They need to constantly think how to make life easier and better for consumers. Value creation will be primary responsibility of everyone in the organization. However, article reminds that all the changes take time. Even though new innovation would be good and would bring a lot of value, there are always people who are sceptic at first. People need time to adapt new innovations and accept the change.

## 3.3 Service Design

Improved services are considered through Service Design which is a new holistic way to develop services that fulfils users' needs and expectations. Customer Service is a heart of the business and continuous interaction between service provider and user is a vital action to maintain a good relationship. Understanding how user acts and thinks are very important to service provider. However, it is good to keep in mind that it still not guarantee that customer is served more efficiently. (Fritsche, 2010, 34.)

Stefan Moritz (Moritz, 2005, 8) describes Service Design with following sentence: "Service Design helps to innovate (create new) or improve (existing) services to make them more useful, usable, desirable for clients and efficient, as well as effective for organisations." He also reminds that new technologies have brought services into a new level and have expanded possibilities to create service systems that provide value in a new way.

Waste Management is a service as any other service providing value to consumers. Actually it is very important service because it has a great impact to every-day life. If waste management doesn't work properly, it is surely noticed. Smart waste uses new technologies and while improving the efficiency it allows customers to have a new service experience thorough a digital platform.

### 3.3.1 Difference between service and product

Katarina Wetter Edeman points out in her research that already early researches of Service Design have argued that marketing logic which suits for products does not suit for services. Intangibility is a key definition for the service because services cannot be evalu-

ated until they have been experienced. The other significant definition for the service is inseparability; production and consumption cannot be separated because they happen at the same time. Services cannot be treated as a replacement of the products because the nature of the service is different. (Wetter Edeman, 2011, 50.)

Polaine, Lovlie and Reason (2013, 19-34) summarize in their book that when companies are marketing their services like products it is problematic because customer sees the offering as one experience. Service typically has several touchpoints of interaction. If touchpoints are managed as silos they might not be aware of each other's objectives and that may lead to bad customer service experience. In waste management example could be following. Customer would like to know how many times his or her waste bin will be collected per year according the waste management contract. He or she calls to the waste Management Company but the person who answers the call knows nothing about it, and do not have access to contracts in that level. As Polaine, Lovlie and Reason say: "Often, each bit of the service is well designed, but the service itself hasn't been designed."

Even though Polaine, Lovlie and Reason claim that services differ from products, some people might see service design similarly for a service as they see it for a product. Katarina Wetter's opinion is that Service Design is a combination of seeing service as interactions and seeing service as a product. She thinks that those two approaches complement each other and expand aspects of designer's practices in different phases of the service design process. (Wetter Edeman, 2011, 104.)

From economy point of view service economy is a totally different thing than product economy. Polaine, Lovlie and Reason (2013, 28) give a good example when they explain that if person buys a car, he or she buys a product. But if person participates to a shared car program, he or she buys a service which provides him or her an access to the car when needed. When owning the car the person pays the car usually at once, but when participating to a sharing car program he or she pays monthly fee of the service.

### 3.3.2 Relationship building

According to Moritz (2005, 4), Service Design is essential part building relationships between organizations and clients. Innovative service experiences can create competitive advantages when satisfied clients remain loyal to the organization. It can allow higher profit margins and at the best it drives both the organization and economies forward. People share their service experiences and opinions in social media. Great service experience can have an efficient marketing effect and boost the whole business forward.

Service Designers have to understand end-users needs and expectations. The BE-onomics blog (2016) uses following quote to describe Service Design: “When you have two coffee shops right next to each other, that each sell the exact same coffee at the exact same price, Service Design is what makes you walk into the one and not the other.” In order to provide successful performance of the service, customer needs have to be embedded in the service’s lifecycle. That is a main competent because fulfilling a certain need is a fundamental reason why customer uses a service. A certain need answers a question *what* for the service is created. A certain expectations answer to the question *how* the service is delivered. When service provider knows what customer is expecting at each point, the more efficient and effective service can be created. Other key elements are interactions and transactions. Services are based on transactions. Nowadays customers are expecting fast and easy transactions. If service user wants to order an extra collection for the waste bin, he or she wants to do it fast and easy. Sometimes service may require some interactions between user and service provider. Those are the moments when relationship can be strengthened or weakened. Customer usually has certain expectations as a return for his or her money or some other given effort. It can be certain level of respect, information, or speed of the service and it can define dramatically how customer feels the service provider. (Reason & Lovlie & Flu, 2016, 29-31.)

### 3.3.3 Service experience

People react on the service according to experience they have when using the service. Reactions can vary from frustration to delight. If service provider understands user’s experience, it is much easier to respond to user’s behaviour and enable improvements which are good both for the customer and business. (Reason & Lovlie & Flu, 2016, 47.)

Service Design takes a holistic perspective to the user experience and tries to understand what user exactly experience when considering the service and interacting with the organization. Quite often service excellency is seen as luxury and there are worries of increased costs. Actually, from organization point of view the service excellency should be seen as an action that reduces costs and bring more revenue to the company. That requires that user experience excellence is in line with business performance. (Reason & Lovlie & Flu, 2016, 55-56.)

### 3.3.4 Service’s value proposition

Article in ConversionXL’s website (2016) describes a value proposition like this: “Value proposition is the #1 thing that determines whether people will bother reading more about

your product or hit the back button." The article emphasizes that testing the value proposition is an essential activity to find out if people really understand it and see its primary reason. Value proposition should explain how the service solves the problem and what makes it so relevant. Value proposition should also be able to prove service's quantified value for users and indicate clearly how it differs from competitors' solutions.

Service's value proposition reminds us of principles that are used in business value creation. More precisely, it reminds principles of customer value creation which is one part of business value. As Morten Hejlesen from Implement Consulting Group (2012, 5) explains, customers have to realize the emotional, functional, social and altruistic benefits of the service (figure 7).

Service value proposition usually comes as a result of research that examines unmet need in the market. Research is based on reality in the existing markets and indicates if there is a room for a service value proposition that can address both business and user needs. Business perspective from organization point of view is relevant in the behind because all the new services require funding and infrastructure to deliver the service. The most fascinating areas for service proposition research can be found from undeveloped markets, disrupting technologies and from the complicated service infrastructures that could be simplified. (Polaine & Lovlie & Reason, 2013, 110.)

Polaine, Lovlie and Reason (2013, 112) mention three things that have to be considered when developing service proposition further:

1. People must understand what the new service is for and what it does.
2. People must see the value that service can add in their life.
3. People have to understand how the service is used.

Sometimes people do understand the service but they might not see the value of it in their life. Service has to be approved both for the customer and organization providing the service so that they can bring value to each other. Business provides what customer needs and both of them can be winners in the deal. However, understanding the service and seeing the value of it do not guarantee that people understand how to use the service. Any business cannot make a profit if users do not know how to use the service. (Polaine & Lovlie & Reason, 2013, 114.)

# 4 Methods

Target of the thesis is to clarify how Waste Flow Monitoring Service could create value for House Managers in municipal solid waste management and how the service's usability could be improved. House Managers represent residents who are customers of waste management services. The thesis describes current features of Waste Flow Monitoring Service and introduces value proposition for the service. The value of the service is determined based on the feedback of House Managers.

The purpose of the thesis is to collect feedback from House Managers and analyse development needs for the Waste Flow Monitoring Service. Users will feel more engaged once they have had chance to affect the solution. In that sense the thesis also impacts for the final launch of the service. The need for the thesis has been generated by Aalto University Department of Built Environment Engineering.

Objective of the study is to find new features for the service to make it more desirable and useful for House Managers. The thesis finds out what kind of expectations House Managers have for the system and how they would like to use it. Waste Flow Monitoring Service provides an easy to use user interface which supports potential users in their everyday tasks.

Tietomitta Oy is a Finnish company and part of Vitec Software Group. They are specialized in resource planning solutions in the field of environmental business. (Tietomitta.fi, 2016.) Tietomitta Oy has created a wide range of reports on top of the Waste Flow Monitoring Service. Those reports provide deeper analysis of waste flows. Report templates from Tietomitta have been used in the thesis as well and one of the objectives is to improve their reporting functionalities.

## 4.1 Methodology

Research method is qualitative where data collection is done with semi-structured interview process. Qualitative research method was selected because of its characteristics. The method concentrates on holistic perspective and it focuses on respondent's view. It supports on understanding the whole process. (Ghauri & Gronhaug, 2010, 105.) Interviews were held at the interviewees' premises (in House Manager Agencies). Answers were voice recorded for later analyse. It was decided not to transcript interviews afterwards because of the large amount of data. Voice records can be used if data is needed for later purposes.

The thesis uses case study approach which is preferred option when ‘how’ and ‘why’ questions are presented to the target group. Case study can be used in a situation where researcher wants to test the theory presented and its applicability to the organization. Waste Flow Monitoring is a new service which is not in commercial use yet. It is important to find out how it can serve House Managers in a most efficient way. Case study suits very well to a situation which has not studied earlier and which is kind of unique. Case study can point the characteristics that are common in several cases but it also allows researcher to study the phenomena with many dimensions. (Ghauri & Gronhaug, 2010, 109-111.)

### 4.2 Data collection

Altogether eight persons were interviewed. They represented seven different House Manager Agencies. (Appendix 2). Reasonable time was used for the interviews, where six of them were individual interviews and one of them focus group consisting of two members. Duration of each interview session was about half an hour to one hour. All the interviewees were House Manager Professionals which is quite homogenous group in these kinds of topics. That may explain why the answers were so similar and saturation occurred already with low sample size. In scientific research saturation point is achieved when analyzing more sample data won’t provide any more information to the research questions. Saturation provides a confidence that researcher has enough empirical data and can move on to analysis part. (GutFeelings.eu, 2013.) If the study would have included also groups of other users, e.g. household representatives, the answers could have been more variable.

Data collection was done with semi-structured interview process. It is typical for the semi-structured interviews that interviewer has a formal interview with respondents. Before the interview the interviewer has created a list of questions and topics for the conversation but he or she can stray from the list if appropriate. (Robert Wood Johnson Foundation, 2016.) Semi-structured interview was carried out in a way which differs from typical semi-structured interview. Demonstration of the Waste Flow Management Service was presented to the interviewees during the conversation. Respondents’ perceptions and opinions towards the service were asked in an interactive way. The goal was to achieve open and informal atmosphere where interviewees were able to share their opinions freely. Behind the interactive discussion was a structured interview which was used to lead the discussion. Structured interview consisted of predetermined set of open questions. The

questions were designed together with Aalto University Waste Management Research group.

Questions were divided into following themes:

- Data content of the Waste Flow Monitoring server

The aim was to find out to what purposes respondents would like to use the data that is available in Waste Flow Monitoring Service. The aim was to find out what kind of things respondents can figure out based on the data.

- Usability of Waste Flow Monitoring GUI

The aim was to find out how respondents see the Graphical User interface (GUI) and what the most important features from their perspective are. The idea was to find out if they see any missing features or have any opinions to the usability.

- Feasibility within home organization

The aim was to find out how often respondents would use the service and can they use the service when sharing the information in their own organization. Home organization means House Manager's own home organization in House Manager Agency.

- Feasibility with customers

The aim was to evaluate respondents' willingness to introduce the service to their customers. The purpose was also to find out would they gain any significant help from the service in the discussions with customers or when planning the future. Customers mean Housing Cooperatives and households that House Managers are representing.

- Feasibility with other stakeholders

The aim was to find out if respondents see the service useful when they deal with other stakeholders. Other stakeholders mean Waste Management Companies and Service Management Companies to whom the House Managers deal with in their daily work.

- Feasibility and compatibility with other systems

The aim was to figure out if respondents see any integration needs to the other systems they are using at the moment.

- Future development needs

The aim was to collect all the future development needs for the service. The purpose was to find out respondents opinion how the service could serve them better in their daily activities.

The presentation sample was evaluated by Aalto University Waste Management Research group before it was presented to the final target group.  Aalto University Waste Management Research group representatives consisted of Chief Research Scientist and Research Assistant who have already worked around the topic. Final target group consisted of House Managers.

### 4.3 Demonstration screenshots

Following demonstration screenshots were used during the conversation. The first view presented a map where all the House Manager's properties are seen as geographic information markings. All the properties on the map are selectable items for further examination.

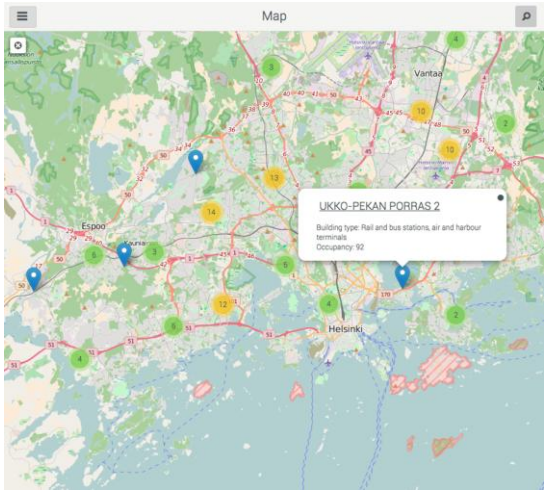


Figure 9: Map view.

By selecting a property from a map, further details per property can be seen as graphical diagrams. The diagram below presents the amount of mixed waste in kilograms per property per week during the year 2013. Each bar represents one week.

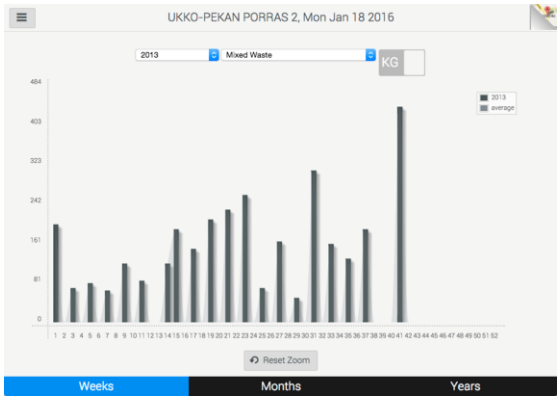


Figure 10: Waste flow per week.

The same kind of view is available for costs follow-up. Following diagram presents the costs of mixed waste in euros per property per week during the year 2013. Each bar represents one week.

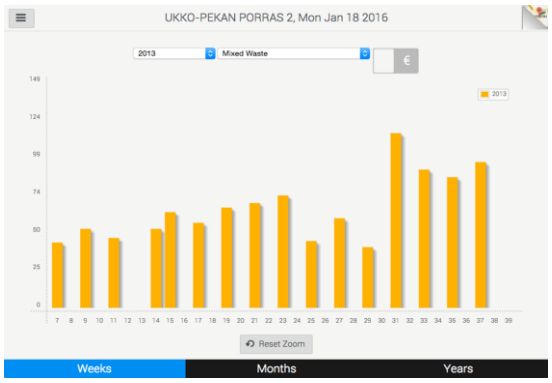


Figure 11: Costs per week.

Waste Flow Monitoring Service provides weekly, monthly and yearly view. Following diagram presents the amount of waste in kilograms per property per month during the year 2013. Each bar represents one month. Light gray color in the front of the bars represents the average.

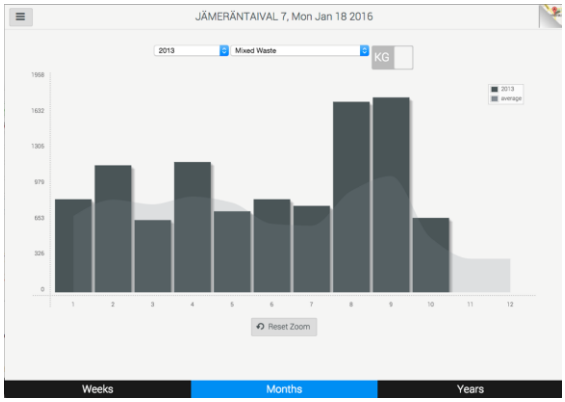


Figure 12: Weight per month.

Yearly view presents the amount of waste in kilograms per property per year. Each bar represents one year which makes comparison between years very easy.

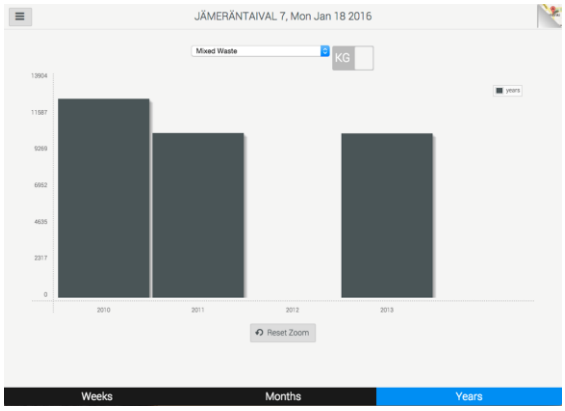


Figure 13: Comparison between years.

When looking at the details of one week, Waste Flow Monitoring Service uses main indicators like total weight in that particular week, weight per inhabitant, average weight, price for the weight in that particular week, price and amount of pick-ups and costs per inhabitant per that week.

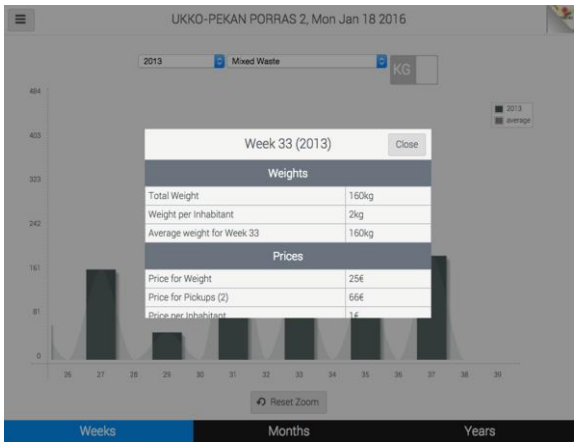


Figure 14: Indicators.

Report templates created by Tietomitta Oy provide deeper analysis of waste flows. Diagram below illustrates the weight and costs of the produced waste. It presents also material- and energy utility by indicating how many percents of the waste can be used as a source of energy or as a source of material.

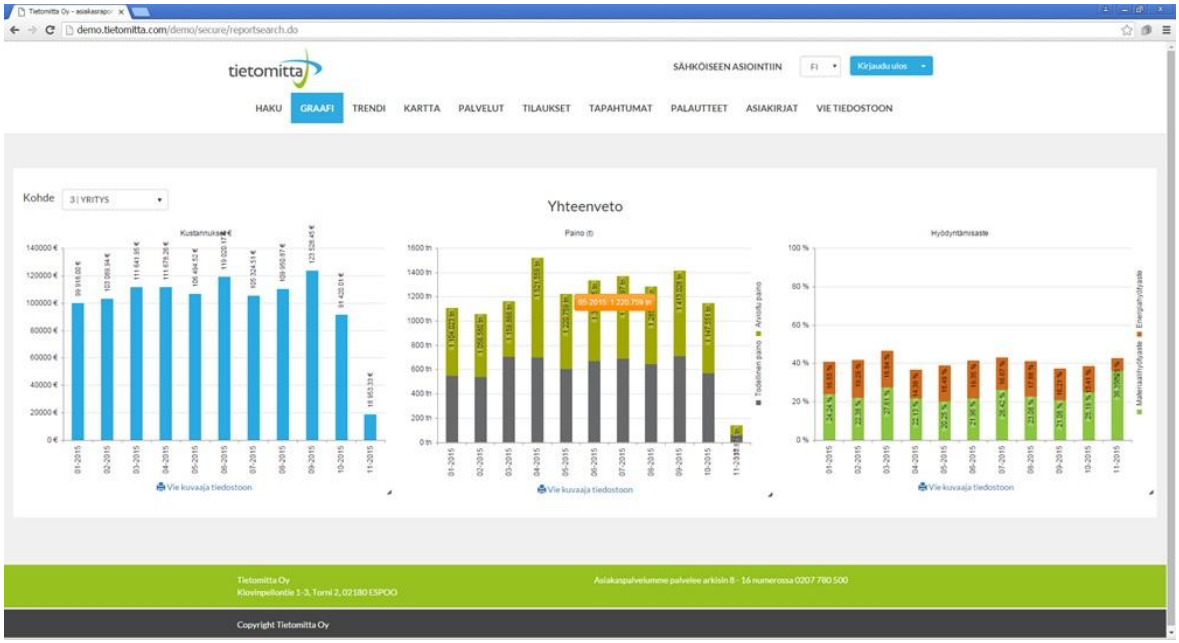


Figure 15: Tietomitta Oy detailed report of costs, weight and utility.

Tietomitta Oy is also able to show costs per waste sort. The diagram below indicates the costs of different waste sorts by separating them with colors.


Figure 16: Costs per waste sort.

Among other reports Tietomitta can provide details per customer. E.g. how many bins the customer have and how often bins are collected.

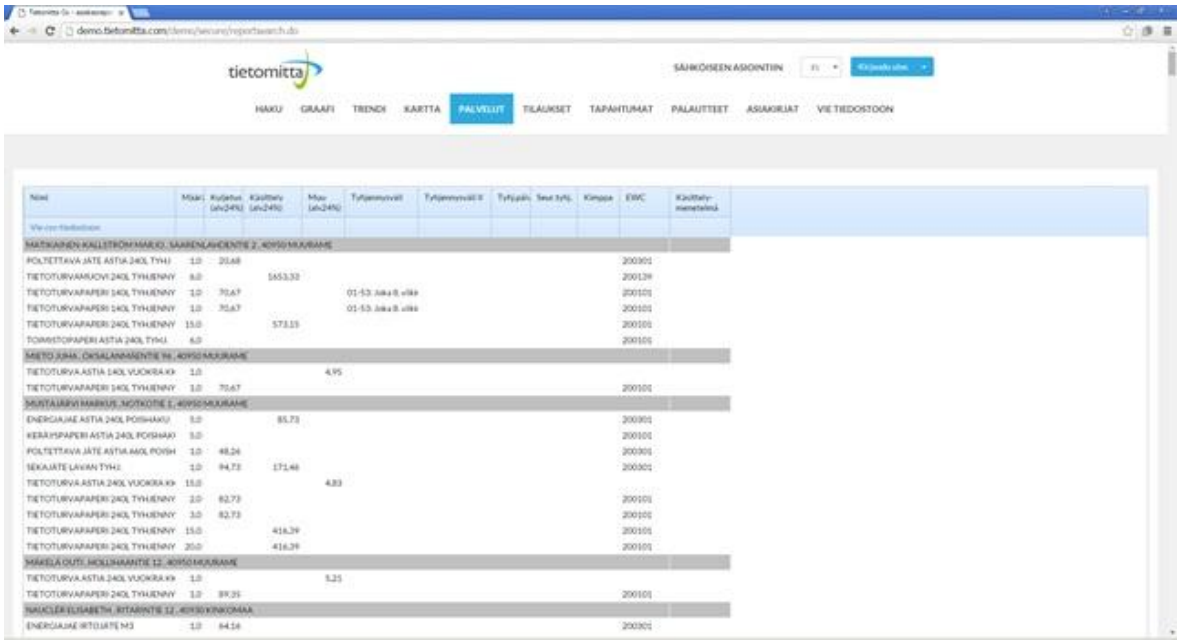


Figure 17: Details per customer.

# 5 Results

The questions were designed together with Aalto University Waste Management Research group in early 2016. The sample of demonstration material was evaluated by Aalto University's Chief Research Scientist before it was presented to House Managers in March and April 2016. Results were analyzed in May 2016 after all the interviews were done.

## 5.1 Analysis methods

Thematic categories are needed that researcher have something to describe, compare and explain. Themes come from the data itself but also from researcher's prior understanding of the researched phenomenon. (Bernard & Ryan, 2003, 86-88).

Qualitative analyze in the thesis follows the following analysis process.

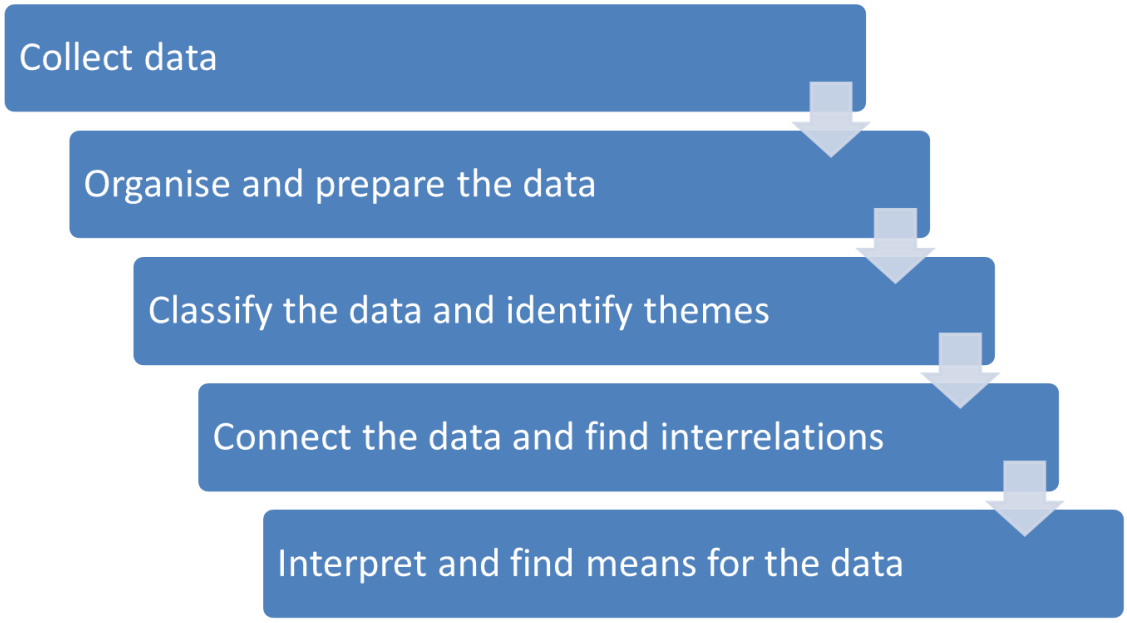


Figure 18: Analysis process (Hoyos & Barnes, 2012, 6).

Data collection was done by following questioning themes (page 26) in the interview. The collected data was organized by classifying the results of the interviews into types. Types conducted from the main research questions. Main headings in the classification correspond the main research questions (Figure 19). The input for the types was concluded by the researcher. Once the data was classified into main types, the interrelations and connections between classes were identified. At the end interpretations and meaning for the data were described.

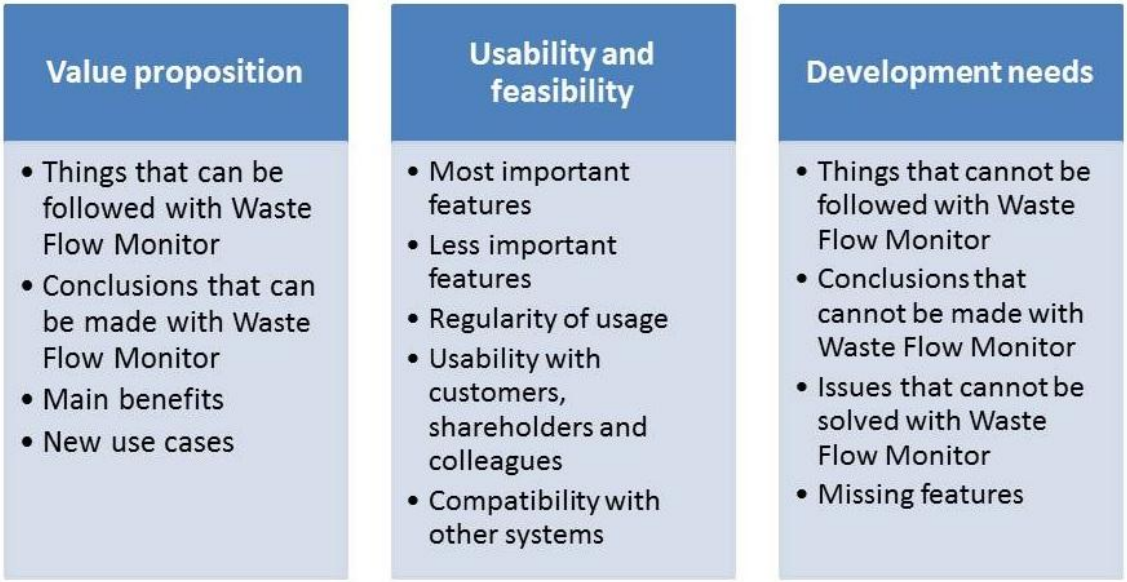


Figure 19: Data classified to types.

## 5.2 Results of the interviews

Interview results are described in the following chapters according the themes and structures used in the interviews. Actual analyze of the interviews is done in later chapters.

### 5.2.1 Data content of the Waste Flow Monitoring server

***Question 1:*** *What kind of things you can or cannot follow with Waste Flow Monitor at your real estates?*

All the interviewees identified that they can follow weight and costs of the produced waste from the Waste Flow Monitoring System. Interviewees mentioned specially the ability to see the peaks in waste production.

Interviewees were not able to see waste collection interval from the Waste Flow Monitor. One of the Tietomitta's report provided the information among other details but interviewees clearly indicated that real-time waste collection interval should be seen also on Waste Flow Monitoring console.

Some interviewees mentioned that households' individual waste amount cannot be seen in the system. The system handles data based on the whole real estate and calculates just the average for each household.

Waste Flow Monitor does not give any help to the situations related to items that are not measured by the system. Example: If someone leaves a broken television in the waste collection room, it is a problem because that kind of waste does not belong there. However, Waste Flow Monitor does not react at the issue because that information is not collected by the system. According to House Managers the real-time information about the problem would be useful. Currently it can take rather long time until House Manager gets the information about additional items in waste collection room.

***Question 2:*** *What kind of conclusions you can or cannot make based on the weight of the waste at your real estates?*

Most of the interviewees mentioned that based on the peaks they can make conclusions of households' waste behavior in the real estate. They can make very accurate conclusions based on the reports. One of the interviewees mentioned the example: If housing cooperative board asks from House Manager how much they have produced waste, the current information is based on the calculation of waste collection interval and capacity of waste bin. The result is not accurate because it assumes that waste bin is always full. With Waste Flow Monitoring System the actual result can be given based on the real-time reports.

Based on the peaks House Managers can identify more easily anomalies compared to average. House Managers are interested to see if two identical real estates have a lot of variation regarding waste generation. Once problem is noticed, they can start actions to find out why one real estate produces waste more than the other. House Managers can plan campaigns to educate households for better recycling behavior, if they see peaks without clear reasoning.

***Question 3:*** *What kind of conclusions you can or cannot make based on the costs of the waste at your real estates?*

House Managers can make conclusions of recycling willingness in the real estate based on the costs. The feedback from House Managers was that when costs are visible it might encourage households for more efficient recycling. One interesting feedback was that information would be even more valuable if it would be tight to invoicing. Waste billing could be opened from the console without accessing separate billing service provided by

Waste Management Company. Waste information in Waste Flow Monitor would be real-time information, but billing could still be as it is now, showing two months costs.

Interviewees would like to see more clearly the impact of recycling in total costs. The meaning of recycling should be pointed out. Report should show if recycling is not done properly in certain house complex. It should show to households what the total costs would be if the recycling was done properly versus current recycling behavior.

***Question 4:*** *What is the main benefit of the Waste Flow Monitoring Server at your real estates?*

Interviewees said that system gives a good overview of real estate's waste behavior and it supports waste management planning for the future. The main benefit is the exactness of the data. According the interviewees the benefit comes from the Waste Flow Monitoring's ability to show peaks in households' waste producing behavior. However, changes in waste management are not done based on one or two peaks, but peaks help to follow average level. Average level gives a good guideline when planning the size of real estate's waste collection room.

***Question 5:*** *What kind of waste related issues cannot be solved with Waste Flow Monitoring?*

Every now and then some items like furniture are brought to the real estate's waste collection room. It is a problem because they are not collected within regular waste collection cycle and items that do not belong to regular community waste cause additional costs. Waste Flow Monitor doesn't provide any follow-up to the items outside of the bin.

Few interviewees said that waste bin's fill-level monitoring is needed to optimize waste collection cycles in real-time. That information should be in the system. According to interviewees the usual issue is related to overloaded waste bins. Households inform the House Manager that additional pick-up is needed. The other side of the issue is half-full bins. Waste delivery costs are crucial thus the bins should be collected only when they are full.

### 5.2.2 Usability of Waste Flow Monitoring GUI

***Question 1:*** *What are the most important features in Waste Flow Monitoring user interface?*

One of the interviewees emphasized that it is very important to have Waste Flow Monitor working with any device. Thus, House Manager can easily check real-time information from mobile device when visiting at the real estate.

Map was mentioned as one of the main things in the GUI. Map gives a clear view of managed real estates. Also graphics that show the peaks are very important.

In overall usability was seen as easy because of clear drop-down menus. It is easy to select e.g. a year. Clear and easy-to-use graphical user interface was appreciated.

***Question 2****: What are less important features in Waste Flow Monitoring user interface?*

In overall interviewees said that Waste Flow Monitor does not include useless features. However, some of the reports provided by Tietomitta were seen too detailed and providing too much information. At the moment House Managers are not so interested how many percentages of the waste has material utility and how many percentages of the waste has energy utility.

***Question 3:*** *What is the most useful time related parameter: week, month or year?*

Month and year were considered as most useful time related parameters. Monthly reports provide useful information in the same context as water- and electric consumption reports provide. Yearly report would be used at closing of accounts.

***Question 4****: What is the least useful time related parameter: week, month or year?*

Weekly reports interest House Managers only if monthly report shows some anomalies in waste behavior.

***Question 5:*** *What features are missing from Waste Flow Monitoring user interface?*

If there are clear peaks in waste generation levels, House Managers would like to see an additional text field which would describe what caused the peak, if the cause is known. In spring time housing cooperative boards arrange a work party to clean up real estate's yard. Those kinds of activities increase the amount of waste within one specific week.

What comes to reporting, a pie graphic would be appreciated. Clear comparison to previous year's results should be included in the graphics. When viewing the current report the previous year(s) should always be seen on the background.

The amount of inhabitants varies. If we think about one big housing cooperative there are always families moving in and moving out. House Managers would like to have possibility to update the amount of inhabitants to the Waste Flow Monitoring System, to make sure that it always calculates weight per inhabitant correctly.

One of the interviewees clearly indicated that real-time waste collection interval should be seen also on Waste Monitoring console. More precise suggestion for that information was the map view, where all the other basic information of real estate can be seen. From the map users could easily see when the waste was collected last time and when it will be collected next time. If waste has not been collected according the regular cycle, a "red light" should start to blink on the console. If households call to House Manager about full waste bins, the House Manager could easily check from the console when the waste is planned to be collected, instead of calling to Waste Management Company. When trucks collect the waste, truck drivers could send real time acknowledgement to the system.

***Question 6:*** *What other use cases you can imagine for the service based on the information available on GUI?*

Interviewees could not imagine any other use cases at this point. Most of them had a vision that reports could be used at closing of accounts to provide households exact data of the amounts and expenses of produced waste.

### 5.2.3 Feasibility within home organization

Home organization means House Manager's own home organization in House Manager Agency.

**Question 1:** *How often you would use the service? If you have already used the service, have you noticed any changes within the use in last 6 months?*

There was a lot of variation in the answers. Some House Managers would use the service only a few times a year and some House Managers estimated monthly usage. Some House Managers would use the service once in a week. One of the House Managers mentioned that their support services could use the service even more often because they receive phone calls from customers and reply their daily questions.

***Question 2:*** *Have you shared the followed waste information within your organization? Would you do so?*

Some House Managers told that their House Manager Agency have several identical real estates to manage. Especially in those cases they could compare the reports.

If it can be shown that waste management costs have been decreased after monitoring system was taken into use, the system brings added value to House Manager Agency. They can use it as a reference when introducing their services to new potential customers. They can introduce that they are doing this kind of monitoring in their real estates and it has brought cost savings to housing cooperatives.

### 5.2.4 Feasibility with customers

Customers mean House Managers' customers like Housing Cooperatives and households.

***Question 1:*** *Have you introduced Waste Flow Monitoring Service to housing cooperative board? Would you do so if you would take the service into use?*

Most of the House Managers would be willing to introduce the service to housing cooperative board. However, some of the House Managers said that they don't see a real benefit for providing housing cooperatives information how many kilograms they have produced waste, if there isn't a direct link to real-time waste collection cycle. In their mind it is actually the waste collection cycle which brings a real cost savings.

***Question 2:*** *Have you used Waste Flow Monitoring Service in the discussions with households? Would you do so if you would take the service into use?*

House Managers saw a benefit for using Waste Flow Monitoring Service in discussions with households. Reports would be a good baseline for discussions. If there is a need for changes regarding real estate's waste management, report provides a good evidence to justify the changes.

***Question 3:*** *Have you found Waste Flow Monitor useful when planning waste collection regularity or when selecting waste bins for the real estates? Would you find it useful if you would take the service into use?*

Almost all the House Managers found Waste Flow Monitor useful when planning waste collection regularity or when selecting waste bins. One example was given: if House Manager sees that there are two bins in waste collection room and report shows that both of them are only half full most of times, it is easy to make a decision that only one bin would be enough. They clearly saw that decisions based on real data are more reliable. One told about experience when he had changed the amount of waste bins based on his instinct, which unfortunately was wrong, so he had to change the old amount of bins back again. However, House Managers mentioned that rental costs of the bin are so low that they don't see much harm if their own estimation goes wrong. But still, some House Managers were willing to always look what is best for customer, even if financial benefit would be minor.

One of the House Managers said that he prefers current method where a member of housing cooperative board checks waste collection room on the day when waste will be collected. Based on his visual observation he informs House Manager if the waste collection cycle is optimal.

### 5.2.5 Feasibility with stakeholders

Stakeholders mean e.g. Waste Management Companies or Service Management Companies to whom the House Managers deal with in their daily work.

***Question1:*** *Have you used Waste Flow Monitoring Service in the discussions with Waste Management Company? If you have, please specify the purpose? Would you do so if you would take the service into use?*

If monitor would also report real time waste collection schedule, it would decrease needs to contact Waste Management Company. When customer calls to House Manager about full bins, the House Manager could check from the monitor that waste will be collected e.g. on the next day and inform customer that issue will be taken care. Currently House Managers call to Waste Management Company to ask additional pick-up.

Some of the interviewees would prefer a business model where Waste Management Company takes care of the monitoring system. In practice the Waste Management Company would actively follow the reports and would suggest changes to waste collecting cycle if they see potential to improve the efficiency.

Sometimes discussion with Waste Management Company concerns about broken bins that need to be renewed, or dirty bins that need to be cleaned. For those issues the reports do not bring any added value at the moment.

***Question 2****: Have you discussed with other stakeholders about Waste Flow Monitoring Service? If yes, what have been the implications? Would you do so if you would take the service into use?*

One interviewee mentioned that if the real estate is very big including many trash bins in the yard, it generates quite a lot of trash when serviceman empties trash bins to real estate's waste collection room. Most likely it will be visible in weekly reports. Waste Flow Monitoring Service could be a discussion topic with Service Management Company.

One of the interviewees suggested that if real estates' housing cooperative boards in the same area are socially active, they could set up a competition to measure which real estate generates the least waste in one specific week. The Waste Flow Monitoring Service could be introduced for that purposes as well.

### 5.2.6 Feasibility and compatibility with other systems

***Question 1:*** *In which other IT systems the Waste Flow Monitoring should be integrated to?*

Many interviewees said that reports generated by the Waste Flow Monitor or the link to Waste Flow Monitoring Service could be attached to a portal which House Manager Agencies provide to their customers. Households could follow their real estate related

information via the portal. Water consumption and waste production information could be in the same portal. One of the interviewees said that it would be great to have kind of RSS feed functionality where person could just click “follow waste information”.

***Question 2:*** *What other reporting needs your organization have related to waste management? To whom you should be able to report regarding waste management?*

Interviewees didn’t see any other reporting needs than reports to housing cooperatives. Waste management details could be added to real estate’s annual report. There is no point to send monthly report to housing cooperative boards or to households but if the information could be easily provided by portal, customers might be interested to follow the reports via the portal.

### 5.2.7 Future development needs

***Question 1:*** *What kind of things you would like to follow with Waste Flow Monitoring Service in addition to things that are already available?*

Interviewees would like to see waste collection interval on the Waste Flow Monitoring console. They would like to see real-time information about waste pick-ups done and the next planned pick-ups.

Interviewees are also interested to follow abnormalities in the waste collection room. House Managers would like to see on the Waste Flow Monitoring console if waste collector has noticed an item that do not belong to waste collection room and requires special services.

Many House Managers would like to see forecasts of real estate’s waste behavior calculated by the system.

As a future development some House Managers are looking for a solution that would change a regular waste collection interval to the need basis waste collection interval. They would like to see Waste Management Companies following the reports in real-time and arranging pick-ups only when needed.

***Question 2:*** *How Waste Flow Monitoring Service could serve you better with waste management planning?*

Waste Flow monitoring system was seen as a supporting tool in waste management planning. However, one House Manager clearly indicated that there should be a connection to waste collection schedule. The system should be tied to bin fill-level monitoring. The system should make sure that bins are not collected when they are half-full.

Most of all the Waste Flow Monitoring Service was seen as a good tool to wake-up households for better waste behavior.

**Question 3:** *How Waste Flow Monitoring Service could serve you better with waste sorting activities?*

Interviewees mentioned that the system does not tell if household puts e.g. glass into mixed waste. The system reports about the weight but it does not monitor what is inside of the bin. Interviewees were not able to identify how Waste Flow Monitor could serve better on that issue.

***Question 4:*** *How cost follow-up could be improved with the Waste Flow Monitoring Service?*

One interviewee reminded that there are house complexes where truck doesn't have access all the way to waste bins. In those cases truck will wait a bit further and waste collector moves bins manually from the waste collection room to the truck. It is special service and causes additional costs to housing cooperative. Those costs should be visible in the tool as well.

So far waste management costs are reasonable compared to other costs in real estates management. One House Manager mentioned an example: The better way to show households decreasing waste amounts is to use example in kilograms. If you tell households that they have decreased waste amounts as size of two trucks it gives a better understanding than telling that waste amount has decreased in worth of 200 euros.

### 5.3 Reliability and validity of research

Trustworthiness is essential character of qualitative research. That's why every researcher should consider the reliability when designing of a study and analyzing the results. Purpose of reliability in qualitative research is to generate understanding for the examined phenomena. Even if repeatability is often associated to quantitative research it applies also to qualitative research with some extents. Reliability proves that findings are repeatable. The same results would be achieved if the study was to be done second time. In qualitative research the role of reliability is more to prove to the readers that results of the study is worth paying attention to. (The Qualitative report, 2003, 599-601.)

Validity of research requires that data collection and analysis are presented transparently and coherently. Validity proves that research really evaluates what it was supposed to evaluate and that the results are truthful. In qualitative research validity is typically improved with triangulation. It combines methods and strengthens the study by proving that same result can be achieved by different methods. (The Qualitative report, 2003, 602-603.)

The thesis complies with definitions above. If House Managers would be interviewed again they would give pretty much the same answers. They might have some new comments or ideas now, when they would see the demonstration second time, but in overall their answers would most likely follow the same pattern. Triangulation was not used in the thesis but on the other hand, saturation proves the validity of research. Similar kind of answers from House Manager after another generated coherent results. That provided a confidence that enough empirical data was gathered and it encouraged to move on analysis part.

# 6 Analysis

Results in previous chapter were analyzed according to analysis method introduced in chapter 5.1. Analysis of the thesis provides answers to main research questions.

## 6.1 Answers to main research questions

Following tables summarize the main findings from the interview results as described in the chapter 5.1. Tables also identify the main target groups who get the benefits. In the tables the interview results have been considered against the theory. Headings in the tables are conducted from the main research questions. Each research question is answered based on the interview results and theory.

Table 1: Value proposition for Waste Flow Monitor.

| Value proposition for Waste Flow Monitor | Target group that receive the added value |
|---|---|
| ▪ Peaks in the produced waste can be followed per real estate. Peaks indicate anomalies compared to average. Anomalies can be identified near real time and actions to find out the reason can be started faster. | House Managers |
| ▪ Reports enable possibility to make accurate conclusions of produced waste and their costs. | House Managers, Housing Cooperatives |
| ▪ Cost visibility might encourage for more efficient recycling. | Housing Cooperatives |
| ▪ Costs saving results support House Manager Agencies in their customer acquisition process. House Manager Agencies can introduce to new potential customers that their agency is using this kind of monitoring which has brought cost savings to housing cooperatives. | House Manager Agencies |
| ▪ Reports provide a guideline when planning the size of real estate's waste collection room. | House Managers, Housing Cooperatives |
| ▪ Reports provide a benefit to House Manager Agency's support services department in their daily work. They receive phone calls from customers and reply their daily questions regarding waste management. | House Manager Agencies |

| | |
|---|---|
| | |
| ▪ Reports enable waste amount and cost comparability between identical real estates. | House Manager Agencies |
| ▪ Reports enable digital follow-up. Reports can be attached to a portal which House Manager Agencies provide to their customers. | House Manager Agencies, Housing Cooperatives |

*What is the value proposal of Waste Flow Monitoring Service?*

- *Do House Managers benefit of the service?*
- *Who else benefits of the service?*

Waste Flow Monitoring Service provides improved reporting possibilities and enables weight-based billing model where each property is charged according to the amount of waste they produce. In Waste Flow Monitoring Service the focus is to provide the right information to the right people when they need it. The value proposal of Waste Flow Monitoring Service is to provide feedback to households and their representatives of the amount of generated municipal solid waste. The Waste Flow Monitoring Service allows House Managers to follow weight and costs of the produced waste per property. Anomalies in the waste producing behaviour can be recognized and House Managers can react to anomalies faster. Households get the main benefit of the service when it encourages them for better recycling which might decrease their waste expenses.

Table 2: Usability and feasibility of Waste Flow Monitor.

| Usability and feasibility of Waste Flow Monitor | User target group that receive benefit from feasibility |
|---|---|
| ▪ Waste Flow Monitor is usable with any device (computer, mobile device) | House Managers, Housing Cooperatives |
| ▪ Graphical user interface is clear and easy to use. | House Managers, Housing Cooperatives |
| ▪ Map gives a clear view of managed real estates. | House Managers |
| ▪ Graphics show the peaks in waste production. | House Managers, Housing Cooperatives |
| ▪ Reports provide information in the same context as water- and electric consumption reports provide. | House Manager Agencies, House Managers, Housing Cooperatives |

| | |
|---|---|
| ▪ Reports enable waste amount and cost comparability between several identical real estates. | House Manager Agencies |
| ▪ Reports provide good evidence to justify the changes in waste management. | House Managers |

*What are the primary use cases for the service?*

- *Who are the stakeholders of the service and for what purposes they use the service?*

Waste Flow Monitoring is a service that waste management companies can offer to their customers. Basically customers are housing cooperatives and households, but because House Managers are representing residences, in practice they are main users of the service. House Managers can follow real estate's waste amount and costs via the Waste Flow Monitoring Service. House Managers can make accurate conclusions based on the information provided by the service and plan both the waste bins collection cycle and the quantity of bins based on that. Reports can be used as an evidence to justify the changes in waste management. House Manager Agencies can use waste flow monitoring reports in their annual reporting to housing cooperatives. House Managers can attach the Waste Flow Monitoring Service to a portal where households can follow the reports similarly as they can follow water and electricity consumption details. Nowadays people are interested of environmental affects and possibility to follow waste amount trends in a weekly, monthly and yearly level most likely is desirable service. People are more conscious to whom they want to do business and functionality of the service really matters. Waste Flow Monitoring Service can also be effective for the waste management organization because it improves predictability of waste collection cycle. That way it can make waste management more efficient.

Table 3: Waste Flow Monitor development needs.

| Development needs | Target group that receive the added value from development |
|---|---|
| ▪ Real-time waste collection interval should be seen on the Waste Flow Monitoring console. The console should show when the waste pick-ups were done last time and also the next planned pick-ups. | House Managers, Housing Cooperatives |
| ▪ Impact of recycling should be shown in total costs. Waste Flow Monitor should show to households what the total costs | Housing Cooperatives |

| | |
|---|---|
| would be if the recycling was done properly versus current recycling behavior. | |
| ▪ If there are clear peaks in waste generation levels, Waste Flow Monitor should have an additional text field which would describe what caused the peak, if the cause is known. | House Managers |
| ▪ Clear comparison to previous year's results should be included in the graphics. When viewing the current report the previous year(s) should always be seen on the background. | House Managers, Housing Cooperatives |
| ▪ House Managers would like to have possibility to update the amount of inhabitants to the Waste Flow Monitoring System, to make sure that it always calculates weight per inhabitant correctly. | House Managers, Housing Cooperatives |
| ▪ House Managers would like to see on the Waste Flow Monitor console if waste collector has noticed an item that do not belong to waste collection room and requires special services. | House Managers |
| ▪ House Managers would like to see forecasts of real estate's waste behavior calculated by the system. | House Managers, Housing Cooperatives |
| ▪ House Managers are looking for a solution that would change a regular waste collection interval to the need basis waste collection interval. House Managers would like to see Waste Management Companies following the reports in real-time and arranging pick-ups only when needed. | House Managers, Housing Cooperatives |
| ▪ Special services which cause additional costs to housing cooperative should be visible in the tool as well. | Housing Cooperatives |

*How the Waste Flow Monitor can serve more efficiently?*

- *What kind of improvement ideas can be found?*

The Waste Flow Monitoring Service could serve more efficiently if the console would show when the waste pick-ups were done last time and also the next planned pick-ups. If the impact of recycling would be shown in total costs, households would see more clearly what the total costs would be if the recycling was done properly versus their current recy-

cling behaviour. Additional items in waste collection room are a typical problem in many housing cooperatives. If Waste Flow Monitor console would notify about the items that do not belong to waste collection room, House Manager could react faster by ordering special services. If the total costs of special services would be visible in the tool, it might encourage households to deliver additional items to the appropriate collection points instead of bringing them into a waste collection room.

### 6.2 Main conclusions

Data which was classified into main types in the previous chapter included interrelations and connections. They are interpreted below as main conclusions.

Comparative reports bring added value to House Manager Agencies who have several identical real estates to manage. House Managers are interested to see if two identical real estates have a lot of variation regarding waste generation. Once problem is noticed they can start actions to find out why one real estate produces waste more than the other. Comparability was also seen as a part of usability because of its easiness. To improve reliability of compared results, the Waste Flow Monitor should indicate if one real estate has some special services which cause additional costs. There should also be possibility to update the amount of inhabitants into the system, to make sure that results are comparable.

Graphics that show the peaks in waste production were seen as easy to use and they provide added value. House Managers can follow more efficiently anomalies compared to average. They can start needed actions immediately when they see peaks in waste producing without known reason. However, there is still a clear need for improvement. If the reason for the peak is known, there should be an additional text field which would tell the reason. E.g. if there is a peak in week 38, there could be a text: “Housing Cooperative’s work party to clean up real estate’s yard”. House Managers will save time if they don’t have to check from other sources what might have caused the peak.

House Managers saw a benefit for using Waste Flow Monitoring Service in discussions with households and housing cooperative boards. If there is a need for changes regarding real estate’s waste management, report provides a good evidence to justify the changes. That was seen from feasibility perspective but on the other hand also from added value perspective. A need for a change can be noticed faster. As an improvement the Waste Flow Monitor should inform also about items that do not belong to waste collection room

and require special services. Items that do not belong to waste collection room are most usual topics to be discussed with households.

Reports provide added value when the size of real estate's waste collection room is planned. From feasibility perspective report provides a good evidence to justify the resizing of waste collection room. However, the improvement which would change a regular waste collection interval to the need basis waste collection interval would optimize usage of waste collection room in most efficient way.

From feasibility perspective House Managers noticed that reports provide information in the same context as water- and electric consumption reports provide. In terms of added value House Managers mentioned that reports could be attached to a portal which House Manager Agencies provide to their customers. Households could follow their real estate related waste information via the portal in a similar way as they can follow water- and electric consumption.

# 7 Development ideas

Analysis of the results gave the meaning for the data. Results indicated clear development ideas for the service. New requirements may lead to new business opportunities and might affect to smart waste evolvement in larger scale.

## 7.1 New requirements for the service

Qualitative research conducted following requirements for the Waste Flow Monitoring Service (table 3).

- Real-time waste collection interval shall be seen on the console
- Impact of recycling shall be shown in total costs
- Additional free text field shall be available in week view
- Graphics shall have comparison to previous year(s) in the background
- House Managers/administrative users shall have possibility to update the amount of inhabitants
- Problems in waste collection room shall be reported on the console (e.g. items that do not belong to waste collection room)
- System shall calculate the forecast of real estate's waste behavior
- System shall optimize waste collection interval to correspond need basis interval
- System shall show cost breakdown including also the special services

New features mentioned above can accelerate the deployment of the service because they provide more added values for the usage. House Managers do not need to call to Waste Management Companies that often if they can check basic things like waste collection schedule digitally. Households' motivation for recycling will increase when they see clearly the impact of recycling in total costs. Additional waste won't be accumulated to waste collection room because House Manager gets the information immediately and can arrange a pick-up. When households see more clearly the price of special services, the amount of additional waste in the waste collection room might decrease. Once the system calculates the forecast for the coming year automatically, the amount of waste bins and waste collection interval can be optimized more efficiently. Implementation ideas for the new requirements are introduced in appendix 3.

### 7.2 Business potential with new features

New features bring more added values to House Manager Agencies. The more cost savings they can show to households via Waste Flow Monitoring System, the more attractive House Manager Agency becomes when housing cooperative boards renew their deals.

Waste Flow Monitoring Service is considered also as socially responsible service. It encourages households for recycling, especially if impact of recycling can be better shown in total costs. Recycling keeps materials' circulation on-going which also brings business value in larger scale. Circulation brings material back to industry. Material can be reused as a raw material for industrial needs. Nowadays households are more conscious to whom they want to do business. Social responsibility aspect cannot be overlooked.

The service would fit perfectly to Waste Management Companies' product portfolio. They could be the ones who provide the service to their customers. Waste Management Companies have the source data to be analyzed by Waste Flow Monitoring Service. System integration would be up to Waste Management Company. By the help of Waste Flow Monitoring Service they can improve their customer experience and build sustainable relationships with customers. Once customers notice that they can get reports of produced waste and they get financial benefit when they are charged based on the weight of the waste, they are not that willing to change the Waste Management Company.

Waste Management Company gets valuable information of the municipal solid waste by following the trends in reports. If they can motivate households for better recycling it makes their work easier and more efficient. Better recycling behavior can increase Waste Management Company's capability to provide material for industry needs.

New features in the Waste Flow Monitor allow better interaction between Waste Management Company and customers. If users are able to add free text to the system regarding known peaks in the waste production, it could be a channel to order extra pick-ups or add temporary additional capacity to a waste collection room.

Waste Flow Monitoring Service provides data of waste producers' behavior. It will be valuable source in the future when Big Data analytics are used more comprehensively. Data of generated waste can be used as one factor to improve operational efficiency. Reasons behind waste producers' behavior can be seen more clearly when other parameters are added to the data of generated waste. One example of other parameters could be weath-

er data. Big Data analytics could show, for example, do the weather conditions have impact to the amount of generated waste.

# 8 Discussion

The topic of the thesis was actual and had a clear connection to every-day life. The topic broadened my personal understanding of waste management. Because of my ICT background I was very interested in seeing how IT can improve waste management efficiency and how digital platforms can be used to provide better service to customers. The thesis process was very inspiring because I had chance to discuss with Aalto University's Chief Research Scientist Ari Serkkola about waste management and technologies around it. I got an opportunity to familiarize myself to Waste Flow Monitoring Service and I really enjoyed discussing about the service with House Managers. I noticed how important it is to go on the field and see the reality of House Managers' daily work regarding waste management. Because of their professionalism I was able to get valuable information how waste management services should be improved. The thesis progressed according to plan but I had to use a bit more time as expected because I didn't have any previous experience of waste management.

The research method was efficient and it fit to the purpose. Demonstration screenshots that were used in the interview gave very practical approach to the subject. Most of the House Managers were delighted to see that Waste Flow Monitoring Service already exists and it is not just something sketched on the paper. Most of the interviews were one-to-one meetings. Only one of the interviews was focus group consisting of two members. One-to-one interview was easier to moderate because the discussion did not meander to the topics that were not relevant. However, even though discussion in the focus group expanded to wider topics around waste management, it appeared to be more efficient method because interviewees compared their own opinions and found new dimensions to the discussion. The challenging part in the research was to find House Managers who had time for the interview. Interviews were done during March and April 2016 which was the busiest time for House Managers because of the ongoing closing of accounts period.

Results of the thesis are very valuable. Results are unambiguous and they are useful for later research and development purposes. Results conducted very practical examples how Waste Flow Monitoring Service could be developed further. Results also provided more information about House Managers' needs and expectations for future waste management services.

The thesis project has increased my personal theoretical knowledge how to execute a research. The terminology related to the topic was quite easy to understand and when studying the theoretical sources it was easy put each term at a right context. My personal

motivation for the thesis subject was high. I'm very interested to see how technology can support consumers in daily routines and at the same time reduce the usage of natural resources.

The thesis started in January 2016 when I met Haaga-Helia's Principal Lecturer Jouni Soitinaho and Jatta Jussila-Suokas, Director of Innovation at Haaga-Helia University of Applied Sciences. We discussed about potential thesis topic in ARVI research program because I had indicated my interest to write my thesis around circular economy, which I had studied recently. As an outcome of the meeting I had chance to meet Aalto University's Chief Research Scientist Ari Serkkola and Research Assistant Abel Terefe. They introduced me the Waste Flow Monitoring Service and we agreed the approach for the thesis. Ari Serkkola and Jouni Soitinaho have been reviewing the thesis during the thesis process and have guided to the direction which fulfills the requirements of scientific study. The thesis was ready for grading in September 2016.

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## Appendix 1 Interview questions

### Data content of the Waste Flow Monitoring server

1. What kind of things you can or cannot follow with Waste Flow Monitor at your real estates?

2. What kind of conclusions you can or cannot make based on the weight of the waste at your real estates?

3. What kind of conclusions you can or cannot make based on the costs of the waste at your real estates?

4. What is the main benefit of the Waste Flow Monitoring Server at your real estates?

5. What kind of waste related issues cannot be solved with Waste Flow Monitoring?

### Usability of Waste Flow Monitoring GUI

1. What are the most important features in Waste Flow Monitoring user interface?

2. What are less important features in Waste Flow Monitoring user interface?

3. What is the most useful time related parameter: week, month or year?

4. What is the least useful time related parameter: week, month or year?

5. What features are missing from Waste Flow Monitoring user interface?

6. What other use cases you can imagine for the service based on the information available on GUI?

**Feasibility within home organization**

1. How often you would use the service? If you have already used the service, have you noticed any changes within the use in last 6 months?

2. Have you shared the followed waste information within your organization? Would you do so?

**Feasibility with customers**

1. Have you introduced Waste Flow Monitoring Service to housing cooperative board? Would you do so if you would take the service into use?

2. Have you used Waste Flow Monitoring Service in the discussions with households? Would you do so if you would take the service into use?

3. Have you found Waste Flow Monitor useful when planning waste collection regularity or when selecting waste bins for the real estates? Would you find it useful if you would take the service into use?

**Feasibility with stakeholders**

1. Have you used Waste Flow Monitoring Service in the discussions with Waste Management Company? If you have, please specify the purpose? Would you do so if you would take the service into use?

2. Have you discussed with other stakeholders about Waste Flow Monitoring Service? If yes, what have been the implications? Would you do so if you would take the service into use?

**Feasibility and compatibility with other systems**

1. In which other IT systems the Waste Flow Monitoring should be integrated to?

2. What other reporting needs your organization have related to waste management? To whom you should be able to report regarding waste management?

**Future development needs**

1. What kind of things you would like to follow with Waste Flow Monitoring Service in addition to things that are already available?

2. How Waste Flow Monitoring Service could serve you better with waste management planning?

3. How Waste Flow Monitoring Service could serve you better with waste sorting activities?

4. How cost follow-up could be improved with the Waste Flow Monitoring Service?

## Appendix 2 Interviewees (confidential)

## Appendix 3 Implementation ideas for the new requirements

From development perspective it still needs to be clarified how the new requirements shall be implemented. Most of the requirements are tied to information which is provided by Waste Management Company. E.g. information of real-time waste collection interval comes from Waste Management Company. They should provide regular schedule and if there are changes, the latest updates should be sent to the system. Most likely Waste Management Companies have their own systems to manage the schedules. Waste Flow Monitoring Server could get the updated schedule via API (Application Programming Interface). It would enable http-based push notification to a mobile application when there are changes in the schedule. If there is a change in schedule, the information would be sent to Business Logic which would send push notification to the mobile application. In practice, users would get e.g. notification “Bins collection cancelled today. New collection day is 27.5.2016.” Following diagram introduces the architecture in general level. Diagram is not based on real architecture of Waste Flow Monitoring System or real architecture of Waste Management Company’s Scheduling System because details are not known.

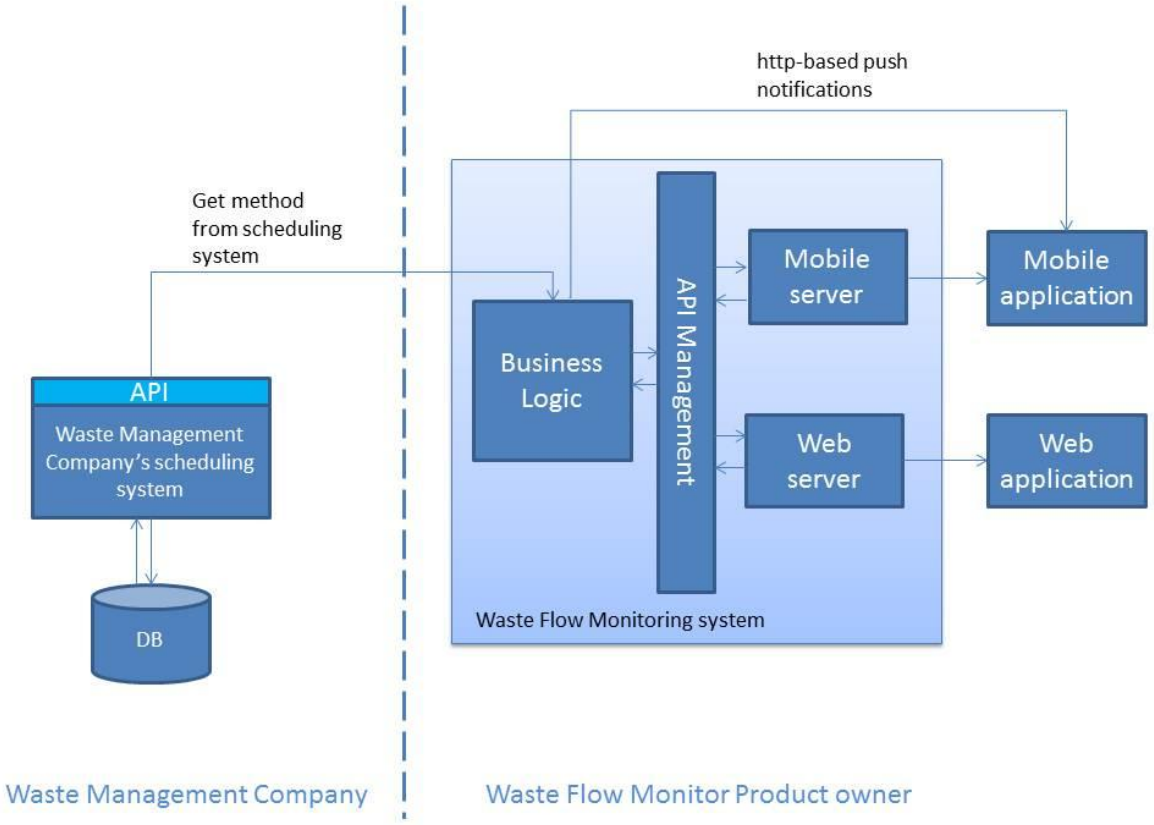


Figure 20: Example of architecture.

Impact of recycling should be shown in total costs. Waste Flow Monitor should show to households what the total costs would be if the recycling was done properly versus current recycling behavior. Functionality should be based on calculation. The system should calculate the most optimized costs based on the weight of the waste, amount of inhabitants and assumption of recyclable items in mixed waste. The system could provide the forecast what the total costs would be with proper recycling. However, the result would not be accurate because it is difficult to estimate how many items in mixed waste really are recyclable.

Additional free text field for the week view could be implemented but the usage of the text field might be problematic. Current solution provides information to users but does not allow them to add or modify any information. Process should be defined carefully. Who are administrative users that can add information to Waste Flow Monitoring System? Are they House Managers or members of housing cooperative boards? Who is responsible for keeping additional information up to date? All those questions have to be considered.

Comparison to previous years' results in the background can be implemented rather easy. It is just a matter of calculation done by the system. At the moment graphics show the average in the background. It might be a bit challenging to add previous years' results on the graphics so that they are readable on the screen and do not mix with the actual and average data. The following diagram shows the current implementation. Average can be seen with gray color in the background.

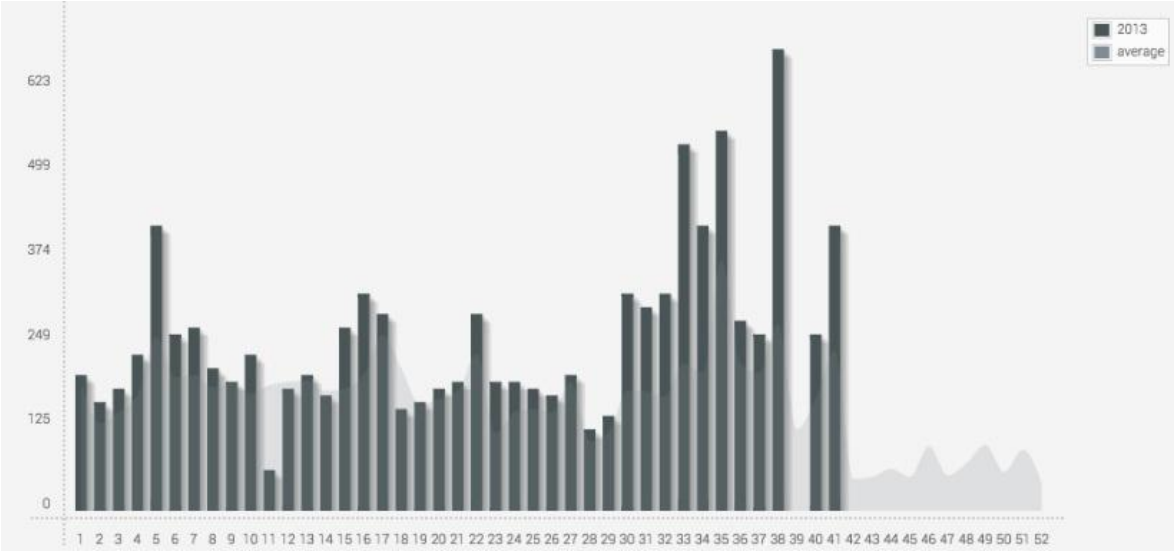


Figure 21: Actual and average kilograms of waste per week within one year.

An administrative right to update the amount of inhabitants is very important feature. It supports reliability of the data. House Managers are the persons who get the information

when people are moving in or moving out of the real estate. House Manager would be a right person to keep the information up to date in the system.

Items that do not belong to waste collection room could be identified by the waste collector. He/she could send the update to Waste Flow Monitoring System that additional items noticed in the room and special services required. Whenever additional items are noticed in the room, the notification should be sent to House Manager either by http-based push notification to the mobile application or by SMS or email. For the email option the system should be integrated to mail server. For the SMS option system requires SMS gateway. Following diagram introduces the architecture in general level. Diagram is not based on real architecture of Waste Flow Monitoring System or real architecture of Waste Management Company's Scheduling System because details are not known.

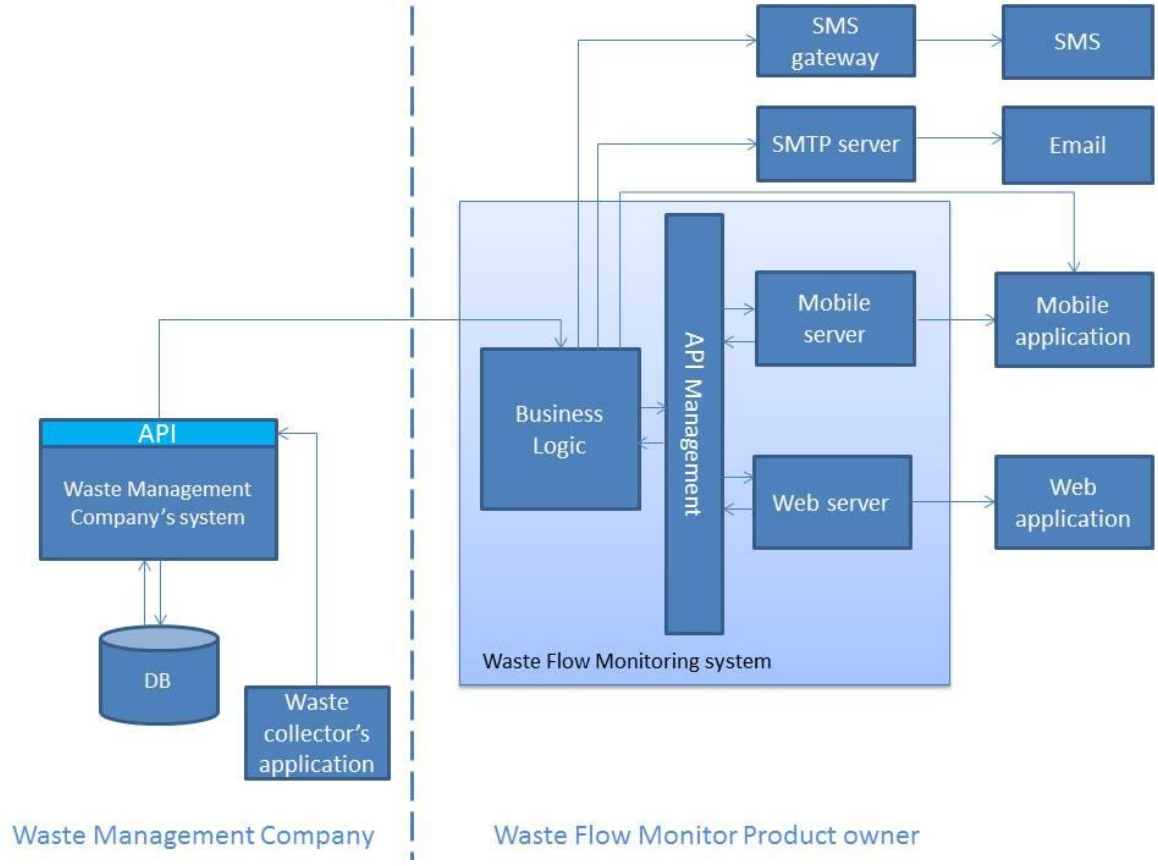


Figure 22: General level example of notification services.

System could calculate the forecast based on real estate's waste behavior. System has all the needed information for calculation. Forecast could be used as a guideline but it does not mean that waste behavior remains the same as it was in previous year.

It might be a bit challenging to build a process that would optimize waste collection interval to correspond need basis interval in real time. In practice it would mean that either Waste Management Company should follow reports actively and create their waste collection routes based on that, or House Managers should follow the reports actively and constantly adjust the collection interval. The first option would require a lot of resources from Waste Management Company and the latter option would cause a lot of extra work for House Managers. Most likely Waste Management Companies are not that agile that they could even accept constant changes in the collection interval. To make need basis interval happen in real time there should be improved automation in the background and also sensors to follow bins fill-in levels.

System could show costs breakdown if it can get all the needed data from original sources. If original sources can provide API (Application Programming Interface) Waste Flow Monitoring Service can get the data and use it for calculations. The data could be seen on the report e.g. by separating different costs with different colors. At the moment graphic shows only the handling costs of the waste based on the weight. On top of that there could be delivery costs per month and also special services per month marked with different colors. The following diagram shows the current implementation.

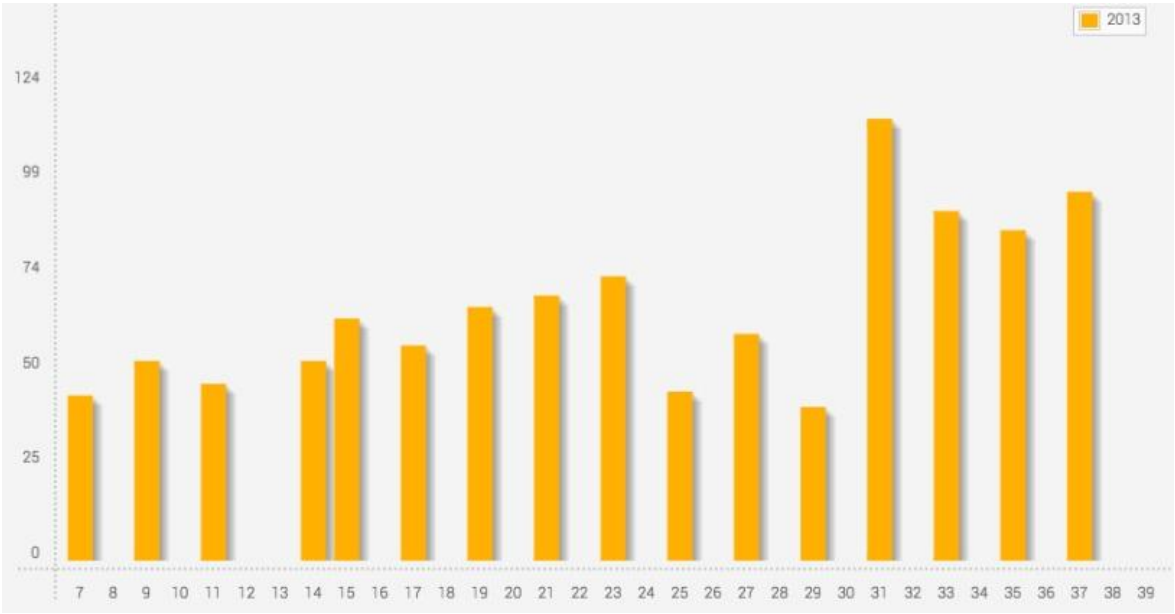


Figure 23: Actual cost of waste based on the weight within one year.