Chapter 1
Users or Taxpayers? Drafting a Pay-As-You-Throw Programme for Madrid's Districts

R. del-Amo and R. Carrasco-Gallego

Abstract Most Spanish municipalities, including Madrid, cover the costs of their waste management programmes through fixed fees or directly from taxes, regardless of the amount of waste generated in each household. In this study, we investigate the features of variable fee schemes for municipal solid waste services and we identify two successful European case studies of pay-as-you-throw systems. Next, we set the foundations for the design of a variable rate pricing system in Madrid, complemented with a survey capturing some key aspects required to gain citizenship acceptance. The results show that approaching waste services design from an usage perspective, just like other utilities, such as electricity or gas, provides economic incentives for waste prevention and recycling increased rates, and it is aligned with the European objectives of diverting waste from landfills.

Keywords Municipal solid waste (MSW) · Circular economy · SDG 11 cities

1.1 Introduction

The rise of Municipal Solid Waste (MSW) in large cities such as Madrid leads to more complex management and treatment system. The increase in MSW generation is mainly due to overpopulation society, economic growth and higher consumption rates [5]. The latest report on MSW generation by the Spanish Ministry of Ecological Transition (MITECO) [8] shows that each citizen produced in average 385 kg of waste that year, which 65% ended in landfills, 18% in energy valorization treatment plant and only 13% was recycled in 2016. The actual solid waste management in Madrid is not only unsustainable but also it has led to many issues between municipalities within the region.

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In this context, it is of pivotal importance to move from a linear to a circular economy with the aim of understanding waste as a resource, encouraging its prevention and source separation activities. The European Union has recently issued a number of new ambitious goals dealing with MSW management:

1. "Member States shall take the necessary measures to ensure that by 2035 the amount of municipal waste landfilled is reduced to 10% or less of the total amount of municipal waste generated (by weight)". (Directive 2018/850 on the landfill of waste)
2. Increasing recycling rates for 2025 by weight for specific materials in packaging waste; 50% of plastic; 70% of glass; 75% of paper and cardboard; 50% of aluminium; 70% of ferrous metals. (Directive 2018/852 on packaging and packaging waste)
3. Member States must take measures to prevent waste generation such as promote sustainable production and consumption models, re-use of products or encourage the reduction of food waste in households. (Directive 2018/851 on waste and Directive 2018/852 on packaging and packaging waste).

In order to achieve these goals, member states are allowed and encouraged to use economic instruments, for instance landfill and incineration fees or Pay-As-You-Throw (PAYT) schemes.

A research carried out by the European Environment Agency in 2016 shows that PAYT programmes help to reach a recycling rate up to 45% of the total MSW generated [4]. In PAYT systems, citizens are charged a variable fee for the amount of residual waste, either on the volume or on the weight, thrown away. These programmes create a direct economic incentive to prevent waste, to foster re-use, refurbishment and recycling and to apply the "polluter pay" principle [13]. The most common charge method for financing the waste management system in Spain is through a flat rate scheme in which the fee is applied independently of the amount of waste generated, so it does not provide any incentive to reduce the waste or recycle [9].

The structure of the paper is as follows. Section 1.2 describes the objectives and methods applied to conduct the research. Section 1.3 carries out a literature review to describe the state of the art on PAYT programmes. Section 1.4 proposes an approach for implementing a PAYT system in Madrid, while Sect. 1.5 describes the results of a survey on citizenship willingness to accept a variable charge for MSW management. Finally, the most relevant conclusions of this research are provided in Sect. 1.6.

1.2 Background and Methodology

Researchers have found that MSW generation is one of the most challenging issues that urban areas must face due to the large and non-stop increasing amounts of

household waste [1]. This research studies an economic incentive known as pay-as-you-throw, designed to encourage citizens' awareness on the amount of waste they generate and to promote a more sustainable use of resources.

The methodology used in this research is based on two main approaches. First, a literature review followed by a comparative case study research in which we study the best practices found after implementing the PAYT system. Secondly, a survey has been designed and delivered to Madrid citizens to quantify the environment awareness among the population as well as the PAYT programme acceptance might have, once it is implemented.

1.3 Literature Review and Benchmarking

This chapter further analyses the actual context and legislation regarding MSW in Europe through a literature review approach and a case study research in which we describe the best practices and results found after applying the PAYT system (Fig. 1.1).

The figure above describes the amount of MSW generated (kg per inhabitant) in EU-27 and in Spain in 2018 (Eurostat). Even if the total amount of waste produced was similar, the proportion that ends up in landfills differs significantly (23.6% in the 27 European countries while 50.1% in Spain). Madrid's city performance is below average in the Spanish context: the latest available data show that in 2016 landfills received the amount of 2.5 millions of tonnes of household waste (65% of the total MSW that was produced in Madrid city centre) equivalent to 342 times Eiffel Tower's weight.

The European Union has approved the restriction of waste landfilled up to a 10% of the total amount generated for all member states by 2035. This new legislation aims

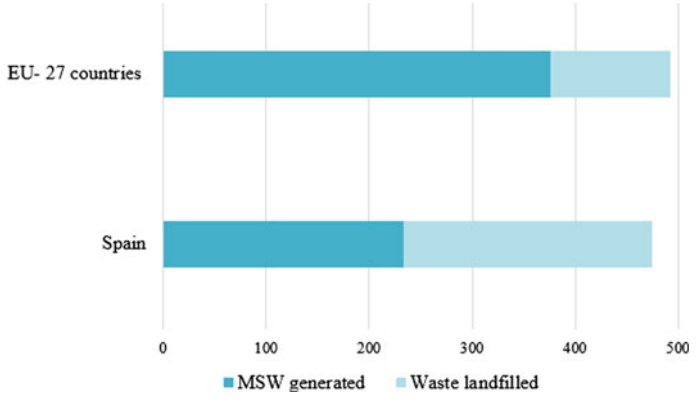

Fig. 1.1 MSW generation and disposal in landfills (kg per inhabitant) in European member states and Spain in 2018 (own development from Eurostat database)

Fig. 1.2 Waste management hierarchy (Directive 2008/98/CE on waste)

at enforcing society to follow the waste hierarchy proposed in Directive 2008/98/CE (shown in Fig. 1.2), which has revealed an effective strategy to achieve several goals in terms of waste management.

The PAYT system is considered an economic incentive that follows the waste hierarchy in which it promotes "the best waste is no waste" through reinforcing prevention. This system lies in applying a proportional fee based on the amount of waste that a citizen generates and therefore the corresponding service obtained for its management. The most common methods to define the service fee are [3]:

1. Volume based (container volume): size of the container
2. Weight based
3. Pickup frequency based: actual number of emptying the container
4. Volume based (actual volume collected).

Once the fee has been defined, how to identify the user that throws the waste is the next step. To do so, there are many ways, for instance using a RFID access card to open the container, identifying the individual containers if the fee is defined based on the pickup frequency or its size. Another method is using standardized bags for the fraction of waste the system charges (option 4, volume-based fee) [13, 9].

The different waste fractions are paper and cupboard, glass, packaging, organic and residual. Researchers have found that charging the amount of waste that goes to residual fraction[1] and providing the others free of charge is the best way to encourage not only reduction of residual waste but also to improve the source separation activities [2].

Some undesirable practices or behaviours would come up after applying this system such as illegal dumping or disposal the waste in the wrong fraction container because is free of charge. However, surveys showed low actual incidence of illegal dumping problems [6].

[1] Residual waste is the fraction of solid waste that is non-compostable and non-recyclable. Therefore, it ends in sanitary landfill.

This research identifies, through a case study approach, two regions that have achieved the best results after applying the PAYT system. Firstly, the region of Flanders in Belgium where the recycling rate have been increased to a 51%; the landfill rate decreased to a less than 1% and prevention have been encouraged through this system due to the reduction of 10% of total waste generation in 4 years (Public Waste Agency of Flanders).

The second region that has been analysed is Aschaffenburg in Germany that achieved a 74% recycled rate and 0% landfill rate, and the 86% of the total MSW generated came from selective collection which means that the citizens in this region actively participate in recycling their waste.

Therefore, we can conclude that applying a PAYT system not only improves the recycling rate but also promotes awareness of environmental protection with the aim of reducing waste generation and its disposal in the right container.

1.4 Madrid Implementation Proposal

As the capital city of an EU-27 member state, Madrid must accomplish the ambitious goals in terms of waste diverted from landfills set up in the new directives. However, our review on the current solid waste management system shows that holistic policies encouraging the waste hierarchy are still lacking. The local government has made some improvement in the last two years regarding selective collection and encouraging prevention through communications campaigns. In addition, separate collection for organic waste has been gradually introduced in Madrid's 21 districts in order to increase the composting treatment rate, which at the same time improves the amount of MSW diverted form landfill. However, the percentage of organic waste is roughly 30% of the MSW weight [7], so additional measures will be required to reduce the amount of waste that ends in landfills even more significantly. Thus, the implementation of a PAYT scheme is proposed in this context.

The PAYT system that we proposed is based on charging a variable fee depending on the amount of waste thrown into the residual fraction container (orange bin), meanwhile the other fractions remain free of any charge (Fig. 1.3). This decision is made due to the outcomes of many researches in which the authors highlight that is

Fig. 1.3 Selective waste containers in Madrid (own development)

the best way to reduce waste generation and improve source separation activities [2] and because of our conclusion in Chap. 3 after studying the PAYT system that have been already running in different countries.

To determine the most effective way to identify the user and measure the waste, it is required to study the current waste collection system in the city. As of November 2020, there are two ways of household waste collection in Madrid either through large containers placed in the street (800, 2400 or 3400 L) or through door-to-door collection with small or individual containers (120, 240 or 320 L). Madrid's citizens are encouraged to participate in the selective waste collection through the use of selective waste (large and individual) containers shown in the Fig. 1.3.

The method proposed to identify the user in a large container is with RFID access card to open the dumpster. In order to measure the waste, the container must be equipped with a weight sensor. The process is depicted in Fig. 1.4a.

Regarding the door-to-door collection, we propose to identify the small container through a barcode tag and measure the waste by the size of the container (volume-based fee). Therefore, the charge is calculated according to the container's volume times the pickup frequency (Fig. 1.4b). For instance, in a building in Madrid City centre equipped with a 240-L container, the fee will be more expensive than in the case of a 120-L container.

In order to prevent undesirable behaviours, the following actions could be applied: firstly, providing all containers with electronic locks and weight sensors to keep track of the amount of waste that a citizen throws in each container. Doing so, we are able to calculate the average waste that is dumped in each fraction and identify the users that are throwing a significant deviate quantity from the mean. For instance, if the average amount generated is 385 kg/inhabitant per year in which 33% corresponds to food

Fig. 1.4 **a** PAYT implementation for large containers in Madrid (own development) and **b** PAYT implementation for door-to-door collection in Madrid (own development)

Fig. 1.4 (continued)

waste that must go to organic fraction container and if a household is throwing nearly 70% to this container, it might be the case of an undesirable practice in which the citizen throws organic and residual waste into the same container in order to avoid the charge placed for residual fraction. Secondly, encouraging waste collectors to found and notify unwelcome behaviours. Thirdly, promoting awareness campaigns about the importance of every action made.

Since the proposed PAYT system directly engages Madrid's citizens, it is reasonable that prior to the implementation, the local government should give the society the possibility of expressing themselves about the system. Hence, changes on the current regulation and logistic processes of collective MSW are needed. Researchers agreed that the steps that should be followed before implementing a PAYT are the following [10]. Firstly, consult citizens' opinion through for instance a citizen participation forum which could lead to Changes on legislation (taxes). Study and implementation of the best technical and logistic solution. After that one of the most important stages is the communication campaign. Later on, the local government should select one area or district to start implementing the PAYT with the aim of monitoring and controlling any problem that might happen. Figure 1.5 shows an estimation about the duration of each phase.

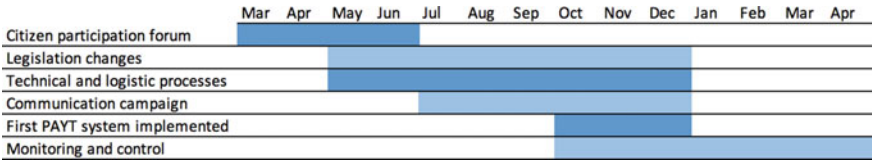

Fig. 1.5 Stages (adapted from Puig Ventosa et al. [10])

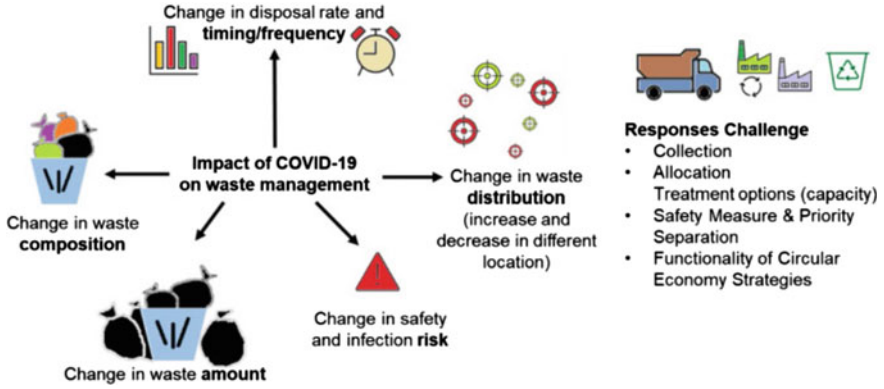

Fig. 1.6 Impacts and challenges of COVID-19 on waste management [11]

As of November 2020, there are several regions in Spain in which the PAYT system has been successfully implemented. Those are mainly in Catalonia (15 districts) and in the Balearic Islands where the PAYT has been implementing progressively through all the regions.

The COVID-19 pandemic has brought us new challenges for solid waste management such as the significantly increase in medical waste, toxic residues, plastic packaging, single used items such as masks, gloves or hand sanitizers. For instance, the medical waste in China (Hubei Province) has increased by 600% from 40 tonnes per day to 240 tonnes [12]. Researchers have found that common plastic packaging waste (PP, PET, etc.) is likely to continue increasing due to online shopping [11]. Therefore, now more than ever we do need a change to improve the efficiency of the MSW system and spread awareness about the huge impact of our waste. Figure 1.6 shows the impact and challenges that waste management systems have been facing due to the pandemic.

1.5 Survey Results

A survey has been conducted to quantify society's environmental concerns and PAYT acceptance. The survey has been delivered to Madrid's citizens mainly through social media platforms. Even though these platforms are more frequently used by millennials, we have obtained answers from different ages. Figure 1.7 shows the age ranges of the interviewees. Respondents were anonymous, so personal data were not collected during the surveying process. The purpose of the study was clearly described in the heading of the questionnaire and respondents consented the use of their responses for that purpose.

Two hundred seventy-eight answers were received in a two-week time frame. The major outcomes of the survey are: first is the rise of environmental concerns due to

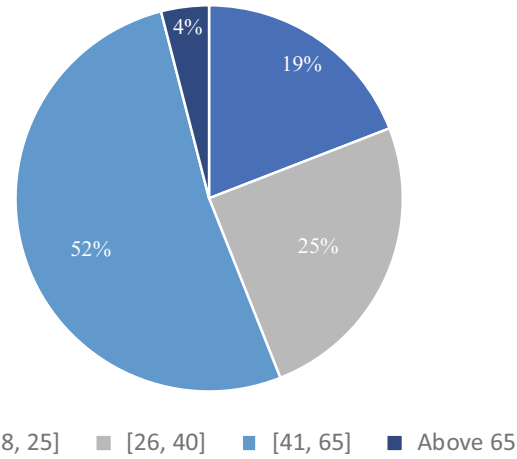

Fig. 1.7 Interviewees' age range (own development)

the high percentage obtained about "How important is environment protection for you?" with nearly the 100% (97%) answering "high relevance". Second, the 97% respondents claimed that they ignore any information regarding waste management in Madrid (recycling rate; collection and treatment costs; landfill rates). Third, the 65% replied that they consider it reasonable to apply a "pay-as-you-throw" and "polluters pay" principles. Lastly, the following question was asked "Why do you think some citizens tend to not recycle their domestic waste?" and 50% replied that the waste system is not trustful meaning that they recycle doing the source separation activities but ignore what happens with their waste if, for instance, was finally recycled or landfilled.

Survey results show that a relevant share of citizens distrusts Madrid's MSW management system, and most of them ignore the costs and results that come out from waste treatment and collection. Local authorities could possibly increase their transparency and communication efforts in this regard.

1.6 Conclusions

Through our work, we have identified a complex and unsustainable situation in Madrid concerning municipal solid waste management. PAYT system has been identified as one of the possible courses of action that, combined, could address this challenge. Variable fee schemes significantly improve recycling rates while reducing the waste dumped to landfills. Since PAYT systems price the service depending on the amount of waste thrown away, users have a clear economic incentive to prevent waste generation and engage in source separation activities. PAYT is a transparent and fair system that applies the principle "polluters pay" and transfers the costs of waste collection and treatment services from taxpayers to users. However, it is not

exempt of difficulties in its implementation such as free-riding behaviours, impact on low-income households, waste management costs distribution in residents' associations and acceptance of a variable fee by citizenship in general (that currently show a very scarce knowledge on their MSW system as the survey results reveal). Those challenges will be further researched in upcoming studies.

Compliance with Ethical Standards The Ethical Committee for Research Activities at UPM ("Comité de Ética de actividades de I + D + i de la UPM", https://www.upm.es/Investigacion/soporte/ComiteEtica) approves the survey procedure conducted in this research. No personal data of the respondents of the survey were collected or treated (survey respondents were anonymous); hence, there is no need for a particular reference for the authorization for the experiment, as mentioned in the waiver (MOD.6 Identificación de Cuestiones Éticas en los Proyectos, Contratos, Subvenciones o Colaboraciones).

References

1. Al-Khatib IA, Monou et al (2010) Solid waste characterization, quantification and manage ment practices in developing countries. A case study: Nablus district–Palestine. J Environ Manag 91(5):1131–1138
2. Connett P (2013) The zerowaste solution: untrashing the planet one community at a time. Chelsea Green Publishing
3. Dohogne J-J (2014) Waste management costs & financing and options for cost recovery
4. Environment European Agency (EEA) (2016) Municipal Waste Management across European Countries
5. Guerrero LA, Maas G, Hogland W (2013) Solid waste management challenges for cities in developing countries. Waste Manage 33(1):220–232
6. Hogg D, Wilson D et al (2006) Modelling the impact of household charging for waste in England. Department for Environment Food and Rural Affairs (defra). Eunomia Research and Consulting Ltd
7. Madrid City Council (2019) Estrategia de Prevención y Gestión de Residuos
8. MITECO, Ministry for Ecological Transition and Demographic Challenge (2016) Memoria annual de generación y gestion de residuos de competencia municipal
9. Puig-Ventosa I (2008) Charging systems and PAYT experiences for waste management in Spain. Waste Manage 28(12):2767–2771
10. Puig Ventosa I, Calaf Forn M, Mestre Montserrat M (2010) Guía para la implementación de sistemas de pago por generación de residuos. Agència de Residus de Catalunya
11. Sharma HB, Vanapalli KR, Cheela VS, Ranjan VP, Jaglan AK, Dubey B, Goel S, Bhattacharya J (2020) Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic. Resour Conserv Recycl 162:105052
12. Van Fan Y, Jiang P, Hemzal M, Klemeš JJ (2020) An update of COVID-19 influence on waste management. Sci Total Environ 754:142014
13. Zeschmar-Lahl B, Schoenberger H et al. (2016) Background report on best environmental management practice in the waste management sector. Report for the European Commission's Joint Research Centre, Seville