**Abiola Rukayat Akamo Alimi**

# Visão geral de Pay-As-You-Throw (PAYT) no mundo: Oportunidades e desafios

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisites necessários à obtenção do grau de Mestre em Estudos Ambientais, realizada sob a orientação científica da Doutora Ana Paula Duarte Gomes, Professora do Departamento de Ambiente e Ordenamento da Universidade de Aveiro.

Dissertation submitted to the University of Aveiro for the fulfilment of the necessary requirements to obtain the degree of Master in Environmental Studies. This dissertation was conducted under the supervision of Professor Doctor Ana Paula Duarte Gomes, Assistant Professor from the Department of Environment and Planning of University of Aveiro.

**o júri / the jury**

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*— To the memory of my dear Dad.*

"A clever person solves a problem. A wise person avoids it."
— Albert Einstein

**Palavras-chave** Incentivos Económicos, Pay-As-You-Throw, Princípio do Poluidor-Pagador, Gestão de Resíduos Urbanos, Resíduos Alimentares Domésticos, Reciclagem.

**Resumo** Atualmente existe legislação rigorosa na área do ambiente, que visa proteger o meio ambiente de vários impactes negativos, associada à crescente preocupação sobre o consumo de recursos, bem como ao desenvolvimento económico. Estes são os principais impulsionadores para que cada vez mais países se esforcem em reduzir a quantidade de resíduos enviados para os aterros e em aumentar as taxas de reciclagem. Além disso, tem havido esforços concertados, não só na redução do aumento incessante da produção global de resíduos, mas também na sensibilização dos cidadãos relativamente à necessidade de prevenir a geração de resíduos. Neste sentido, tem sido preocupação em todo o mundo, a exploração e aplicação de várias medidas. Além disso, diferentes países têm vindo a rever os mecanismos financeiros de gestão de resíduos, passando a ter em consideração a política ambiental. Por norma, os pagamentos de impostos e de taxas, são usados por muitos países para financiar os serviços de gestão de resíduos. Esta abordagem não é suficientemente justa para fornecer uma ligação objectiva entre a produção individual real de resíduos e os custos cobrados pela sua correta gestão. Como resultado, os cidadãos têm pouco ou nenhum incentivo motivacional para estarem conscientes da quantidade de resíduos produzidos. Uma abordagem alternativa para isso é o sistema de pagamento diferenciado, do serviço de gestão de resíduos, conhecido como pay-as-you-throw (PAYT). O sistema PAYT tem sido alvo de crescente atenção, pois ele contribui para a redução de resíduos gerados, devido à justa proporcionalidade entre os custos de gestão de resíduos e a quantidade de resíduos produzidos. Esta dissertação apresenta uma visão geral do sistema PAYT em todo o mundo. O principal objetivo desta dissertação é analisar as oportunidades e desafios do PAYT no mundo, de modo a estudar sua eficácia, não apenas na redução de resíduos, mas também em oferecer justa proporcionalidade entre os custos de gestão de resíduos e a quantidade real de resíduos produzidos. Para atingir os objetivos propostos, a dissertação apresenta resultados da pesquisa realizada sobre a gestão municipal de resíduos em algumas partes do mundo. Além disso, a dissertação enfatiza os efeitos dos diferentes sistemas municipais de cobrança do serviço de gestão de resíduos nos esforços dos municípios e munícipes na separação para reciclagem. São consideradas diferentes formas de cobrança, associadas aos diferentes tipos de legislação municipal, na tentativa de avaliar o comportamento de diferentes municípios e famílias sob esquemas alternativos de cobrança / tratamento de resíduos. Nesse sentido, são apresentados resultados de pesquisas conduzidas em diferentes municípios e domicílios em todo o mundo. Com base nos resultados, infere-se que a quantidade de resíduos gerados é comparativamente mais baixa nos municípios onde o regime de cobrança PAYT está sendo implementado, devido ao facto de que as pessoas tendem a separar seus resíduos e gerar menos resíduos indiferenciados. São apresentados alguns fatores que influenciam a separação adequada de resíduos. Os fatores analisados podem ser de grande ajuda em recomendações na decisão política para a introdução e implementação de sistemas de cobrança PAYT, em vários países. Além disso, uma série de questões relacionadas com os sistemas PAYT, tais como legislação, projeto, implementação e impacto, são discutidas. A análise realizada em diferentes países, sobre os resultados da implementação do sistema PAYT, mostra que este pode resultar num aumento de 15 a 30% na reciclagem de resíduos, bem como uma redução de 30% a 40% nos resíduos enviados para aterro.

**Keywords** Economic Incentives, Pay-As-You-Throw, Polluter Pays Principle, Solid waste management, Household food waste, Recycling.

**Abstract**

There has been strict environmental legislation that aims at protecting the environment from various detrimental actions. Besides, there have been increasing concerns on resources consumption as well as economic developments. These turn out to be major drivers for a growing amount of countries to strive towards a reduction in the quantity of solid waste that are being sent to the landfills as well as to enhance diversion and recycling. Furthermore, there have been concerted efforts not only on lowering the incessant increase in the aggregate waste production but also on improving the awareness of the citizens on the need for waste reduction. Consequently, various viable measures that can be exploited have been the main concerns worldwide. Besides, different countries are reviewing the waste management financial mechanisms and giving more considerations to the environmental policy. Conventionally, general tax payments or levies are used by a lot of countries to fund their waste services. This approach fails to be fair enough to provide an objective link between the actual individual waste production and costs charged for waste disposal. As a result, the citizens have little or no motivational incentive to be conscious of the produced waste quantity by the conventional approach. An alternative approach to this is differentiated fee systems known as pay-as-you-throw (PAYT). The PAYT has been receiving growing attention under the waste reduction goal due to the fair proportionality between waste management costs and amount of produced waste. This dissertation presents overviews of PAYT across the world. The main aim of this dissertation is to analyze the opportunities and challenges of PAYT in the World so as to study its effectiveness not only in waste reduction but also in offering fair proportionality between waste management costs and actual amount of produced waste. To achieve the research objectives, the dissertation presents results of research on municipal waste management in some parts of the world. Moreover, the dissertation emphasizes mainly on the effects of different municipal solid waste charging systems not only on separating but also on recycling efforts of the respective households and municipalities. Furthermore, different relevant waste charging systems are considered along with the applicable ideologies of the municipal legislations in an attempt to study the behavior of different municipalities and households under alternative waste treatment/charging schemes. In addition, results of surveys conducted on different municipalities and households across the world is presented. Based on the results, it is inferred that the generated waste is comparatively low in municipalities where PAYT charging scheme is being implemented due to the fact that people tend to separate their waste and generate lesser residual waste. Also, some factors that influence adequate waste separation are presented. The analyzed factors can be of great help in policy recommendations for the PAYT charging systems introduction and implementation in various countries. In addition, a number of PAYT systems related issues such as legislation, design, implementation and impact are discussed. The analysis carried out in different countries, about the PAYT results, shows that PATY systems implementation can result into 15–30% rise in recycling as well as 30–40% reduction in waste to landfill.

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# List of Acronyms

| | |
|---|---|
| **3Rs** | Reduce, Reuse, and Recycle |
| **CAPEX** | Capital Expenditure |
| **CSRs** | Customer Service Representatives |
| **EPA** | Environmental Protection Agency |
| **EU** | European Union |
| **FCA** | Full Cost Accounting |
| **FW** | Food Waste |
| **GHG** | Greenhouse Gas |
| **GWP** | Global Warming Potential |
| **HSW** | Household Solid Waste |
| **LAs** | Local Authorities |
| **MPS** | Multi-tiered Pricing System |
| **MSW** | Municipal Solid Waste |
| **NGOs** | Non-governmental Organizations |
| **PAYT** | Pay-As-You-Throw |
| **PPS** | Proportional Pricing System |
| **RSD** | Rate Structure Design |
| **RVM** | Reverse Vending Machine |
| **SWM** | Solid Waste Management |
| **VPS** | Variable-Rate Pricing System |

Chapter

# 1

# Introduction

Municipal solid waste (MSW) is generally used to define a heterogeneous collection of wastes that are produced in urban areas. Illustrations of MSW are shown in Figure 1.1 on the following page. The nature of MSW varies from region to region because, the features and amount of the SW produced in a region is a function of characteristics such as the lifestyle of the region's inhabitants, living standard, as well as the quantity and type of the region's natural resources. Moreover, urban wastes can be classified into two main parts which are organic and inorganic [1].

Usually, the organic constituents of urban solid waste (SW) can also be categorized as: fermentable, putrescible, and non-fermentable. The putrescible wastes have high tendency of decomposing quickly. Therefore, to prevent the associated offensive odors and visual unpleasantness, putrescible wastes have to be cautiously managed. Furthermore, fermentable wastes also decompose quickly, but it happens with no distasteful accompaniments of putrefaction. In addition, non-fermentable wastes on the other hand have high tendency of resisting decomposition, so, breakdown very gradually. The major source of putrescible waste is food preparation as well as consumption. Consequently, its nature varies with standard of living, lifestyle, and seasonality of foods. Also, the main sources of fermentable wastes are crop and market debris. The main difference between the wastes produced in developing countries and those generated in industrialized countries is that the former wastes have higher biodegradable organic content. Table 1.1 on page 3 illustrates the amount and composition of MSW produced in a number of countries [1]. It can be inferred from Table 1.1 on page 3 that, foods which have been categorized in putrescible group are the main source of solid waste. The major problem for the MSW management is the putrescible waste that comes mainly from food waste (FW).

FW has been receiving increasing attention from entities such as non-governmental organizations (NGOs), international organizations, as well as academia. Also, policymakers from local to international levels are playing significant roles on FW [2–4]. The reason for intense consideration in this field can be attributed not only to the growing worries about food security as well as environmental impacts, like greenhouse gas (GHG) emissions and resource

depletion such as underground water [2, 3, 5, 6], but also to the significance of the problem to both developed and developing economies [7]. For instance, the Food Waste Reduction Alliance (FWRA) was established in 2011 by a set of food manufacturers and retailers in order to give more consideration to the developing issue. This is a joint project that is aided by the Food Marketing Institute (FMI), the Grocery Manufacturers Association (GMA), and the National Restaurant Association (NRA) [8, 9]. In addition, with reference to the European Commission DIRECTIVE 2008/98/EC, it is important to put into consideration and apply the waste hierarchy. This will not only help in preventing and managing waste but also aids in reducing greenhouse gas emission being generated from waste deposited on landfills.

Figure 1.1: Municipal solid waste.

Table 1.1: Comparison of solid waste characterization worldwide [% wet wt] (adapted from [1, 11, 12]).

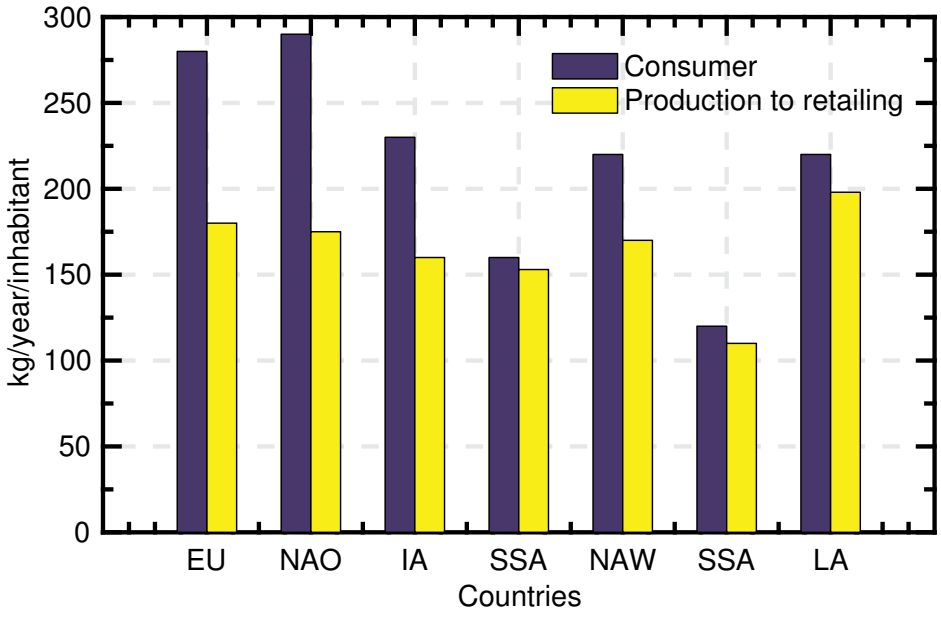
| | Solid waste | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **Putrescibles** | **Paper** | **Metals** | **Glass** | **Plastics, Rubber, Leather** | **Textiles** | **Ceramics, Dust, Stones** | **Wt (g)/cap/day** |
| Bangalore, India | 75.2 | 1.5 | 0.1 | 0.2 | 0.9 | 3.1 | 19.0 | 400 |
| Manila, Philippines | 45.5 | 14.5 | 4.9 | 2.7 | 8.6 | 1.3 | 27.5 | 400 |
| Asunción, Paraguay | 60.8 | 12.2 | 2.3 | 4.6 | 4.4 | 2.5 | 13.2 | 460 |
| Seoul, Korea | 22.3 | 16.2 | 4.1 | 10.6 | 9.6 | 3.8 | 33.4 | 2000 |
| Vienna, Austria | 23.3 | 33.6 | 3.7 | 10.4 | 7.0 | 3.1 | 18.9 | 1180 |
| Mexico City, Mexico | 59.8 | 11.9 | 1.1 | 3.3 | 3.5 | 0.4 | 20.0 | 680 |
| Paris, France | 16.3 | 40.9 | 3.2 | 9.4 | 8.4 | 4.4 | 17.4 | 1430 |
| Australia | 23.6 | 39.1 | 6.6 | 10.2 | 9.9 | | 9.0 | 1870 |
| Sunnyvale, California, USA | 39.4 | 40.8 | 3.5 | 4.4 | 9.6 | 1.0 | 1.3 | 2000 |
| Bexar County, Texas, USA | 43.8 | 34.0 | 4.3 | 5.5 | 7.5 | 2.0 | 2.9 | 1816 |
| Portugal | 37.2 | 11.0 | 1.8 | 7.1 | 11.3 | 4.0 | 31.2 | 1300 |

Furthermore, it helps and aids proper bio-waste treatment and separation for easy digestion and composting for a conducive environment, use of environmental friendly material which are produced from bio-waste, according to legislation and policy [10].

Meanwhile, it has been observed that, globally, approximately one third of food made for consumption is lost or wasted. Annually, the affected amount can be equated to a total of 1.3 billion tonnes of food [2, 6, 13, 14]. Figure 1.2 on the next page illustrates FW scenarios while Figure 1.3 on page 5 shows the per capita food losses and waste in different regions. It is remarkable that, food production is resource-intensive, hence, food losses and wastes have indirectly connection with a broad range of environmental effects like deforestation, soil erosion, air and water pollution. Besides, GHG emissions arising during the processes of production, transportation, storage, and waste management of food also have significant environmental impacts [2, 14–16]. Consequently, FW is one of the atypical impediments that cuts across various social issues ranging from food security and economic efficiency to environmental degradation [17]. There have been strong indication in Europe that the emissions should be minimized through reduction of FW in stages of food production and consumption chain [2, 18]. This is obvious in several new legislative proposals on waste management offered by the European Commission in 2015 as well as the advocacy of a "circular economy" (COM(2015) 595) [19]. With reference to the U.S. Department of Agriculture, approximately 50 million Americans of which 16 million are children are food insecure. This implies that they do not have sufficient money to secure enough nutrition. In an effort to address FW, groups like Feeding America are working to assist individuals and families in securing access to nutritious food [8, 9].

There has been a growing amount of studies in industrial ecology, waste management, and circular economy that are trying to attend to issues of food wastage by adopting the concept of a "hierarchy," normally referred to as the "3Rs" (reduce, re-use, recycle) of waste management. It is noteworthy that, for global environmental sustainability, there have been concerted efforts on thinking beyond the 3Rs. Consequently, there have been other variants of the 3Rs such as "5Rs", "8Rs", and "9Rs" that have been presented. In these variants,


Figure 1.2: Food waste




| | | | |
|---|---|---|---|
| EU | Europe | NAO | North America and Oceania |
| IA | Industrialized Asia | SSA | Sub-Saharan Africa |
| NAW | North Africa, West and Central Asia | SSA | South and Southeast Asia |
| | | LA | Latin America |

Figure 1.3: Per capita food losses and waste (kg/year), at consumption and pre-consumptions stages, in different regions (adapted from [13]).

apart from the notions of the common reduce, reuse, and recycle; other concepts such as replace, repair, recover, refuse, restore, reject, and rethink have been introduced [20, 21]. In this work, for generality purpose, the "R's" will be employed to refer to any applicable form of the variants.

The European directive initial put the hierarchy into law in 1975 (EC, 1975). Furthermore, the U.S. Environmental Protection Agency (EPA) endorsed a similar framework in guidance documents that specifically addressed food [22]. The food recovery hierarchy is shown in Figure 1.4 on the next page. The hierarchy has a set of preferable categories of solutions with prevention (reducing surplus at the source) having the utmost preference while landfilling is the least option [2, 15, 16, 22].

Meanwhile, it has been observed that collection, processing, storage, transportation, treatment, and disposal of SW are really challenging for the responsible local authorities (LAs) and they are even more demanding in developing countries [1]. This can be attributed to factors such as urban migration, perpetual population growth, and higher consumption level that give rise to an increase in the volumes of generated. Another notable factors are the technical, financial, institutional as well as social constraints that make SWM challenging [23–25].

In addition, the aforementioned constraints bring about the LAs choosing cheaper but inefficient SWM approaches that eventually contributes to environmental pollution and social dissatisfaction [23–25]. However, a better solution can be achieved through the reduction of produced waste to a manageable level in conjunction with a revenue generating scheme [24]. Meanwhile, it has been observed that Household Solid Waste (HSW) is the key contributor of the waste in residential areas. For instance, 75% of the total MSW in developing countries

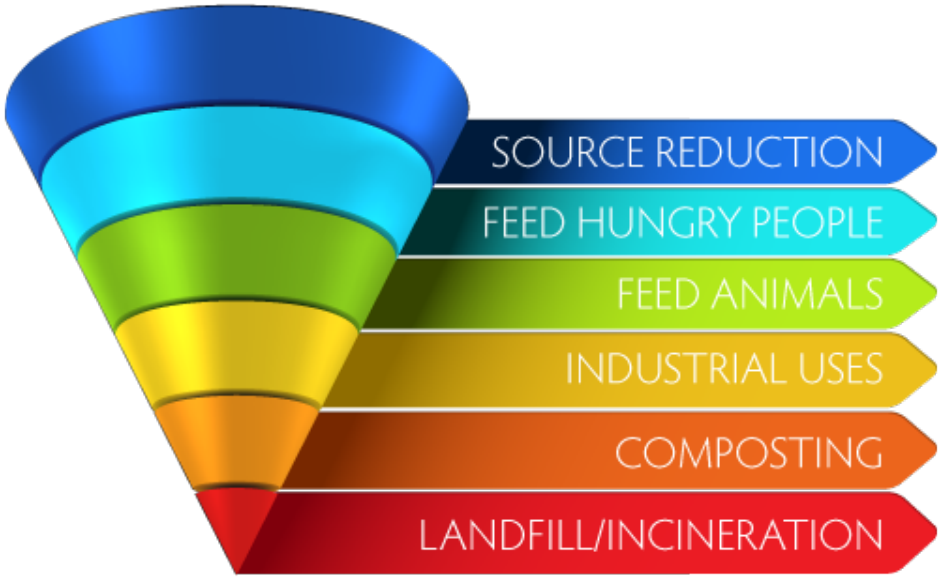



Figure 1.4: EPA food recovery hierarchy [8, 9].

contains HSW [24, 26–28]. Therefore, effective means of reducing the HSW to be disposed deserve considerable attention. A promising approach is to encourage activities such as reduction, separation, recycle, reuse, and recovering of waste among households [24, 29]. The existing encouragement approaches like awareness programs, facilities provision, as well as command and control approach alone have been observed to be insufficient [24, 30–32].

The Pay-As-You-Throw (PAYT) scheme is a charging or pricing notion that has been adopted by the local authorities for waste collection and management services. The PAYT scheme is based on the "polluter pays" principle in which the rate of the waste service payment ascribed to a household significantly depends on the amount of waste it produced. Consequently, people will be motivated to reduce the quantities of waste that they are generating through various means such as composting, separation for recycling, and consumption behavioral change [33–36]. No wonder PAYT has been observed as a cost-effective measure for reducing and preventing FW that constitute enormous percentage of MSW [2, 4, 19, 37–39]. Furthermore, such measures have been extensively adopted around the world and most especially in the European Union (EU) and United States (US) [33–36]. The United States Environmental Protection Agency (EPA) has explained MSW generation status and recommends the preferred waste management hierarchy for the environmentally effective MSW management and control. In the hierarchy, European Commission (EC) directive 2008/98/EC on waste gives a preference for reuse and recycling options while disposal in combustion facilities and landfills are the least advisable options [10]. The proposed waste management hierarchy is shown in Figure 1.5 on the following page [27, 40–44].

The major objective of PAYT method that is likewise known as unit pricing, user pay, variable rate pricing and differentiated tariff system in the waste management is to achieve the polluter pays principle in a fair way [45]. This is realized by billing citizens in line with the real quantity of waste that they generated [33, 34, 46–49]. Comparatively, the idea is similar to paying for utilities such as water and electricity. The notion has been adopted by nearly 7100 jurisdictions in the US [35].

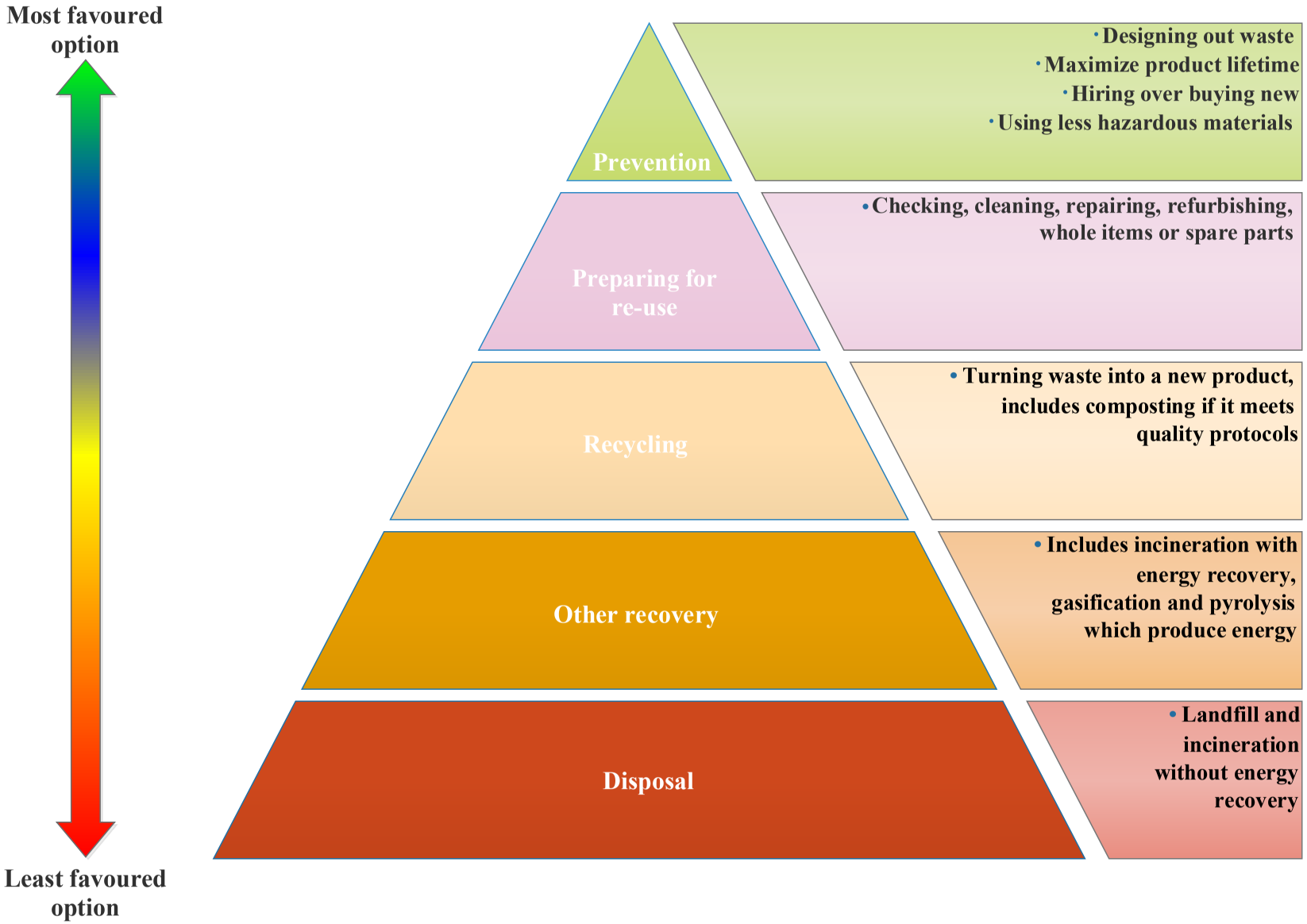



Figure 1.5: Waste management hierarchy (adapted from [40])

The traditional systems for household waste management in Europe are normally financed based on [33, 50, 51]:

- A fraction of general property taxes; or
- A fixed periodic fee in bill of another supply services such as electricity, that is independent of the actual amount of garbage content taken away or waste produced.

It is noteworthy that in the traditional systems, the major metrics that are normally employed for the bill evaluation are the number of household members as well as the living space. However, the methodology employed for billing in this system is unfair for populace who produce a small amount of waste either because they do not over-consume or owing to their separation for recycling and composting efforts [33].

In addition, another salient point is that the traditional systems make the people indifferent about their mode of consumption and the amount of waste that they are contributing to their environment. Therefore, they are uncaring about the environmental impact of the disposed waste. Consequently, in an effort to curb the shortcomings of a traditional approach, the PAYT redefines how wastes can be effectively managed by handling services that are connected to waste management fairly like other utilities such as telecommunication, electricity and water supplies. Therefore, PAYT schemes enables the household to pay a flexible rate that is in accordance with the scale of waste produced by them and the comparable service that they acquired for its disposal [33, 52–55].

Furthermore, with its different applications and precise implementation objectives in various countries, the major aims of variable waste charging are to [33, 56–59]:

1. improve people awareness concerning environmental protection.
2. conserve raw materials by preserving natural resources by means of recycling and composting.
3. create justness and further fairness in waste charging between inhabitants.
4. minimize waste disposal to landfills without raising the treatment required beyond recycling and composting.

It is noteworthy that, the main motivation for the establishment of the PAYT scheme is the advancement in waste management field through the local authorities. The variable waste charging scheme can be basically initiated in the metropolitan area with existing integrated and functional recycling infrastructure. Another factor that influence ease of acceptance of the PAYT schemes is the implementation of compost. In general, in the PAYT schemes, environmental concerns and justness of treatment together with fair charges to the people are highly essential [33].

## 1.1 Motivation and Justification

The traditional fixed-fee systems for household waste management is still dominant in different part of the world. Moreover, the growing population and unprecedented development go hand in hand with huge solid waste generation across the world. The colossal generated

waste management cost is escalating perpetually. Furthermore, the traditional approach of disposing all generated waste quantity at the landfill normally result into continuous reduction in the volume and lifespan of the landfill. Besides, there are rising concerns not only about the public health but also regarding the environmental impacts of landfilling. This can be associated with its possible adverse effects. One of these is the accumulation of methane ($CH_4$) which is a more powerful greenhouse gas compared with carbon dioxide ($CO_2$). $CH_4$ accumulation can eventually lead to explosions in the landfill mass. Besides, the biodegradable waste (mainly food waste) breakdown in landfill sites can discharge leachate which can contaminate not only surface water but also local groundwater and soil. The consciousness of the related landfilling risks result into significant difficulty, strong hostility and intense public resistance to the establishment of new landfills. Therefore, there is an urgent need to evolve beyond the oldest form of waste treatment. An innovative method of addressing the waste management problems is Pay-As-You-Throw (PAYT). Consequently, the motivation for this work is not only on how to attend to the perpetual increase in the quantities of MSW but also to the concern on reducing waste as well as increasing recycling, incuding food waste recovery. In addition, the goals of waste management regarding the R's can be effectively achieved by the PAYT system implementations. This dissertation offers a more comprehensive overview regarding design, planning and implementation of PAYT systems that can be of great help in improving the general waste management structures. To achieve its goals, this work considers the aim and objectives in the next section.

## 1.2 Aim and Objectives

The main aim of this thesis is to analyze the opportunities and challenges of PAYT in the World so as to study its effectiveness not only in waste reduction but also in offering fair proportionality between waste management costs and actual amount of produced waste. Consequently, for a sustainable environment, this study aims at contributing to waste reduction process in order to alleviate the adverse environmental as well as health impacts of waste treatments. This aim will be achieved through the following objectives which are to:

1. Study municipal waste management in some parts of the world;
2. Analyze the effects of different MSW charging systems on separating and recycling efforts of the respective households/municipalities in detail;
3. Evaluate the most relevant waste charging systems along with the applicable ideologies of the municipal legislations;
4. Consider PAYT systems related issues and proffer viable solutions to address them;
5. Investigate factors that influence adequate waste separation;
6. Study the behavior of different municipalities and households under alternative waste treatment/charging schemes;
7. Analyze results of surveys conducted on different municipalities and households across the world and proffer viable solutions as well as benchmarks for any municipalities in the world aiming to adopt PAYT system.

## 1.3 Methodology

An extensive amount of work has been done concerning PAYT systems across the world. Furthermore, a number of articles on the PAYT systems are available on the internet, books, scientific reports, and magazines. Consequently, to achieve the aim and objectives of this study, an extensive literature survey of the available data is carried out for information collection in this dissertation. A descriptive research design approach is then adopted with the intention of understanding the associated concepts, advantages and weaknesses of PAYT systems regarding MSW management. This enables the research to be carried out in a lucid manner.

## 1.4 Dissertation Organization

In order to accomplish the aforementioned objectives, the dissertation is divided into the enumerated chapters:

The current chapter, Chapter 1, introduces municipal solid waste (MSW), and presents food waste (FW) as the main concern in the MSW management. Likewise, waste management hierarchy and food recovery hierarchy are discussed. Moreover, the purpose of this dissertation is well-defined in this chapter.

Chapter 2 presents different concepts on waste management and addresses the related issues. It also presents fair means of implementing the polluter pays principle considering the PAYT system. The rate structure design with the developmental associated steps are presented. Furthermore, the potential options along with their advantages and disadvantages are considered.

Chapter 3 reviews evolution of PAYT and application experiences in some countries taking Europe and United States as case studies. Furthermore, it gives extensively consideration to the associated PAYT legislation including state legislation and local ordinances.

Since the experienced challenges during the introduction of the PAYT program depend primarily on the charging system employed, Chapter 4 presents a number of charging mechanism for PAYT in different countries. Moreover, it discusses the effect of pricing structures on the residents' waste reduction efforts and on the stability of the community's revenues.

In Chapter 5, full cost accounting (FCA) is presented as a tool that facilitates an effective decision on PAYT financial assessment. It aids in quantifying, recognizing, and allocating the associated cost to the PAYT schemes by considering in an appropriate scenario, the social as well as environmental cost.

Survey results of associated effects of PAYT systems on waste reduction as well as source reduction in different countries are presented in Chapter 6.

Chapter 7 summarizes the main findings of the research work with concluding comments. In addition, recommendations for future work are outlined.

## 1.5 Conclusion

This chapter offers comprehensive overview and discussion on MSW. It also shows that the key contributor and main source of solid waste is food. This is due to the fact that about one third of food made for consumption is lost or wasted globally and the affected amount can be equated to a total of 1.3 billion tonnes of food per annual. The chapter presented PAYT as a cost-effective measure for reducing and preventing FW that constitute huge percentage of MSW. Then, different concepts on PAYT systems have been presented. Consequently, it can be inferred form the chapter that PAYT systems are not only viable means of achieving polluter pays principle in a fair way but also offer robust waste reduction incentives to the residents. Furthermore, they are cost-effective solutions for reducing and preventing FW and MSW at large. This is due to the fact that, it motivates people to reduce the quantities of waste that they are generating through various means such as composting, recycling, and consumption behavioral change. Therefore, PAYT systems help in minimizing waste disposal to landfills and alleviate environmental impacts of MSW through improved people awareness regarding environmental protection.

Chapter

# PAYT Structure

RATE structure design (RSD) is a way of fixing the price to be charged per unit of solid waste. The entire resolutions on the PAYT program contribute to the rate structure. It is remarkable that, an efficient rate structure has to create the revenues required for the costs of service. Effective implementation of PAYT program demands a number of possible sequential steps that the planners should followed. This chapter examines the main steps and things to be considered when a rate structure is to be developed. Furthermore, the potential options that can best support different communities depending on their goals are discussed. In addition, merits and demerits of the considered options are analyzed considering a number of public concerns.

## 2.1 Introduction

The principal mechanism that is essential for the adoption of PAYT shows that its application depends on the following enumerated main factors [33, 48]:

1. Identification (for reasons of accountability to the waste generator),
2. Measurement (of the generated amount of waste and/or services obtained for it), and
3. Unit pricing (for individual charging according to the availed service).

In general, the gratification of the three basic factors as well as various means of combining them bring about a huge range of choices for the practical employment of PAYT [33]. Consequently, the key processes that are needed for the estimation of service fee in a PAYT system are based on its structure as depicted in Figure 2.1 on the next page.

### 2.1.1 Identification

Identification is the major factor that helps in the accountability of the collected waste from the generators. Moreover, identification in accordance with the PAYT application com-

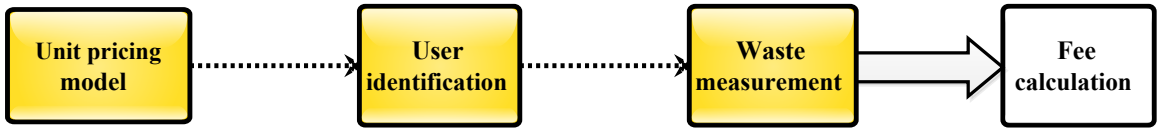



Figure 2.1: Key steps in a PAYT system (adapted from [48]).

mences with the allocation of receptacles such as bins and containers to a particular group of waste generators for waste collection. Similarly, it manifests in the form of access granting by ensuring that inhabitants who are paying for a specific collection service are the ones enjoying it. Therefore, access restrictions are imposed to prevent just anybody to dispose waste. In essence, Identification can be employed to distinguish the user of the service or the associated bin of the user [33].

- User identification: In user identification, it is obligatory for users of the receptacle to have means of identification such as smart cards, electronic keys or transponder. By the special installations that have been employed in the scheme, access restrictions are imposed on the receptacles for the waste collection. Hence, to gain access, user has to officially register or properly identify himself/herself.

- Bin identification: Apart from the user identification, bin identification can also be implemented for classification. In the bin identification, chamber system can be operated in a number of environments. This enables PAYT principles to be harnessed in full by the operators. Chamber systems are waste storage installations in which the users have to pass their waste via a specific feeding chamber. The users can only be authorized to use the service after registration. Access can be granted to the user by means of an electronic key or smart card. As a result, the quantity of waste dumped is logged by the responsible authority. This will enable them to appropriately charge the user by deducting an equivalent amount from prepaid credits.

### 2.1.2 Measurement

There are different means of measuring the generated waste. The measurement can be on a volume basis or by weighing. It is remarkable that the volume basis method is more common. Nevertheless, compared to the weighing scheme, the volume basis option has wider spectrum of measuring techniques which usual makes it to offer a lower accuracy with reference to the real waste quantity [33].

1. **Weighing**

   (a) Weighing is implemented in a distinct installation being offered for waste collection. Therefore, weighing affects each amount of waste dropped into the installation. Waste weighing can be realized as follows:

      i. The waste goes over a distinct weighing chamber in advance to being deposited into the storage container.

      ii. When the waste is being injected into the installation, the whole storage container is weighed and the weight difference of the container is determined.

(b) Moreover, weighing can be realized for the whole collection receptacle in the course of discharging it into the collection truck. Through this approach, the associated weight is determined with the aids of a weighing device that has been integrated into the lifter system of the garbage trucks.

2. **Volume Measurement**

The volume measurement can be achieved by means of the following enumerated basic principles:

(a) Waste collection can be achieved by employing special installations that can only be accessed by means of a feeding chute of defined volume. Subsequently, whenever an access gained into the installation, the volume of the feeding chute utilized will be recorded.

(b) Furthermore, distinguishable receptacles of specified size can be allocated to/subscribed from the households. Subsequently, individual receptacle can then be easily recognized during the waste collection. According to this principle, receptacle size influences the right quantity of waste to be considered.

(c) Moreover, receptacles or installations with a particular equipment that determines the volume of injected waste can be implemented for collection. There are two major means of implementing this system. The inserted waste has to be compressed in a reducible chamber until a specified counter-pressure is signaled when one of the approaches is employed. Consequently, in the approach, the size of the chamber at the instant of the signal decides the amount of waste that should be accounted for. On the other hand, the other method entails determining the real filling level of the receptacle at the instant of collection. This is achieved with the aids of an optical sensors or ultrasound (echo-sounder).

(d) In addition, receptacles of specified sizes can also be purchased for use by the households.

In general, the aforementioned are receptacles (such as plastic bags) are disposable and of specified volume. They are normally retained during the collection by the responsible authority. Further information is provided in Section 3.2 on page 35 of this dissertation.

### 2.1.3 Unit Pricing

The unit pricing is associated with the accounting technique as well as determination of the price charged for a specific service. Fundamentally, it is achieved by relating the frequency of the availed services and the results of waste measurements as well as comparing them with the total management costs per unit of collected waste. Different available pricing systems are discussed in the following subsection [33].

## 2.2 Pricing Systems

The communities in which PAYT is being implemented have to choose the nature of pricing system to be adopted. Respective pricing system has its associated merits and demerits. For instance, some systems may possibly present better revenue stability while others may give greater waste reduction incentive to the residents [60, 61]. Moreover, pricing systems such as

variable rate, proportional, and multi-tiered are normally employed in the rate structure for the PAYT program [60].

### 2.2.1 Proportional Pricing Systems

A direct relationship between garbage amounts and price is ensured in the proportional pricing system (PPS). Communities that are implementing the PPS charge residents on a per-unit basis. That is, they are charged for each garbage container that they intend to dispose. The PPS are typically bag- or tag-based systems in which the bags are sold at municipal offices or local retail stores. This scheme offers the following advantages [60]:

- A robust waste reduction incentive: Since the PPS scheme is a per-unit basis and each bag to be disposed has to be paid for, the residents have strong motivations to improve on waste reduction, recycling, and composting [61].
- Potentially lower program costs: Due to the fact that the residents normally acquire bags right away from the municipal offices or local retail stores, the administrative and other program costs are comparatively lesser.

On the other hand, the main disadvantage of the PPS scheme is:

- Potential revenue uncertainty: In the PPS scheme, the households may purchase a lot of bags at one instant and afterwards none for a number of months. This brings about a potential revenue fluctuations.

### 2.2.2 Variable-rate Pricing Systems

Unlike the PPS, in a variable-rate pricing system (VPS), the per-unit price fluctuates. So, residents are typically charged based on the size of the subscription container selected. In this regard, residents should pay extra fees for the disposed garbage that are more than subscription level. Therefore, the billing of every subsequent container may increase or decrease in accordance with the community's PAYT program objectives. Furthermore, in the VPS scheme, container sizes may vary. Depending on the community, one container size may be offered for additional set-outs or the residents may be expected to use containers that are either smaller or larger than the size of their subscription container for extra set-outs. Additional garbage may be paid for by buying tags or bags. In some cases, the community may weigh the extra set-outs during collection and then bill the residents appropriately.

The major benefit of a VPS is [60, 62]:

- Increased control over the waste reduction incentive: Based on the community program objectives, a price for extra containers that is more than the normal subscription level price may be charged. The extra bill will initiate an effective incentive to reduce and recycle the waste. However, in a situation where the community concern is to prevent the residents from disposing waste in undesirable manners if they are of the opinion that the pricing system is unfair, the households may be charged below the subscription level price for extra containers presented.

Conversely, the main drawback of a VPS is:

- Potentially higher costs: In this scheme, the residents are offered a choice of subscription levels with containers in varying sizes and billing system. Also, the set-outs may be counted during collection. Consequently, this scheme may be costlier to implement and manage.

### 2.2.3 Multi-tiered Pricing Systems

Occasionally, two-tiered or multi-tiered system (MPS) are employed to assist communities in achieving revenue consistency. Like the billing systems that have been adopted by telephone and water utilities, people subscribe to a base level of service in which flat fees are to be paid. The "first-tier" fees can be charged via one of means such as local taxes, regular monthly charge, quarterly charge. This is normally comprised in the utility or other municipal bill. The fees can also be utilized to cover the fixed percentage of the community's solid waste program cost [60, 62].

Furthermore, residents pay "second-tier" fees that are in line with the amount of waste they intended to dispose. Second tier fees can be priced like the VPS or PPS. The fees realized by this means are usually employed to cover the costs of collecting and disposing extra quantities of waste. Also, provided that multi-tier fees are variable, they can decrease or increase for extra waste containers as the case may be. The major advantage of a MPS is [60]:

- Revenue stability: The MPS enables communities to be certain that, no matter the extent of waste reduction and increase in recycling efforts by the residents in order to save money which eventually decrease PAYT revenues, the program's fixed costs will still be covered.

The major disadvantage of a MPS is:

- It offers less incentive for waste reduction. Also, the aggregate cost of garbage services might not be transparent to residents since a fraction of the program cost is based on flat rate charges. Hence, the demerit may lessen the incentive to reduce and recycle waste.

It is remarkable that, there is a typical system might be unsuitable for all community. Hence, all of the three pricing systems as well as combinations of them have been effectively employed in several communities across the world. Also, to make decision on the approach to be adopted for a given situation, solid waste planners typically consider the goals being set for their program. The goal can range from increasing recycling to minimizing administrative costs. Table 2.1 on the next page Summarizes different pricing options.

## 2.3 Container Options

In communities where a volume-based unit pricing program is to be adopted, consideration should be given to the size and type of waste collection containers to base their rate structure as well as billing system on. It is remarkable that the choices concerning containers and rate structures go hand in hand with the billing systems. Therefore, in certain situations, container type helps in determining the rate structure and billing system. In other situations, a well-established billing system governs and aids in determining container type and rate

Table 2.1: Pricing Options [63]

| System | Rate |
|---|---|
| Proportional (linear) | Flat rate per container |
| Variable container | Different rates for dissimilar size containers |
| Two-tiered | Flat fee (charges are normally on a monthly basis) and flat rate per container |
| Multi-tiered | Flat fee (charges are normally on a monthly basis) and different rates for dissimilar size containers |

structure. A unit pricing system can be based on the following enumerated container options [36, 46, 47, 63, 64]:

**Large cans:** With large can system, households are offered a single but large waste cans. The cans normally have a typical capacity of 0.189 or 0.227 $cm^3$. Then, individual household is charged in line with the number of cans that they have used.

**Small or variable cans:** In small or variable can system, a set of standard and variable can sizes are used. The typical volume/capacity ranges from about 0.076 to 0.227 $cm^3$. This approach is normally run on a subscription basis. It offers the residents the chance to choose the number as well as the size of cans they desire in advance.

**Prepaid bags:** In this approach, colored or else uniquely marked standard-sized garbage bags are used. The typically capacity ranges from 0.076 to 0.114 $cm^3$. Residents can buy the bags from the solid waste agency through outlets like retail stores and municipal offices. In this system, the waste that is placed in the specified bags is collected.

**Prepaid tags or stickers:** This system is implemented by selling tags or stickers to the residents. The tags or stickers can be procured from the solid waste agency outlets. They can then be attached to the garbage bags. Normally, the tag or sticker signifies the size of bag it covers.

With these options, source-separated materials can be encouraged as illustrated in Figure 2.2 on the following page because different containers being used for different materials have different prices. Consequently, the mixed waste container will be the most expensive. Advantages, disadvantages and list of communities where different container options have been implemented are given in Table 2.2 on page 19, Table 2.3 on page 20 and Table 2.4 on page 21.

## 2.4 PAYT Impacts

The PAYT impact recognition is the major means of considering it as an alternative for the communities. This can really reflect from the envisaged amount of tonnage diversion and costs with the PAYT introduction and implementation. Nevertheless, impact measurement

is highly challenging due to the fact that most communities do not make changes in isolation. Normally, PAYT changes can be achieved through concurrent modifications in programs such as yard waste, recycling, outreach or other changes. This subsection presents the impacts of diversion based on PAYT programs in the US. So, the main benefits as well as the associated concerns of the PAYT implementations are presented in Table 2.5 on page 22 and discussed in this subsections [35].

### 2.4.1 Benefits

The reported advantages are enumerated as follows [35]:

**Equity:** The PAYT programs are professed to be fair by different communities. Compared with the fixed-fee tax options, in the PAYT schemes customers who more services are rendered to pay comparative more. That is customers that want more garbage to be disposed for them pay more while those who intend to dispose the amounts that are equal to or less than the stipulated ones pay approximately the same related fees. Furthermore, it has been observed that people tend to prefer PAYT programs when it is implementation. This observation has been validated in the surveys which revealed that PAYT systems are preferred by over 95–98% of the households [35, 63].

**Economic signal:** Another benefit is that, unlike the fixed-fee tax options, customers' behavior influences the collection service charges in the PAYT system. It is remarkable that without PAYT (i.e. fixed-fee tax options), low and large disposers pay (charge) the same amount. PAYT system offers a relapsing economic signal to transform customers'


Figure 2.2: Source-separated materials

behavior. Consequently, PAYT enables small disposers to save more money compared to those who cost the system more expenses by using more service [35, 63].

**Lack of restrictions:** It has been observed that some elected officials in some municipalities

Table 2.2: Advantages and disadvantages of can systems implementation in USA (adapted from [57, 63]).

| **Advantages** | **Disadvantages** | **Implementation Communities** |
|---|---|---|
| Fairly stable and easy to forecast revenues. | Cans frequently have higher application costs. This includes new cans purchase and distribution. | Hennepin County, MN<br>Seat tle, WA<br>Anaheim, CA<br>King County, WA (in unincorporated areas)<br>Marion County, OR<br>Pasadena, CA<br>Glendale, CA<br>Oakland, CA<br>Bellevue, WA<br>Santa Monica, CA<br>Duluth, MN<br>Richmond, CA<br>Walnut Creek, CA<br>Santa Clara, CA<br>Auburn, WA<br>Hastings, MN |
| Unlike the bag system, cans are commonly effective for semi-automated or automated collection equipment (provided that the chosen cans are compatible with the equipment) [57]. | Limited incentive to reduce waste by customers. As residents are generally charged on a subscription basis, there is no incentive if the purchased cans are not filled. Furthermore, no achievable savings beyond the smallest size garbage can. | |
| In a situation where the residents already have garbage cans of approximate uniform volume, new cans may not be needed. | Comparatively complex billing schemes are required to track residents' selected subscription level and bill. | |
| Cans can be labeled with addresses to aid in implementation. | Complex inventory, storage, as well as distribution systems are needed in order to offer new cans to households that change their subscription levels [57]. | |
| Cans have the tendency of averting animals from scattering the waste. | There is a need for scheme for charging and collecting waste that is outside subscription levels. | |
| | These are also required for bulk waste. Residents could find it difficult or confusing to select a subscription level at the outset [57]. | |
| | More time and effort are required compared with bag-based waste collection when the collection system is non-automated. | |

frequently have anxieties that resident behavior is restricted by the PAYT. To clear the misconception, program planners have informed communities that customer choices are not constrained by the PAYT scheme. The fact is that, customers are not prohibited from putting out extra garbage, however, customers who put out more should pay more [35].

**Efficiency:** The PAYT programs are usually economical to employ. Moreover, compared

Table 2.3: Advantages and disadvantages of bag systems implementation in USA (adapted from [57, 63]).

| **Advantages** | **Disadvantages** | **Implementation Communities** |
|---|---|---|
| The bag systems are easier to understand residents. | | |
| Compared with can systems, bag systems can offer a better waste reduction incentive because fees are normally based on smaller increments in waste. | Bag systems have higher revenue uncertainty than can systems, because the number of bags procured by the residents can fluctuate considerably. | |
| Bag systems exhibits lower accounting costs than the can systems, because there is no need for a billing system. | Additional staff time will be required if bags are sold in the municipal offices. | |
| Distribution, storage, and inventory costs of bag systems are lower than can systems when bags are sold at municipal offices and local retail establishments. | Purchasing and storing bags might be awkward to residents [57]. | Grand Rapids, MI<br>Reading, PA<br>Lansing, MI<br>St. Cloud, MN<br>Darien, IL<br>Carlisle, PA<br>Quincy, IL<br>Oregon, WI<br>Fallbrook, CA |
| Compared with non-automated can collections, bag collections tend to be more efficient and faster. | Tags or stickers are comparatively cheaper than the bags. | |
| Bags can be employed to show that proper fees have been paid for white goods or bulky items, since fees for pickup of these items are evaluated by communities. Communities can ask residents to attach a certain number of bags to the items in relation to the cost of disposal. | Bags are unsuitable for automated or semi-automated collection equipment [57]. | |
| | Bags can tear while handling. It can as well tear by animals that may even scatter the garbage [57]. | |
| | Bags are unlike cans that are reusable. So, bags add to the quantity of solid waste that is entering the waste stream. | |

to recycling programs, PAYT system does not require additional routes or collection trucks. Also, PAYT aids in averting solid waste services abuse. In addition, unlike

Table 2.4: Advantages and disadvantages of tag and sticker systems implementation in USA (adapted from [57, 63]).

| **Advantages** | **Disadvantages** | **Implementation Communities** |
|---|---|---|
| Compared with can systems, tag and sticker systems implementations are less expensive and easier. | Compared with the can-based systems, tags or stickers systems have higher revenue uncertainty, because the number of tags or stickers that residents purchase can fluctuate considerably [57]. | Tompkins County, NY<br>Aurora, IL<br>Grand Rapids, MI<br>Lansing, MI |
| Tag or sticker systems are simpler to comprehend. | To prevent misperception among residents, the size limits allowable for each sticker should be well established by the municipality. | |
| They present a greater waste reduction incentive compared to can systems, due to fees that are based on smaller increments of waste. | Additional staff time has to be devoted if tags or stickers are sold in municipal offices. | |
| As no billing system is required, accounting costs are lower compared to can systems. | Purchasing and storing tags or stickers might be awkward to residents [57]. | |
| Sales of tags or stickers at municipal offices and local retail establishments give lower storage, distribution, and inventory costs than can systems. | Tags and stickers normally do not cling well in cold or rainy weather. | |
| Cost of tags or stickers production is lower than for bags. | Additional time may be required at curb for collectors to enforce size limits. | |
| Stickers can be employed to show payment for white goods or bulky items, as fees for pickup of the items are determined by communities. | Tags or stickers that are attached to garbage and left at curbside may be detached by vandals or other residents trying to avoid waste service payment. | |
| | Unlike bags or other prepaid indicators, tags and stickers are not obvious. | |

Table 2.5: PAYT implementation benefits and concerns (adapted from [35, 65]).

| **Merits** | **Concerns** |
|---|---|
| Economic signal | Concerns about large families or the poor |
| Equity | Illegal dumping |
| Efficiency | Administrative burdens/work loads |
| Flexibility | Revenue uncertainties |
| Environmental benefits | Charges for programs |
| Speed of implementation | Multifamily buildings |
| Waste reduction | Implementation and political support |
| Lack of restrictions | |

the fixed buffet-style charges that encourage abuse of the service, volume-based rates systems inspire customers to make use of the actual quantity of service that they really needed [35].

**Waste reduction:** Another significant and appealing characteristics of PAYT is that, it is not like recycling programs which only encourage recycling. In the PAYT systems, all behaviors such as composting, separation for recycling, and source reduction that can help in reducing the amount of garbage disposed are rewarded. It should be noted that out of these source reduction is the least expensive waste management approach. Consequently, it deserves highest priority [35, 46, 63].

**Speed of implementation:** The PAYT programs can be established very easily and quickly. According to an inventory, a community launched a PAYT system in less than 3 months. Nevertheless, most of the program can take much longer mainly owing to the time needed to gain the required political support. Also, it has been shown that technical issues are seldom the limitation in getting PAYT effected [35].

**Flexibility:** According to the community inventory, PAYT systems have been employed in a broad range of types and sizes of communities. This includes a wide variety of collections such as licensed, municipal, contracted, as well as franchised collectors. These can be based on semi-automated, fully-automated, and manual collection approaches [35].

**Environmental benefits:** The environmental benefits of PAYT program can be easily discerned from the following [35, 56]:

- It encourages increased recycling
- It results into waste reduction
- It reduces emissions related to landfilling
- It reduces the use of virgin materials and the environmental externalities that are related to materials extraction

The enumerated advantages of PAYT make the scheme more appealing to communities that are working towards *green* goals.

### 2.4.2 Associated Concerns

Although PAYT programs have a lot of advantages, there are several public concerns over the schemes that require attention. Some of the concerns of the PAYT programs introduction are discussed here [35, 56].

**Illegal dumping:** According to a survey of over 1000 communities where PAYT is being implemented and those without-PAYT system, it was found that illegal dumping is the major concern of the program planners and elected officials. The survey also found that the anxiety about illegal dumping might be far from reality. This is due to the fact that; it was found to be an issue in nearly 20% of communities out of which a major problem is only 3%. Moreover, further effort on the analysis of the actual constituents of illegally dumped material reveals that only approximately 15% of the material originated from the household. Besides, the analysis also shows that the main household components that are illegally dumped are white goods such as refrigerators and washing machines, that are bulky electrical goods. It has been observed that illegal dumping can be prevented by the active enforcement of illegal dumping ordinances from the onset of the program. Moreover, another viable approach is to ensure that the PAYT system incorporates a bulky waste sticker or other suitable removal scheme for bulky white goods and other items in order to enhances the success of the PAYT system [35, 63, 66, 67].

**Concerns about large families or the poor:** There has been a lot of concerns about the effects of PAYT on the poor or large families. It should be noted that, large families pay more for water, groceries, as well as other services that they use more than other families. Fundamentally, PAYT extends the same concept to the garbage services. It is remarkable that, large families are opportune to reduce their garbage via recycling. In some cases, for the low income families, communities offer "lifeline" discount rates for important services such as energy and telephone. Hence, these kinds of reductions can also be applied to garbage fees by means of discounts or free bags/tags allocations. It has been revealed that special measures for the infirm or poor are being implemented in less than 10% of the PAYT communities. However, they have been incorporated in communities with policies for other services [35, 66, 67].

**Revenue uncertainties:** Studies have shown that revenue issue is another main concern for haulers and municipalities that are taken PAYT systems implementation into consideration. For instance, it has been shown that the amount of garbage cans or bags set out reduces considerably with PAYT. This can be attributed to the collective influences of tonnage reduction as well as stomping ("compaction"). This is evident from the communities' sample which indicates that average household set outs drop from 3 cans or nearby 340 L (90 gal) demand to 1 or 1.5 cans per household or approximately 114–170 L (30–45 gal). Comparable results have been observed in Washington, Seattle and other case studies. Therefore, this represents about 50–67% reduction in the "revenue units". This figure is substantially more than the related 17% decrease in tons. It should be noted that PAYT rate decision is more intricate than the traditional fixed-fee systems [51]. The traditional approach is just to divide the total revenue requirement by the total number of households in order to determine the rates. However, in the PAYT system, the rate setter which can either be the community or hauler have to

assess the number of "revenue units" such as tags, bags, and cans that will be utilized by the households. This has to consider the effects of PAYT based on the induced increase in application of recycling as well as diversion options. Consequently, the PAYT system demands enhanced rate evaluations. From experience, the haulers and communities have learned to adjust their anticipations on the amount of set outs in the rate calculations. This is in an effort to guarantee that the fixed costs of collecting solid waste are covered [35, 63, 66, 67].

**Administrative burdens/workloads:** It has been shown that workloads remained the same or reduced in the communities where PAYT is being implemented. However, the workloads at the initial stage of the implementation are normally high (increase). This is partly due to the calls and communities note. Therefore, at the initial stage of the implementation (1–3 months), temporary staffs are occasionally required for effective operation [35, 63]

**Multifamily buildings:** In the US, the PAYT scheme is usually employed in single family conditions up to probably 8-unit apartment complexes or condominiums/townhouses. On the other hand, they are not commonly employed in big multifamily buildings. In this case, multifamily buildings are normally serviced by dumpsters. So, the building owners get volume-based incentives that the single family households that are not employing PAYT are not receiving. In addition, there is a common recommendation from municipalities that, PAYT should not be hindered based on the reason that it does not so far apply perfectly to the multifamily sector [35, 63]

**Charges for programs:** The statistical analysis of PAYT programs have shown that nearly two-thirds of recycling diversion amount increases when there is no distinct fee for the recycling program. This occurs when the costs are "embedded" in the garbage fee. Also, similar results have been experienced in the analysis of yard waste or compost diversion program. Nevertheless, appropriate policy is not established merely on statistical results. A good number of communities that incorporate recycling cost into the garbage fee so as to maximize diversion and gain support the program. This can be attributed to the fact that households cannot simply transform recyclables into another material at the household level. As a result, embedded fee intended for recycling is attractive. Nonetheless, a lot of curbside yard waste/compost programs have separate service charges due to the followings [35]:

- it is expensive,
- the volumes vary by household,
- removal of the fee may hinder the best solution i.e. back-yard composting.

**Implementation and political support:** It has been noted in some communities that making PAYT systems ratified is commonly tougher than planning and running the actual program. This is mainly due to political issues that serve as the major barrier for the PAYT. The technical issues such as equipment, litter, haulers and administration are not often a problem and they have their respective solutions. Furthermore, it has been revealed that PAYT is well-liked by the citizens when it is in position. For instance, it has been stated that about 89%–95% of residents usually have a preference for the scheme after inception. Consequently, the principal barrier is acquiring the

political will and support for the program approval and implementation. Also, it has been suggested by the communities that besides gaining political support for the PAYT program, the most significant concern is how to disseminate information to the press, residents, and stakeholders. The information has to entails details concerning what the community expects to realize in the course of the change, the main objectives of the change, and means of making the program applicable to residential customers [35].

## 2.5 Structure of PAYT Program Implementation

In order to implement PAYT program effectively, there are a number of steps that the planners should engaged in. A sample of structure of PAYT program implementation is given in Table 2.6. It should be noted that, the sample timeline is just a guide to help planners in the program development and not the only yardstick PAYT program. So, with different communities with their own unique issues and conditions, the respective implementation steps as well as the timing of each steps could differ considerably. Moreover, there might also be further implementation steps that are not listed that should be included in certain planners‘ program while engaging in public and political support for PAYT in their communities.

## 2.6 Conclusion

This chapter offers comprehensive overview and discussion on rate structure design. It also establishes that adoption and application of PAYT depends on major factors such as Identification, Measurement, and Unit pricing. Moreover, variable rate, proportional, and multi-tiered pricing systems have been presented as the normally employed pricing schemes in the PAYT program rate structure. The associated merits and demerits of the respective pricing system have been considered. Moreover, the impacts of diversion on PAYT programs along with the main benefits and the associated implementation concerns have been considered. Likewise, a typical sample of PAYT program structure implementation have been presented. In general, the respective implementation steps and the timing of each steps in the PAYT program could differ significantly across communities depending on their unique issues and conditions. Consequently, a PAYT program structure and a timeline can only guide but are not the yardsticks for the PAYT program implementation.

Table 2.6: Structure of PAYT Program Implementation (adapted from [60]).

| **Key Concept** | **Challenges** |
|---|---|
| 18 months before implementation | • PAYT study with solid waste staff and goal setting<br>• Presentation of program to the head of a town/county council<br>• Implementation plan and timeline development |
| 15 months before implementation | • Establishment of task force to include civic groups and collection crews<br>• Planning of public outreach and education effort<br>• Establishment of data collection/program monitoring<br>• Proposition of collection and reporting measures<br>• Evaluation of available collection options and selection of appropriate ones<br>• Establishment of rate structure design (RSD) group |
| 12 months before implementation | • Monitoring of recycling level and quantity of waste shipped to the landfill<br>• Decision on expansion of recycling program and<br>• Establishment of yard trimming collection program<br>• Deliberate on the RSD group findings like pricing and equipment required<br>• Propose a pilot program for the environs<br>• Acquaint the task force with primary program planning activities |
| 9 months before implementation | • Implementation of the pilot program and result monitoring<br>• Implementation of public outreach with different enlightening programs<br>• Determination of bag specifications and distribution of RFP<br>• Recruitment of bag retailers<br>• Examine customer service representatives (CSRs) and administrative issues<br>• Assess the current ordinances for amendments or introduction of new ones<br>• Create program enforcement measures<br>• Rate assistance for low-income or other special populations<br>• Present proposed rates by the RSD group for task force and staff evaluation<br>• Request for input from the task force |
| 6 months before implementation | • Assessment of lessons learned and continuous result monitoring<br>• New yard trimming program implementation and recycling change with PAYT application<br>• Establish procedure for gathering bulky waste items<br>• Choose bag vendors and arrange the scheme for purchasing/selling bags to retailers<br>• Assist retailers on invoice schedule, bag delivery, and inventory monitoring<br>• Determine conditions for special population assistance<br>• Presentation of final rates by the RSD group<br>• Report to the task force and request for input |

Structure of PAYT program implementation continue

| **Key Concept** | **Challenges** |
|---|---|
| 3 months before implementation | • Continuation of public outreach and program participation fact sheet consideration<br>• Ratification of new ordinances<br>• Task force/enforcement personnel training<br>• Dedication of trained CSRs to attend to the residents' enquiries<br>• Employment of "error tags" that collection crews can attach to any garbage does not conform with specifications<br>• Reception and processing of appeals for support from special populations<br>• Selling of bags to the residents a month before implementation |
| Upon implementation | • Commencement of yard trimmings collections, expanded recycling collections and new bulky waste collection system<br>• Ensure that adequate CSRs are available to attend to the residents' enquiries<br>• Ensure that collection crews continue collecting garbage that does not conform with specifications for a month, before using the "error tags"<br>• Continuation of waste quantity and recycling levels monitoring |
| Ongoing activities | • Reconsideration of CSR staffing requirements<br>• Continuous bag inventory monitoring and obtaining/selling new bags as required to retailers<br>• Continuation of program monitoring with report to the appropriate councils<br>• Annual customer service evaluation<br>• Required program adjustment should be considered<br>• Review and circulate new public education materials as desired |

Chapter

# Evolution of Pay-As-You-Throw (PAYT)

The MSW management is one of significant services being rendered by municipalities to the citizens. However, the concerns of reducing waste have turn out to be one of most persistent environmental issues in a lot of countries. This is mainly as a result of different difficulties about the landfills. For instance, the landfill capacity happens to be progressively scarce as the existing landfills are moving towards the end of their lifespans. Using Ireland as a case study, the total municipal waste generated in 2005 was estimated to be over 3 million tonnes, whereas the annual landfill size was assessed to be approximately 1.8 million tonnes [67]. Besides there is an intense public resistance to the establishment of new ones. Moreover, strong hostility to extra incinerators siting are also evident in some jurisdictions. Consequently, the concerned authorities have realized the need for the introduction of unit-charging programs, known as PAYT not only to attend to an increase in the amounts of MSW but also to the concern on reducing waste as well as increasing recycling. Furthermore, the major goal of waste management is to set up a reliable material cycling society by means of the R's. The PAYT is capable of offering an effective stepwise guiding policy for a viable campaign of the R's. Also, studies have shown that attitudinal changes of residents caused by the implementation of PAYT schemes have a significant influence on the waste control. This results to reduction and reuse of waste in associated municipalities. In addition, PAYT offers an efficient platform for waste recycling promotion. Consequently, this chapter reviews evolution of PAYT in some countries taking Europe and United States as case studies. Moreover, their respective application experiences are well discussed. Furthermore, the associated PAYT legislation including state legislation and local ordinances are extensively considered.

## 3.1 Introduction

One of the main current and future topics of environmental protection is household waste management. In different parts of the world, there have been a number of consensus not only

on means of minimizing the aggregate quantity of the household waste but also on the maximization of recycling as well as recovery of household waste. These serve as the main pivot on which the key objectives of MSW management policies lay [68]. The concept of internalizing the external costs that are associated with waste production and disposal to the households with the intention of constraining them is the main idea of waste disposal quantity-based fee. Additionally, household waste can be minimized by changing the individual purchasing behavior. This can be achieved by purchasing goods with more recycling packaging or less packaging [67, 69]. It is remarkable that, the approach by which a lot of public authorities set comparatively uniform and arbitrary charges for municipal waste is inadequate. Also, it has been observed that the imposed charges are [67, 70]:

- usually not only insufficient to cover local authorities' waste management costs but also do not incorporate the external costs.
- not producing any incentive for people in order to reduce their waste generation or improve recycling efforts of the respective households.

Unlike the fixed charge systems, PAYT schemes are more efficient due to the subsequent justifications [67, 70]:

- considering environmental effects, it typically leads to 15–30% rise in recycling as well as a 30–40% reduction in waste to landfill.
- based on the economic effects, treatment and collection expenses are adjusted in accordance with the weight treated.
- PAYT schemes are the fairest system due to the fact that people are billed in line with what they produce.

In order to achieve the waste management goal effectively, a number of tools as well as institutional settings have been introduced by both the governments and municipalities [68]. Take for instance the United States (US) where PAYT schemes have received significant recognition, over 6000 communities that signify 20% of the total population have embraced the PAYT systems [73, 74]. In general, several communities normally charge households a fixed rate for their waste disposal. However, a fixed rate scheme is not effective for waste reduction. Consequently, the amount of waste produced grows persistently. Besides, the costs for waste treatment rose owing to the demand for state-of-the-art facilities as well as the associated challenges of obtaining new ones. Based on the aforementioned challenges, PAYT has been presented as an attracting scheme not only for waste reduction through waste generation control but also for facilitating waste recycling. For instance, a survey of US PAYT policies shows that variable rates are important factor that helped in increasing levels of recycling by 8–11%. Also, after accounting for the effects of garden waste and recycling programs, it was also shown that 5–7% of municipal waste reduction can be attributed to a variable rate policy in place [67]. Subsequently, various countries have acknowledged PAYT as an essential waste management tool in the 1990s and have supported its initiation through different programs in order to suit the precise structures of each municipality.Towards promoting PAYT schemes, a guidebook for the introduction of PAYT was published in 1994 by the US Environmental Protection Agency (US-EPA). Besides, the US-EPA proactively supports the PAYT establishment. With PAYT, communities have been observing considerable reductions in the quantities of waste, thereby treatment costs are reduced while recycling rates increases [73].

Moreover, the EU and Korea introduced PAYT programs as a waste management measure. Also, a number of other countries such as Canada, Australia, and Mexico, have introduced PAYT programs as well. In the 1990s, the EU organized pilot programs and studies on PAYT and in 2004, a handbook for the PAYT introduction was produced. Another main motivating factor for waste reduction is the EU's landfill directive (1999) [73].

It is remarkable that landfill happens to be the oldest form of waste treatment. However, it the least appropriate alternative due to its various associated possible adverse effects. The greatest and serious impact is the production as well as release of methane into the air [75]. Methane is a powerful greenhouse gas with a global warming potential (GWP) of 25 times more potent compared to carbon dioxide ($CO_2$) [71, 72, 76]. It can accumulate in the landfill mass and then eventually leads to explosions. Besides, biodegradable waste breakdown in landfill sites can discharge chemicals like heavy metals that may bring about a run-off called leachate. It should be noted that leachate can contaminate not only surface water and local groundwater but also the soil. These can cause risks to public health as well as the environment [75, 76]. No wonder it has been stated categorically that regarding municipal waste treatment, the economic instrument that functions best is the PAYT system [71,72]. Table 3.1 summarizes the key associated environmental effects of landfilling. Furthermore, Table 3.2 on the following page shows the changes in the municipal waste landfilled, incinerated, recycled and composted in the EU-27 from 1995 to 2009. Also, Figure 3.1 on page 32 illustrates the

Table 3.1: Major environmental impacts due to landfill of mixed waste [71, 72]

| **Environmental aspects** | **Advantages** |
|---|---|
| Infrastructure construction and maintenance | • Landscape appearance and loss of amenity value<br>• Biodiversity displacement<br>• Abiotic resource depletion<br>• Fossil resource depletion<br>• Land occupation |
| Machinery operations | • Acidification<br>• Photochemical ozone formation<br>• Fossil resource depletion<br>• Global warming |
| Sequestered resources | • Abiotic resource depletion |
| Landfill gas leakage | • Global warming ($CH_4$)<br>• Acidification and eutrophication ($NH_3 and NO_x$)<br>• Photochemical ozone formation ($VOC and NO_x$)<br>• Odour nuisance |
| Landfill gas capture and energy recovery | • Avoided fossil fuel combustion burdens<br>• Acidification<br>• Photochemical ozone formation |
| Leachate generation | • Eutrophication<br>• Eco-toxicity<br>• Waste water treatment plant burdens |

Table 3.2: Municipal waste landfilled, incinerated, recycled and composted in the EU-27, 1995 to 2009 [77]

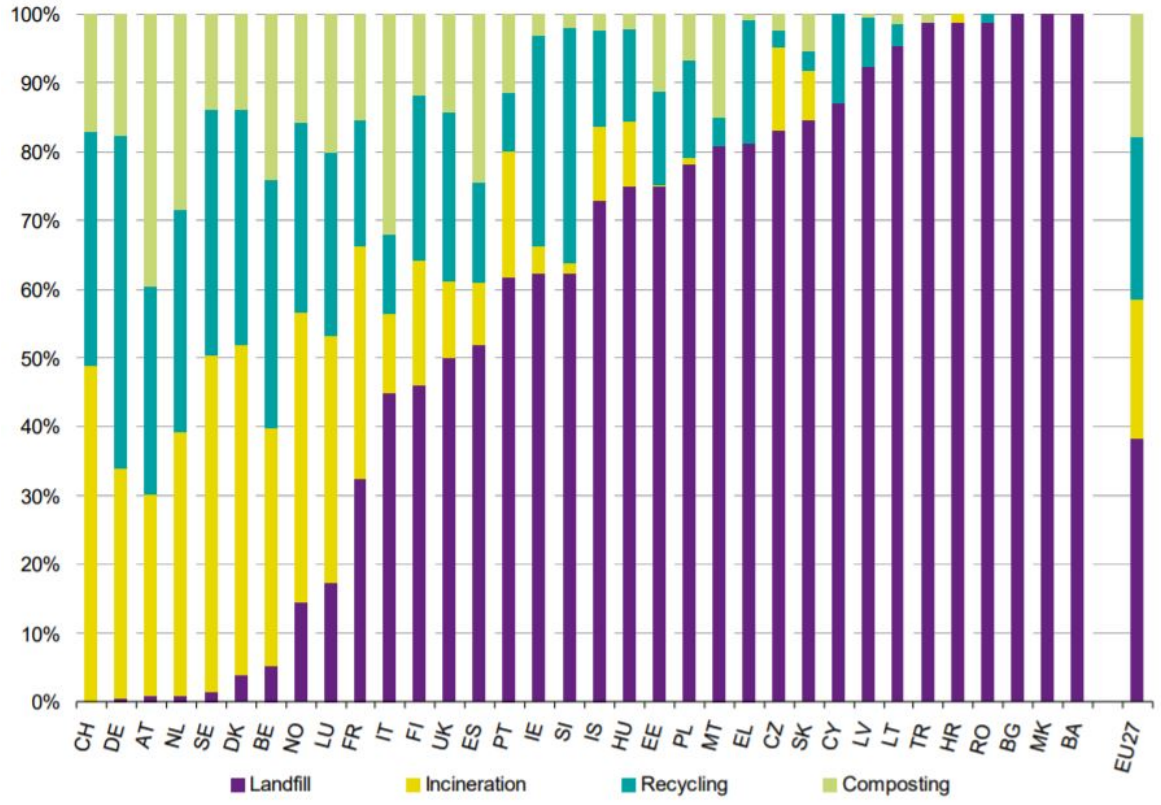
| Year | Landfill | Incineration | Recycling | Composting |
|---|---|---|---|---|
| | (millions tonnes) | | | |
| **1995** | 141 | 31 | 22 | 13 |
| **1996** | 138 | 32 | 23 | 15 |
| **1997** | 140 | 33 | 28 | 16 |
| **1998** | 137 | 34 | 30 | 18 |
| **1999** | 138 | 36 | 37 | 21 |
| **2000** | 139 | 38 | 38 | 27 |
| **2001** | 135 | 39 | 40 | 28 |
| **2002** | 131 | 41 | 46 | 32 |
| **2003** | 124 | 41 | 47 | 34 |
| **2004** | 117 | 43 | 49 | 36 |
| **2005** | 109 | 47 | 51 | 38 |
| **2006** | 108 | 49 | 54 | 40 |
| **2007** | 106 | 50 | 57 | 42 |
| **2008** | 100 | 50 | 59 | 44 |
| **2009** | 96 | 51 | 59 | 45 |
| **Change 1995-2009** | -32% | 63% | 172% | 239% |

amounts of municipal waste landfilled, incinerated, recycled and composted in 2008. It is evaluated as a percentage of the total amounts treated. [77].

Furthermore, the quantity of municipal waste being generated per person in the EU in 2015 was estimated to be 477 kg. This represents a 9% cut compared with its peak of value of 527 kg per person in the year 2002. However, it is to some extent up compared with the 474 kg noted in 2014. The generated amount varies considerably among the EU Member States. It has been observed that waste generated per person happed to be highest in Germany, Denmark, Malta, Cyprus, and Luxembourg. Figure 3.2 on page 33 depicts the amount of municipal waste generated per person (in kg per person) in the EU [78].

Furthermore, there have been several surveys and reports from different cities in America and European which indicate that, aggregate quantity of the household residual waste can be minimized while at the same time the recycling rate are maximized if citizens were charged in accordance with the actual quantity of the mixed (residual) waste that they generated. This result into the initiation of PAYT charging models. Likewise, it has been learnt that, public awareness has a huge impact and is a very essential factor for the effectiveness of the PAYT charging models [68].

There have been a lot of success stories and news of the PAYT system implementations around the world. Most of the reports confirm the positive effects PAYT charging models as means of considerably reducing the aggregate household generated residual waste. One of such is the reported 17% reduction in the residential disposal in the United States [79]. Similarly, there has been an approximately 20% reduction in the aggregate waste production of Germany based on PAYT system implementation. Furthermore, a 22% total waste production reduction in the cities of Czech has been reported [68].




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BE | Belgium | ES | Spain | MT | Malta | FI | Finland |
| BG | Bulgaria | FR | France | NL | Netherlands | SE | Sweden |
| CZ | Czech Republic | IT | Italy | AT | Austria | UK | United Kingdom |
| DK | Denmark | CY | Cyprus | PL | Poland | HR | Croatia |
| DE | Germany | LV | Latvia | PT | Portugal | MK | Macedonia |
| EE | Estonia | LT | Lithuania | RO | Romania | TR | Turkey |
| IE | Ireland | LU | Luxembourg | SI | Slovenia | IS | Iceland |
| EL | Greece | HU | Hungary | SK | Slovakia | NO | Norway |

CH Switzerland BA Bosnia and Herzegovina

Figure 3.1: Municipal waste treated in 2009 by country and treatment category, sorted by percentage of landfilling, (% of municipal waste treated) [77]

Moreover, the case studies of four municipalities in Japan have shown that employment of PAYT schemes reduces the quantity of generated residual waste by 20–30%. Also, it has been revealed integration of other procedures such as recycling of containers and packaging with PAYT systems may results into drastic reduction in the waste [73]. Also, there was a significant increase in the waste diversion rates in British Columbia when PAYT system was implemented. So, a 15 % reduction in disposal rate was noticed from 1992 to 2003 [80].

## 3.2 Evolution of PAYT in Europe

The European waste policy can be traced back to the publication of European Economic Community (EEC) directive 75/442/EEC in 1975. Then, it took considerable period before formal legislative backup and due attention was paid to the realization of the waste reduction

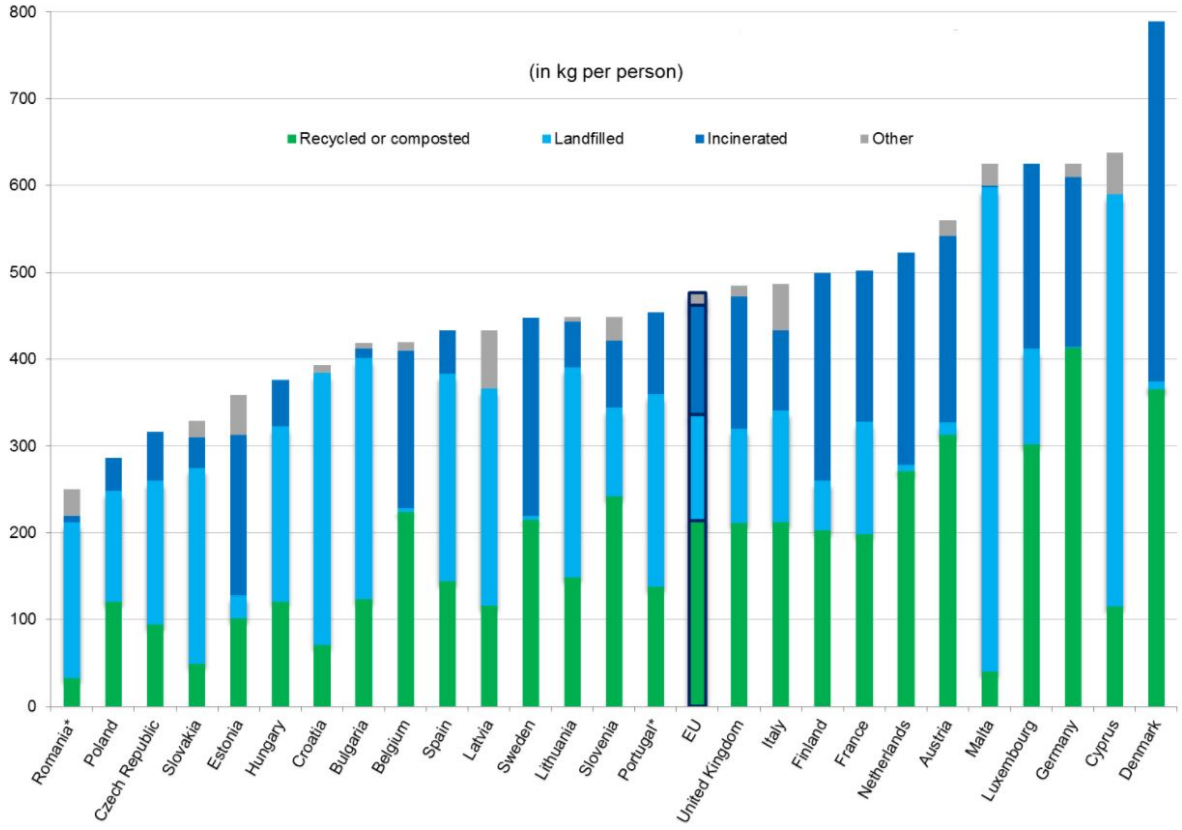



Figure 3.2: Municipal waste generation and treatment in the EU Member States in 2015 [78].

goals and diversion from landfilling [34]. The consciousness of the related landfilling risks brings about the calls for legislation at European level. According to the EU legislation, it is the responsibility of environmental authorities to issue permits, conduct inspections and ensure that the standards are met. The Landfill Directive (1999/31/EC) requires Member States to reduce the quantity of biodegradable waste send to the landfill to 35% of 1995 levels by 2016. This will lessen the problem of methane production considerably [76].

Furthermore, a formulation was incorporated in the aforementioned waste framework directive in 1991. According to the formulation, part of the costs which are not covered by the material reuse revenues should be retrieved according to the polluter-pays principle. Besides, Article 15 of the waste directive states that, waste management costs should be accepted either from the product consumer that produced the waste or the producer of the product that resulted in the waste. This indicates that the stipulation shifted the waste management costs burden on the waste producer [34, 81].

It is noteworthy that, the implementation of variable rate pricing in waste management based on the policy was not an invention. This is due to the fact that different type of PAYT system have been in practice in some counties. For instance, since 1932, San Francisco City in the US had practiced a kind of PAYT scheme. Also, around 1945, Austria had been employing the notion of individual waste charging [34].

Moreover, when PAYT implementation started in Europe, transponder equipment for tampering-proof electronic identification are deployed for waste collection services. This fa-

cilitates development of effective PAYT schemes that are applicable in densely populated urban settings where individually assigned waste containers are uncommon. This paves the way for a variable waste charging system to be feasible in a growing number of diverse settings. However, it should be noted that, the financial mechanisms being implemented for household waste management by the European countries are really distinct. For instance, there are some countries that are entirely tax-based with Great Britain being an instance of a kingdom that presents a legislation that disallows households so far an economic inducement for individual waste reduction via the application of a waste-related charging mechanism. Besides, there are some countries that engaged in an entirely waste generation-oriented as well as individualized charging schemes. Good examples of this are Switzerland as well as Luxembourg [34]. The map in Figure 3.3 shows the implementation of PAYT system within Europe [50].

Furthermore, for a polluter-pays-principle to be viable on the local ground, the municipal authorities in most European countries have to create enabling environment and appropriate framework. For instance, Italy, Denmark, Netherlands, and France have their national legislations that detailed or presented guidance on means of designing and rating the level of their waste charges. Additionally, national legislations have been complemented with regional or federal states' specific regulations on waste management and fundamental principles for the waste charges implementations in countries like Belgium and Germany. Moreover, extensive

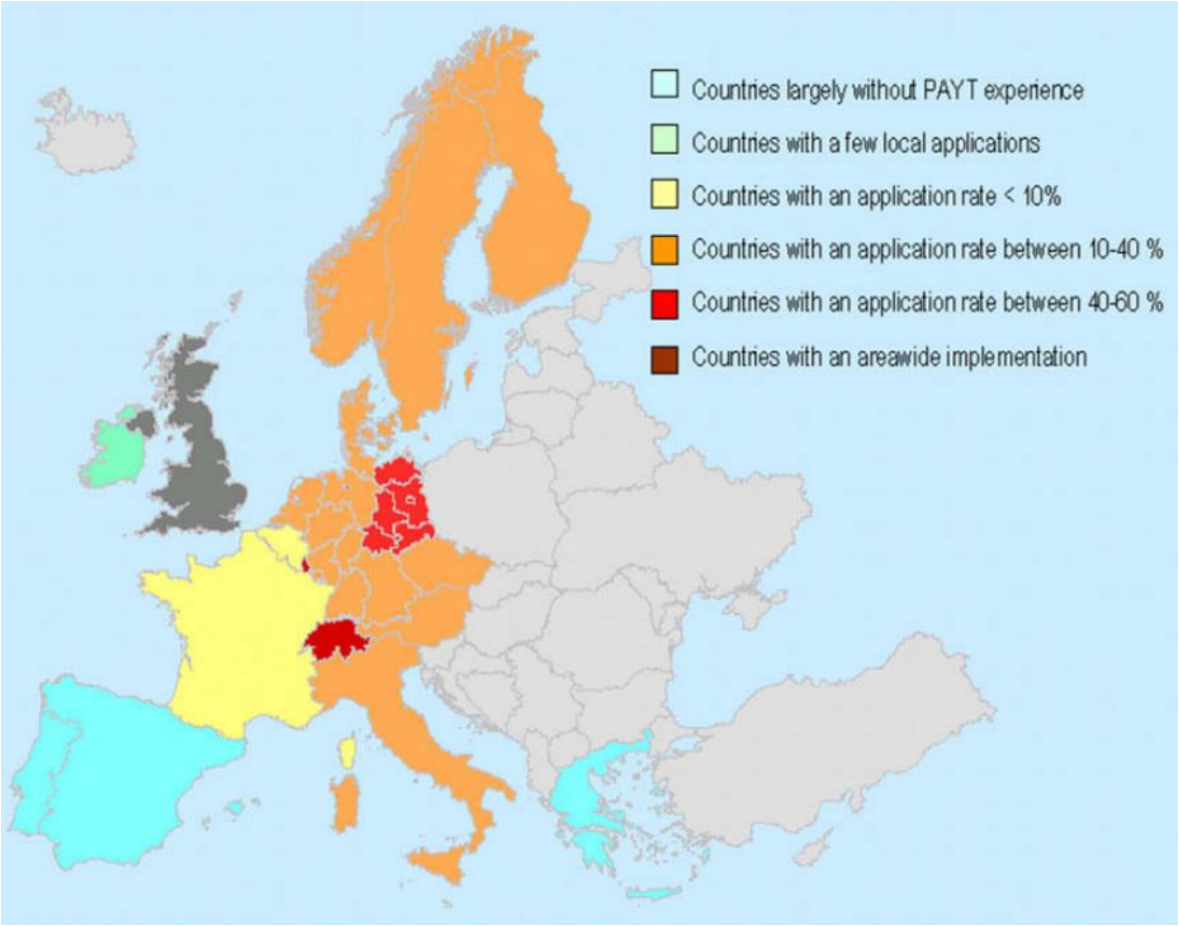



Figure 3.3: Application of PAYT in Europe in 2005 [50].

studies have verified that, incorporation of polluter obligation in the national legislation along with conditions concerning potential financial implementation mechanisms are the prerequisites for effective PAYT schemes. These usually incite not only the commencement of the pilot trials but also the full-fledged programs to apply PAYT and reduce disposal costs as well as residual waste amounts [34,82,83]. The majority of analyses on efficacy of PAYT programs in the US show that by the year 2000, there were 4032 communities in 43 states that embraced the programs. These communities jointly cover approximately 10% of the US population [67]. It is remarkable that, the majority of the countries that are joining the EU since 2004 and 2007 are incorporating the notion of user fees as the waste management financing core in their innovative waste legislation. For instance, in Poland, the approach facilitates individual service contract negotiations between the households and waste collection companies [34].

Moreover, the European waste policy recycling objectives and remarkable positive experiences in the PAYT implemented areas serve as substantial reasons for the review of waste management policy and structures in rather conservative states. They now focusing means of adjusting the waste disposal behavior among people with the aid of economic incentives [34].

Additionally, France and Ireland happened to adopt PAYT system later. Their respective governments reviewed the national policy programs with the intention of paving the way for more and stronger PAYT consideration for municipal waste management. Besides, the French government that has been criticized for not paying significant and due attention to reduce the waste growth and for ignoring the recommendations on national regulation as well as application of economic instruments for waste generation minimization, took action in 2005. Then, for the first time, the government presented an environmental charter that integrated the notion of prevention and polluter-pays principle in the French constitution. The policy attracted substantial awareness on the existing PAYT employment in France. Also, it led to a considerable growth in the amount of municipal corporations that had interest in analyzing as well as experimenting the potentials and effects of PAYT adoption [34].

Conventionally, Ireland relies on flat financing mechanisms and landfilling in waste management. However, during that period, a considerable progress was achieved. A notable instance was the recycling growth. This was about 40% of the accumulated waste compared to landfilled material rate of 90% in 2000. With better collection infrastructure on the ground that made waste diversion programs and selective collection accessible to over half of the population within a few years, 2005 was proclaimed as the variable waste charging initiation year by the environmental minister. The announcement then led to the weight-based charge establishment for the households in several municipalities. Also, a substantial drop in the waste quantities sent for final disposal were recorded [34].

In addition, even in Great Britain where waste charges were banned constitutionally and a movement to present waste bins that are recognizable with the aids of micro-chips caused furious headlines, a general awareness that paying for the quantity of waste generated is advantageous has been attracting considerable attentions. Consequently, waste charging can be discussed openly as an alternative to assist community councils in meeting the environmental and waste related challenges. Similarly, in Greece, flat rate waste charging system is in operation. However, when recycling rates started to grow at a snail's pace, in 2006, PAYT was included in the political parties' agenda [34]. The European Directive (EC, 2006) in Article 14 has inspired employment of the 'polluter pays' concept regarding household waste [67]. However, a resent study shows that Brussels has no PAYT system and waste management activities are funded by tax that includes fees [84].

There are a number of countries where PAYT has been effectively implemented. In those

countries, it has been observed that there are various technical options and charge models that have been embraced to enable the households to pay in accordance with their contribution to waste generation. By and large, a weight-or volume-based accounting and unit pricing are the widely employed schemes as depicted in Figure 3.4. In these schemes, the local authorities typically use their discretion in determining the best solution to be employed that can meet the local conditions. It should be noted that, determination of a fee structure that distinctly shows various waste services cost components while not only guarantees that the waste management marginal expenses as well as services are effectively covered but also ensures that incentives can be offered to households to reduce their waste, is really challenging. Moreover, European countries primarily have to enhance their waste management-specific costs and employ full-cost accounting as discussed in Chapter 5 on page 55 to ensure adoption of efficient procedures.

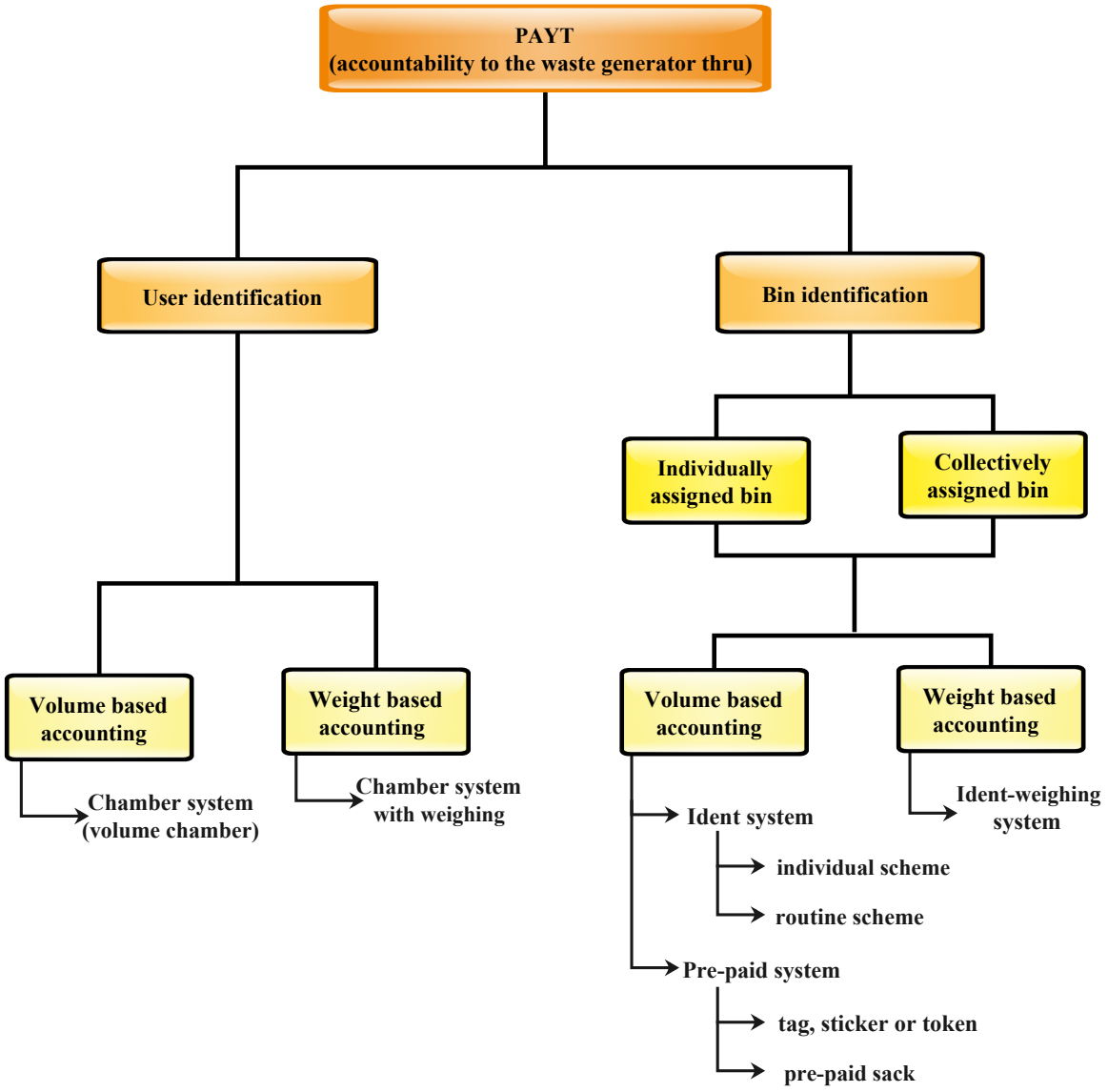



Figure 3.4: Principal alternatives for implementation of PAYT (adapted from [34]).

Besides, discovering appropriate and reasonable combinations of fixed as well as variable fee components that ultimately form individual household waste charge will then be another essential factor for the acceptance and realization of PAYT objectives [34].

Presently bin identification is the highly prevalent option for municipalities as well as waste management associations in Europe. Moreover, effectiveness of bin identification demands a reliable bin allocation system. This is even more essential in densely inhabited, multi-family areas, for guaranteed accountability for the generated waste. Different solutions such as locked container boxes, individually locked bins, and wire cages set up can be employed for a known circle of users. Apart from the maintenance and investment costs for these systems, the accessibility issue that can increase the required time for hauling processes deserves further considerations [34].

Moreover, as an alternative to a bin identification collection system, user identification collection system can be employed. In this system, the highly generic technical solution is provided in the form of chamber systems. These are also well-known as the lockhopper or waste lock installations. In these waste storage installations, users are required to dispose their waste via a specified feeding chamber. To use the facility, users has to be registered while accessing the chamber and deposited waste quantity has to be recorded. Subsequently, the authority in charge can bills the user or alternatively, the system itself subtracts an equivalent amount from prepaid credits of the users. The schemes have been employed for implementing PAYT on a full-scale not only in large housing blocks and shopping malls settings but also in a single-family house areas [34].

The well-established advantage of PAYT that distinguish it from other conventional household waste services charging schemes is the offered incentive by the PAYT. This facilitates diversion of certain percentages of waste material away from landfills or incinerators. Besides, with optimized collection, considerable savings can be achieved. Although each waste management system component has its own efficacy and influence on the quantity of saved and diverted waste, however, any instance of PAYT implementation has certain typical inherent patterns. For instance, there are various crystal clear results on the collected residual waste reduction as well as relative increase in the amounts collected in the systems for source-separated materials. Nevertheless, shortage of storage capacities in addition to space for the households' source-separated waste and uncomfortable or poorly developed systems for selective waste collection, have a discouraging impact on these efforts.

## 3.3 PAYT Schemes in United States

As stated earlier, PAYT systems have received substantial recognition in the US where over 6000 communities that signify 20% of the total population have embraced its implementations [73]. In another development, it has been presented that nearly 7100 jurisdictions in the US have adopted the PAYT systems. Consequently, it has resulted to diversion of probably 6.5 million tons of MSW per year (4.6–8.3 million). The aforementioned amount would have been landfilled without PAYT application. Moreover, the stated tons are as a result of the aggregate tons diverted to composting, recycling, and source reduction. Furthermore, the PAYT systems have been shown to be accessible to around 25% of the US population as well as approximately 26% of communities. This comprises 30% of the main cities in the US [35].

### 3.3.1 Penetration of PAYT Programs in the US

In the US, PAYT systems have developed from approximately 100 in the late 1980s to around 1000 in 1993, to almost 4150 in 1997 and then, to 5200 in 2001. Moreover, according to 2006 inventory, PAYT is accessible to residents in nearly 7100 jurisdictions around the US. Figure 3.5 on the following page shows 2006 PAYT Programs by State while Table 3.3 depicts the count of PAYT communities as well as the portion of total PAYT communities in each state. It has been shown that, the systems are accessible in nearly one-fourth of the communities in the US. This implies that the systems are open to approximately 75 million persons, or almost 25% of the US population. The states of Washington, Pennsylvania, Wisconsin, Iowa, New York, California, and Minnesota have the greatest amount of programs, each one of them has more than 200 programs in which some are mandated. Similarly, states with the largest portion of PAYT communities are California, Washington, New Hampshire, Minnesota, Oregon, Massachusetts, Wisconsin, Iowa, Michigan, and New York. They all have PAYT accessible in 40% or more of the communities in the state. Besides, New Hampshire and Wisconsin had over 75% of the communities with PAYT. In general, there has been a development of nearly 70% in the PAYT communities and some states that had no programs are now adopting it [35].

Table 3.3: US PAYT communities and share of communities covered by state [35, 60].

| State | Number of PAYT communities | % PAYT of all communities in state (%) | State | Number of PAYT communities | % PAYT of all communities in state (%) | State | Number of PAYT communities | % PAYT of all communities in state (%) |
|---|---|---|---|---|---|---|---|---|
| AK | 3 | 1.0 | KY | 1 | 0.2 | NY | 445 | 42.4 |
| AL | 2 | 0.4 | LA | 1 | 0.3 | OH | 243 | 23.1 |
| AR | 80 | 15.4 | MA | 139 | 59.1 | OK | 2 | 0.3 |
| AZ | 5 | 2.0 | MD | 49 | 13.3 | OR | 336 | 100.0 |
| CA | 536 | 50.0 | ME | 158 | 7.4 | PA | 253 | 18.0 |
| CO | 59 | 17.0 | Ml | 302 | 48.0 | Rl | 9 | 33.3 |
| CT | 25 | 21.0 | MN | 1850 | 100.0 | SC | 13 | 3.5 |
| DC | 0 | 0.0 | MO | 36 | 4.0 | SD | 20 | 6.0 |
| DE | 12 | 16.0 | MS | 0 | 0.0 | TN | 2 | .5 |
| FL | 9 | 1.0 | MT | 14 | 5.1 | TX | 20 | 1.3 |
| GA | 43 | 7.2 | NC | 64 | 10.0 | UT | 65 | 22.5 |
| Hi | 0 | 0.0 | ND | 8 | 2.1 | VA | 7 | 2.0 |
| IA | 539 | 57.0 | NE | 18 | 3.4 | VT | 180 | 20.3 |
| ID | 25 | 12.2 | NH | 45 | 75.0 | WA | 522 | 100.0 |
| IL | 170 | 13.0 | NJ | 55 | 11.0 | Wl | 512 | 81.3 |
| IN | 173 | 29.0 | NM | 2 | 1.0 | WV | 20 | 7.1 |
| KS | 8 | 1.3 | NV | 4 | 6.0 | WY | 2 | 1.0 |

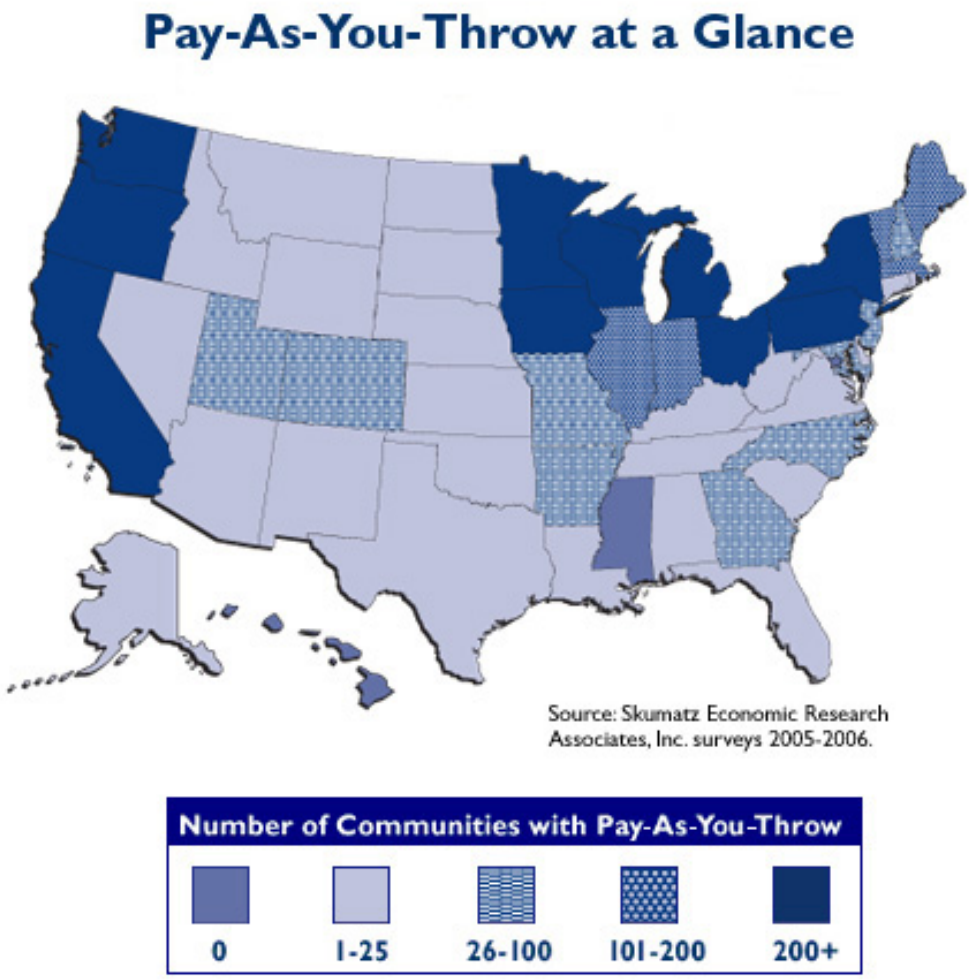



Figure 3.5: States with PAYT system implemented in the US in 2006 [35, 85].

### 3.3.2 PAYT Legislation in the US

There are different notable drivers for the PAYT implementation. The main drivers such as state legislation; instances of effective programs in other communities; higher landfill fees; and other drivers. Due to various success stories of PAYT, many states have deemed it fit to promote PAYT more officially and promote its implementation beyond a community-by-community basis. Also, several US states in addition to counties and cities have applied local or state legislation to the PAYT in the following ways:

#### 3.3.2.1 Mandatory

This implies that the entirely communities should apply PAYT. For instance, Minnesota has this system for all communities and Washington demands it from all certified haulers.

#### 3.3.2.2 Mandatory if goals are not met

In this, communities that are unable to reach 25% or 50% diversion by other methods are expected by some states to implement PAYT. Examples of this can be found in Wisconsin and Iowa where different approaches that are based on this system have been employed.

#### 3.3.2.3 Requirements to adopt a subset of menu strategies

This approach entails listing PAYT as part of list of options of recommended strategies in which a subset of the choices have to be adopted. Also, it is mandatory for the urban areas to employ more of the policies on the list than the rural areas. This approach is being implemented in Oregon.

#### 3.3.2.4 Other

This includes financial incentives such as grants for PAYT. It also entails active campaign/awareness about PAYT and voluntary recommendations that can been seen in states where PAYT is included in the state comprehensive plans or master plans.

#### 3.3.2.5 PAYT ordinances

Some cities or counties have been employing legislation that demands PAYT for the haulers (garbage companies). This enables them to be collecting waste from households within their jurisdiction. Studies have shown that, this is an effective approach for PAYT implementation as the haulers are enthusiastic about it provided that there is a level playing field for all haulers.

### 3.3.3 State Legislation and Local Ordinances

This subsection presents some analysis on the requirements, implementation, enforcement, as well as other features of the current PAYT legislation been employed at the local and state levels [35].

#### 3.3.3.1 Embedded fees and access for recycling

Embedded fees as well as access for recycling are the fundamental media for guaranteeing that households have tasks with the materials being diverted from the disposal stream owing to the PAYT incentive. Generally, this entails provision of curbside recycling containers to all households. Also, it demands that the curbside recycling program costs should be embedded into the garbage fee. It should be noted that, this does not necessitate that the service should be accessible at no cost, instead, it is believed that the garbage collection costs will be adjusted to include the aggregate cost of the trash as well as recycling collection efforts.

#### 3.3.3.2 Can size or service increments

Realization of the PAYT's incentive goal demands that the households should have service levels in place that can accommodate and reward diversion. Based on this, local as well as state PAYT legislations have incorporated conditions that cities or haulers must provide an alternative for a small trash container or bag. In reality, it has been shown that small

containers can be challenging and may not be suitable for certain application. For instance, they might not fit automated gripper arms properly, could blow over easily, and might not fit husky sized waste. However, it has been shown that many of the complications can be addressed by employing fortnight collection option for the smallest (standard-sized) container. Besides, larger containers are available at higher cost. Furthermore, since larger bags are always heavy and difficult to manage, then, multiple small bags are the key option of the schemes.

#### 3.3.3.3 Incentive levels

It has been noted that, high degree of difference between the service levels would probably increase recycling incentive. Consequently, the legislation section tries to guarantee that PAYT inducements are really significant. In some local ordinances, the minimum "multiples" for additional service level is usually specified. Also, some states demand that the garbage service increments rates should vary in accordance with the rate of service provision. It should be noted that, not only that small variations do not offer recycling incentives but are not also worth the PAYT associated administrative hurdles. With this, the key incentive objectives can be achieved, although this legislation element does not "set" rates for the haulers. The performance of a number of case studies on the employment of local economic instruments in municipalities is illustrated in Table 3.4 [71, 72].

Table 3.4: Reward schemes and PAYT performance (adapted from [71, 72])

| **Municipality or County** | **Instrument** | **Results** | **Additional comments** |
|---|---|---|---|
| Bracknell Forest, UK | Recycling incentive scheme | Improved public awareness and widely acceptability of recycling Increase of a total 1,000 tonnes of recyclables in one year of implementation (around 91 kg per household per year) | Urban, all recyclable |
| Torelles de Llobrgat, ES | PAYT, unit based | Increase of separately collected materials from 33 % to 89 %, reduction of mixed waste by 38 % | Urban, all waste streams |
| Landkreis Schweinfurt, DE | PAYT, weight-based plus fixed fee | Aggregate waste collected reduced by 28%, and mixed waste reduced by 46 %. | Urban, all waste streams |
| Ghent and Destelbergen, BE | PAYT, volume and unit-based | Aggregate waste arising reduced, but not only attributable to PAYT | Urban, all waste streams |
| Valongo and Gondomar, PT | Recycling incentive scheme at drop-off sites (collection centres) | Cardboard and paper increased by 14%, plastic, 9 %, glass, 75 %, batteries, 24 % and used cooking oils 74 %. | Urban, waste streams at 2 collection centers |

**Table 3.4 continued from previous page**

| Municipality or County | Instrument | Results | Additional comments |
|---|---|---|---|
| Limerick, Clare, Kerry Region, IE | PAYT, weight system | Reduction of mixed waste from 79 % to 65 %, and increased in collection of recyclables from 21 % to 32 %. | Urban and rural, all waste streams |
| Aschaffenburg, DE | PAYT, weight system | Increased collection of recyclables up to 86 %, decrease of mixed waste disposal costs, reduction of residual costs down to around 50 kg per capita per year | Urban and rural, all waste streams |
| Rotterdam, Barendrecht and Krimpen aan den Ijssel, NL | Recycling incentive system | Increased collection of 24 % (total waste), reduction of mixed waste of 37 %. | Called 'Cash for Trash', rewards are direct cash paid back to citizens |
| Bradford, Aire Valley Recycling, UK | Recycling incentive scheme | Increase of 36.5 kg recyclables collected per participant per year | Urban, all recyclables |
| Bath and North Somerset, UK | Recycling incentive scheme | Increase of 57 kg of recyclables per participant per year | Urban and rural, all recyclables |
| Birmingham, UK | Recycling incentive scheme | Increase of 5.2 kg of recyclables per participant per year | Urban, paper and cardboard |
| Gloucestershire, UK | Recycling incentive scheme | No increase or decrease of recyclables per participant per year | Urban and rural, all recyclables |
| Norfolk County, UK | Reuse and recycling incentive scheme | Increase of 99 kg of re-usables and recyclables per participant per year | Urban and rural, implemented through reuse shops |
| Student association in Bristol, UK | Recycling incentive scheme | Increase of 57 kg recyclables per participant per year | All recyclables |
| Preen Community in Bedfordshire, UK | Re-use incentive scheme | Increase of 67 kg recyclables and reusables per participant per year | Urban and rural, implemented through reuse shops |
| Westminster, UK | Recycling incentive scheme | No increase or decrease of recyclables per participant per year | Urban, all recyclables |

#### 3.3.3.4 Education and reporting

The local PAYT legislation inclines to incorporate two additional requirements. Communities as well as counties have recommended periodic education for the participating entities. They believe that this will help in enhancing the success of PAYT programs through the explanation of options and incentives to the communities. It has also been observed that collaboration between haulers and communities can even make the PAYT outreach program

more fruitful. Furthermore, communities understand that the required reporting of garbage as well as recycling tonnages helps in monitoring the progress and impacts PAYT programs. Also, the right to audit is additional significant legislation or ordinance element.

## 3.4 Conclusion

This chapter offers comprehensive reviews of PAYT evolution and application experiences in various countries with more focus on Europe and United States. In addition, extensively consideration is given to the related PAYT legislation such as state legislation and local ordinances. From this chapter, it can be inferred that attitudinal changes of residents caused by the implementation of PAYT schemes have a significant influence on the waste control. Consequently, PAYT has the capability to attend to the increase in the amounts of MSW. Moreover, it can significantly help in reducing waste and also encourages recycling. Therefore, PAYTs are effective tools for achieving the goal of waste management regarding the R's.

Chapter

# Waste Management Charging Systems Case Studies

The major concern in deciding on among the varieties of pricing structures is their effect on the residents' waste reduction efforts and on the stability of the community's revenues. Consequently, the PAYT charging mechanism is a key part in the system design. This is due to the fact that, the experienced challenges during the introduction as well as the effects of the PAYT program, depend mainly on the charging system employed. Therefore, this chapter presents various mechanism of charging for PAYT in different countries.

## 4.1 Czech Republic

The waste generated through the households, small businesses as well as town's operations are normally the responsibility of the municipality in the Czech Republic. Consequently, the municipality is in charge of the treatment of the resulting waste. In accordance with the enacted law, the main originators of waste are the municipalities. Their responsibility starts when a person (waste producer) disposes the waste in any designated receptacles such as bins and/or containers. The idea of bestowing responsibility on the municipalities causes economic challenges. Notwithstanding, a number of methods have been adopted for making the households pay for their waste treatment [68].

Furthermore, there have been considerable practice with both PAYT as well as flat fees schemes for waste treatment in the Czech Republic and its municipalities. Also, there is room for a hybrid scheme that entails different implementation approaches of both PAYT and flat fees schemes. It is remarkable that, prior to 2002, Czech municipalities have the privilege to select the preferred fee model. Nevertheless, as a result of legal regulation effected on January 2002, municipalities are constrained to charge a flat per capita fee for the waste treatment. However, as a result of political influence, the regulation was amended in 2003. The amendment then enables the municipalities to select a fee model that is contingent on and relevant to the local conditions [68].

### 4.1.1 Municipal Waste Fees Options in the Czech Republic

This subsection presents different options that can be employed by municipalities for waste payment collection. The options are based on the stipulated Waste Act No. 185/2001 Coll [68].

#### 4.1.1.1 Section 17, subsection 5 of the Waste Act

The subsection is based on the fee for the separation, accumulation, collection, recovery, transport and disposal of municipal waste from the actual waste producers. It is noteworthy that, this has to be a written agreement. Moreover, the actual amount of the fee should be specified. In addition, the municipalities are neither allowed to demand a fee for municipal waste as explained in 4.1.1.2 nor a local fee as discussed in 4.1.1.3 [68].

It is remarkable that, the fee is unregulated as no details or restrictions are provided by the Act. Consequently, the fee is completely negotiable and subject to the contractual agreement of the involved parties. In this scheme, the revenues are typically obtained from the waste bin volume as well as the frequency of waste collection. Similarly, the payment is not in the form of a charge but a consented payment for the rendered service. This choice is often employed settings such as restaurants, small craft businesses and accommodation facilities [68].

#### 4.1.1.2 Section 17a of the Waste Act

This section is on the fee for municipal waste. A municipality may stipulate a mandatory regulation for collection, accumulation, separation, recovery and disposal of waste generated within its cadastral territory based on its autonomous capability. However, the fee cannot be demanded in conjunction with a local fee for municipal waste as discussed in 4.1.1.3 [68].

Moreover, the property-owner of the real estate where the waste is produced is accountable for the fees. In a setting where there are association of owners of flat units, according to the law, the payer of the fee is going to be the association. So, the payer can then charge the fee proportionally to the respective contributors 4.1.1.3 [68].

Additionally, the utmost fee is usually established based on the justified costs of the municipality. This is as a results of the waste management system assigned to the respective contributors. Also, it is also determined by the amount and capacity of containers for waste disposal per individual section of the real estate. Besides, it can also be based on the number of people that are staying in an apartment and with regard to the extent of waste separation. In addition, the fee can also reflect the related costs for waste container leasing 4.1.1.3 [68].

#### 4.1.1.3 Section 84 of the Waste Act

The fee discussed in this Act Section entails the local fee for the operation of the system regarding collection, accumulation, separation, shipment, disposal and recovery of municipal waste. The fee is not meant to be concurrently applied with the fees discussed in 4.1.1.1 or 4.1.1.2. Furthermore, it is the duty of all local permanent resident to pay the local fee. Consequently, the fee can be turned over to the associated authority by the representative of the household. Moreover, the administrator or owner of the building for all households or permanent residents in the house can also remit the fee [68].

In a situation where there is no permanent resident residing in a building, the owners have to pay a waste fee for a recreational building. The payable amount is equivalent to 1%

resident. Furthermore, the aggregate yearly rate of this fee could amount to about 10 Euros (250 CZK) per recreational building or per person [68].

## 4.2 Japan

The PAYT scheme in Japan is based on a charging system that enables waste disposers to be charged part- or all of the waste treatment expenses independently from their taxes. Generally, the PAYT systems can be grouped into unit-charging and flat-fee systems. Besides, in some systems, specified disposal bags are used. Nevertheless, specified bags schemes are not normally considered in the PAYT systems. This can be attributed to the fact that, the specified bags schemes failed to achieve the fundamental objective of a charging system as it has been shown that do not contribute to waste reduction. Moreover, the charging systems that are being implemented in Japan can be categorized as simple unit-pricing programs and two-tiered pricing programs [73].

### 4.2.1 Simple Unit-Pricing Program

This program entails charging the residents in line with the quantity of waste that they generated for disposal and incineration. Also, a simple payment mechanism like prepaid bags or waste stickers are usually employed. Moreover, simple unit-pricing program is a fair scheme in which different sizes of bag are available depending on the individual choice. With this feature, it is envisaged that the program will be really effective in the reduction quantity of generated waste [34, 73]. Consequently, a lot of municipalities in Japan have adopted the program [73].

### 4.2.2 Two-Tiered Pricing Program

The rates charged for waste disposal in two-tiered pricing program depend mainly on the actual quantity of generated waste. Subsequently, the rates change with a change in the quantity of waste generated. In general, the two-tiered pricing program has three different categories. For instance, if a stipulated amount of waste is exceeded in the first category, the rates increase. Unlike the first category, there is no charge up to a specified amount in the second category. However, there will be fee if that amount is exceeded. The third category presents incentives to households that generate below a given quantity of waste [73].

It is noteworthy that, in a two-tiered pricing program, the impression of fairness as well as waste reduction effect are to some extent not up to the one perceived in a simple unit-pricing program. Also, compared with simple unit-pricing program, the two-tiered pricing program present more administrative. As noted in a municipality where a two-tiered pricing program is being practiced, residents tend to increase the intensity of inappropriate backyard burning with the intention of getting incentives. This prompted the municipality to shifted to a simple unit-pricing program. Moreover, there are programs that put low income households or ones that are in need of social care into consideration by exempting them from waste disposal charges [73].

Figure 4.1 illustrates the relationship between PAYT and the 3Rs in Japan's waste flow. It should be noted that, charging for waste dumping is mainly initiated in the residual waste (i.e. waste flow to be incinerated and landfilled). Therefore, the likely activities that can

be engaged in to avoid waste disposal charges are (1) reduce, (2) reuse, (3) recycle, and (4) illegally dump or burn in the backyard [73].

#### 4.2.2.1 Reduction

This is the fundamental option that can be employed to reduce the quantity of residual waste. Besides, it can be a means of reducing the quantity of natural resources that are inputted into the manufacturing process by encouraging the product design review. Also, reduction in the quantity of waste can cut the burden on collection services, on treatment

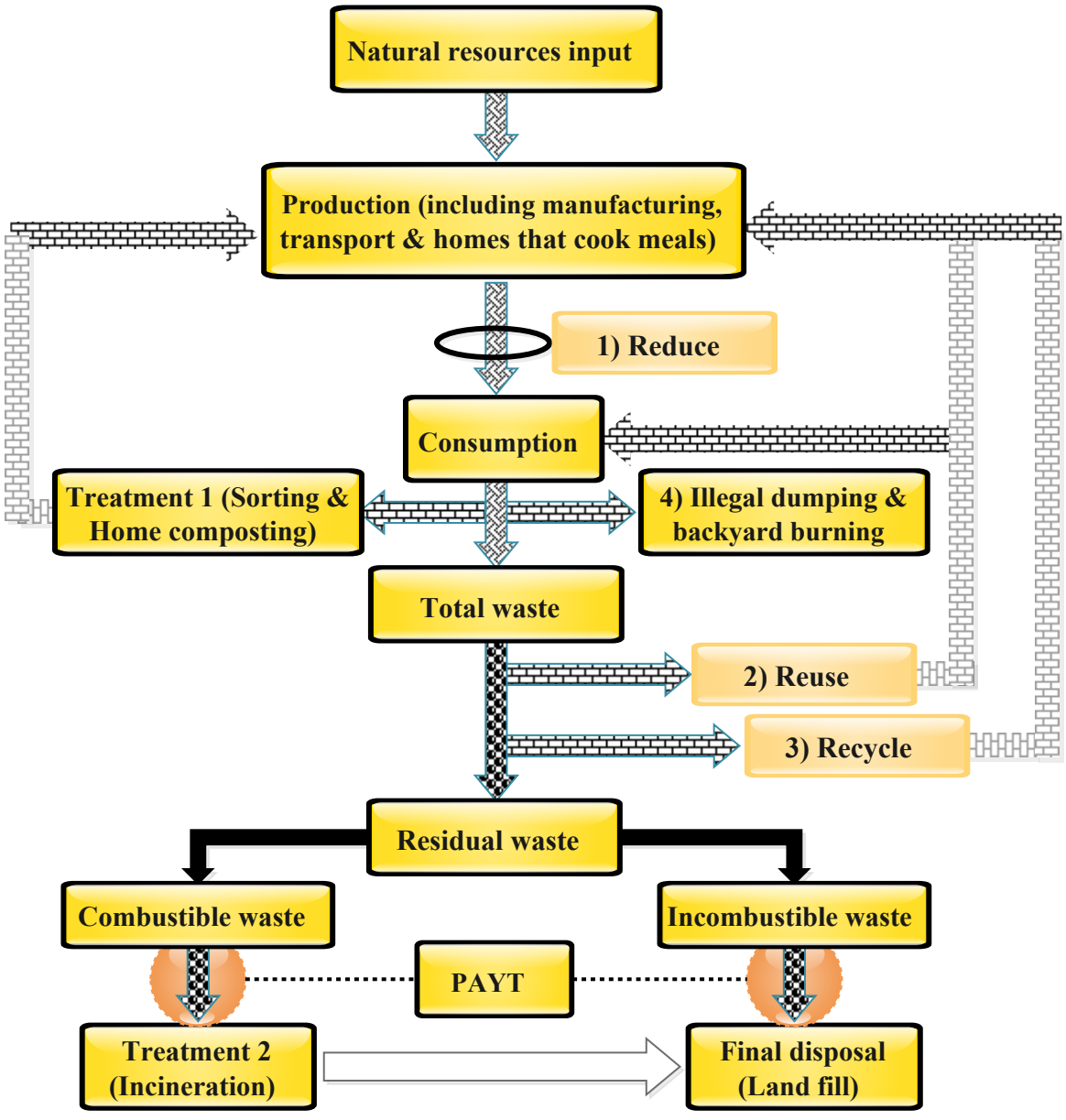



Figure 4.1: 3Rs (reduce, reuse and recycle) in the waste flow in Japan and its relationship with PAYT (adapted from [73]).

and on final disposal facilities. An instance of this is the reduction in the consumption which eventually minimizes the quantity of what will finally become waste.

#### 4.2.2.2 Reuse

This can be achieved by using items over again for the original or another purpose. So, the items or parts them can be use again.

#### 4.2.2.3 Recycling

This entails resource recovery that may be willingly performed by the communities and residents. Also, it can be achieved through the sorted collection of recyclables like containers and packaging by municipalities. Besides, it comprises home-based composting of garden and food waste. It should be noted that composting signifies that fewer waste goes to landfills.

#### 4.2.2.4 Backyard burning and illegal dumping

These are likely consequences of the control. Nevertheless, backyard burning has been prohibited and systems for monitoring illegal dumping have been improved.

In addition, a significant consequence of PAYT is the reduction in the quantity of generated residual waste. Generally, the waste reduction can be evaluated in terms of the quantity of residual waste that are shipped to disposal facilities. Here, unless otherwise specified, waste reduction represents a reduction in the amount of waste treated and eventually disposed.

## 4.3 United States

In major sections of the US, garbage collection is normally once or twice a week. Generally, the revenues for this come from the following methods of payment [35]:

- a portion of property taxes; or
- a fixed bill that is independent of the actual quantity of garbage collected.

It is noteworthy that, none of the aforementioned approaches offers any form of incentives for waste reduction. For instance, in the property tax method, customers do not even see their bills. Also, they do not have any idea on the required amount for a normal garbage collection [35].

Furthermore, the number of communities around North America that have been embracing the user-pay concept has been on the increase. This enables customers to have valuable information on means of reducing their waste. They are made to be aware of the fact that, garbage bills rise in accordance with the waste volume or weight to be disposed. Accordingly, PAYT has been implemented in a lot of communities to generate incentives for extra recycling as well as waste reduction in the residential area [35].

In addition, the PAYT systems are usually flexible and have been employed by various communities in different forms. Each of the forms is based on the concepts that less generated waste implies less charges. Moreover, the PAYT systems such as bag programs, can-based programs, tag and sticker programs, as well as hybrid programs are highly common forms of

PAYT programs in the US. It should be noted that, there were pilot programs on weight-based systems in the US, however, full-scale installation for residential service have not been reported. The weight-based approaches have been implemented in countries such as Germany, Denmark, and some other locations in Europe. The program types being employed in the US are discussed as follows [35]:

### 4.3.1 Variable- or Subscribed Can

This program enables the customers to select suitable number of cans (i.e. one can, two cans, etc.) or size of containers (i.e. 114–132 l [30–35 gal], 227–246 l [60–65 gal], etc.) for their typical weekly disposal. The rates for customers with two- or three-can service contract are greater than that of customers with one-can contract. Furthermore, in a number of communities, 49–76 l (13–20 gal) mini-can or 38 l (10 gal) micro-can service levels have been introduced with the intention of offering incentives to aggressive recyclers.

### 4.3.2 Bag Programs

This program offers the opportunity to purchase bags customers. On each bag, a particular city or hauler logo is imprinted. Accordingly, any waste that they are intending to dispose should be put in the correctly marked bags. Also, bags supporting from 114 to 130 l (30–35 gal) are more frequent, however, there several bags that are smaller. The bags are usually available for sales in places like grocery stores, community centers and convenience stores. This minimizes the usual inventory and invoicing issues. It should be noted that the bag cost includes collection-, transportation-, and disposal-cost of the waste placed in the bag. Moreover, some communities charge all costs in the bag price while others enforce an independent customer charge so as to reduce the associated risks of recovering the fixed system costs.

### 4.3.3 Tag or Sticker Programs

The tag/sticker programs are similar to bag programs. However, rather than using a particular bag, customers attach a given sticker or tag with logo to the waste that they are planning to dispose. The respective tags should be perceptible enough to collection personnel. This will enable them to know that the waste collection service has already been paid for. Similarly, tags are typically acceptable for 114 l (30 gal) with chances for increment of service like the bag scheme. Furthermore, the pricing as well as distribution alternatives are similar to the bag programs.

### 4.3.4 Hybrid System

A hybrid system is the combination of an incentive-based- and the existing collection systems. In this scheme, rather than getting unrestricted collection for payment of the tax bill or monthly fee, the customer acquires just a smaller and limited volume of service for the fee. Normally, this can be 1 or 2 cans or bags for the required service. Therefore, dumping of additional cans/bags that are outside the consented service necessitates the use of bags or stickers as aforementioned. The hybridized system is very appealing to the communities because change in the containers, billing system or collection system is not required. Also,

the service can be designed to suit the respective community. In general, several customers do not see the change in bills and heavy disposers are offered an incentive to be moderated.

### 4.3.5 Weight-based System

The weight-based system is known as "garbage by the pound" (GBTP) in its initial US pilot-test. It employs truck-based scales for weighing garbage containers. The customers are then charged in accordance with the real mass (either kg or lb) of garbage that is set out for disposal. Usually, there are on-board computers that record the household garbage weights and the customers are billed based on the measurement. Furthermore, radio frequency (RF) tags are normally affixed to the respective containers in order to identify the associated households that are responsible for the billing after weighing. The scheme has been experimented in the US. Also, there different certified scale systems in the US; nevertheless, in spite of several pilot tests in North America, there is no full-scale implementation in US or Canadian communities. The only application is in one community that employs the charging method for commercial businesses. Likewise, a new evolving development is a variant on the weight-based system known as "RecycleBank $^{TM}$". The salient benefit of this is that, it is very encouraging in areas where PAYT implementation is politically challenging. Rather than weighing the trash on-the-truck and charging by the garbage weight, the RecycleBank $^{TM}$weighs the recycling materials that the household presented and offers rewards and coupons for setting out more recycling at partaking stores. The RecycleBank $^{TM}$scheme can be employed with or without the PAYT alternatives and then offers a recycling incentive. It is remarkable that, the scheme does not give incentives for waste prevention or composting like the PAYT.

### 4.3.6 Other Variations

There are a number of communities or haulers in the US that present PAYT as an alternative in conjunction with their typical unrestricted system. Besides, other programs such as Waste drop-off, bag charging or by means of punch cards or other available customer tracking systems, are offered in various communities, more specifically in the rural areas.

In general, each of the considered scheme has benefits and drawbacks. Furthermore, based on the local conditions, certain schemes are more suitable than others. According to the US PAYT programs inventory review, it has been observed that, bigger communities and urban as well as suburban communities have a tendency to employ can programs. This is even more realistic with automated collection in place. Similarly, rural and smaller communities incline to adopt schemes such as tag or sticker and bag programs. It has also been observed that the drop-off and bag programs are more predominant in the East while the bag and can programs are mainly popular in the South and Midwest. Also, in the western US, the can programs are highly prevalent. It should be noted that, the simplest form of PAYT to be employed is the hybrid system.

Moreover, volume-based incentives can supposedly assist communities in achieving savings via reduced landfill usage; higher recycling levels; as well as efficiencies in staffing, routing, and equipment. Nevertheless, they possess some weaknesses. For instance, collection changes can bring about extra costs along with additional administrative burdens such as billing, monitoring and enforcement. Besides, rate fixing as well as revenues are more demanding and uncertain. Also, substantial expenses for public awareness are essential for effective application of a PAYT program.

## 4.4 Ireland

In 2003, Monaghan, a county in Ireland, changed from a fixed-rate bin charge to a weight-based approach in combination with the establishment of kerbside recycling. This resulted in 25% reduction in waste that would have been sent to landfill. This subsequently increased to 40% (average 740 kg per household) in 2005 which is the third year of the weight-based charges implementation. Around half of the estimation are associated with the recycling which happened to increase progressively per household from 0 kg to 210 kg in year 2003 and to 240 kg in year 2005. So, the remaining half of the reduction is perhaps due to organic waste home composting as well as individuals placing a lesser amount of garden waste and miscellaneous objects in the bin. These matters would have filled up much of the space as they normally do in a fixed charge schemes. It is remarkable that, certain percentage of the reduction is also due to individual visits to landfill as well as illegal dumping. Besides, various households can also reduce their waste by adjusting their purchasing behavior since households are billed according to the cost of landfilling the waste. This can be achieved by purchasing things with more recyclable packaging or with less packaging. Additional advantage of the PAYT billing system implementation is that, it gives precise data on household waste which can assist in planning and tracking results of innovative programs that might be introduced [67].

## 4.5 Other Forms of Implementation

It is remarkable that there are other forms of PAYT implementation. One of such has been adopted in a life pilot program in Aveiro Portugal in which Ecopoint is employed. The scheme is based on radio-frequency identification (RFID) that employs electromagnetic fields for automatic identification and track of tags. In this scheme, after the waste producers have been identified, they have access to the waste disposal mechanism and pay the corresponding fees with their card. The system is mainly implemented in a regular container offered by the local municipal. It is usually equipped with electronics for effective operation. The waste receptacle that is normally employed in the scheme is depicted in Figure 4.2 on the following page with black color. However, problems always arise when people tend to take unnecessary advantage and behave awkwardly by dropping their waste beside the containers due to the fact that they do not have subscription access to the containers or the bags are too big to inserted into the container mechanism. For mixed waste and recyclables, there are free differentiated containers This is illustrated in Figure 4.3 on the next page. Besides, when the bins malfunctioned due to one reason or the other and unable to close, people then use the avenue to dispose their waste by taking advantage of the situation. These scenarios are depicted in Figure 4.4 on page 53.

Similarly, another form of implementation is the reverse vending machine (RVM) that is sometimes called ‘return and earn’ or ‘recycle and reward’. RVM are automated machines that equipped with collection of sensors as well as microcontroller. The employed state-of-the-art technology enables RVMs to identify, collect, sort, and process used containers. During the course of the process, the sensors are responsible for user information identification, weighting and final automatic conversion of the weight to the corresponding points. After the process, the users can then claim their points with the aids of RFID point card. The overall process is governed by a microcontroller [86–93]. In general, the concept behind the RVM scheme is that, it takes used containers and give money back to the disposer [88].


Figure 4.2: Ecopoint waste receptacle

Figure 4.3: Ecopoint waste receptacle challenges.

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The RVMs are common in places where there are mandatory recycling laws or container deposit legislations. Countries such as UK, Australia, China, Dubai, Norway implement RVMs in order to encourages recycling. Recently, RVM scheme has also been implemented in Lituania. It is noteworthy that, the majority of the accepted containers are Category B. This implies that it is obligatory to return the containers to an approved collection depot for the subsequent refund. The Environment Protection Act, 1993 (the Act) regarding RVM can be found in [94]. Different scenarios for RVMs implementation are illustrated in Figure 4.5 on page 54.


Figure 4.4: Malfunctioned Ecopoint waste receptacle


Figure 4.5: Reverse vending machine implementation.

## 4.6 Conclusion

This chapter discusses a number of challenges of PAYT pricing structures in different countries considering the residents' waste reduction efforts as well as the stability of the community's revenues. Moreover, it shows that PAYT charging mechanism is a key part in the system design. It has been shown that PAYT incentives can assist communities in achieving savings via reduced landfill usage; higher recycling levels; as well as efficiencies in staffing, routing, and equipment. Nevertheless, are some likely consequences of the PAYT control scheme. For instance, some people likely tend to engaged in illegally dumping or burning in the backyard in to avoid waste disposal charges. Consequently, there is a need for backyard burning prohibition and improved monitoring of illegal dumping in different countries. Other viable forms of PAYT implementation that encourage recycling have been presented.

Chapter

# Financial Assessment of Pay-As-You-Throw Schemes

It has been observed that, municipal waste services expenditure has been escalating persistently. Moreover, the alternative SWM currently in practice renders the associated schemes more challenging. To address the situation, municipal organizations have been working towards limiting and re-allocating the cost of SWM through a series of measures. One of such is by revolutionizing the rendered services structure. Besides, the municipal organizations are campaigning for the reduction/avoidance of MSW generation. Nevertheless, SWM policy development as well as decision making are experiencing diverse challenges and limiting factors. This chapter presents means of estimating the PAYT charging unit price for various implementation scenarios of the "polluter-pays" principle. The waste management cost input is computed for each considered scenario. Moreover, the total waste charges for households are evaluated as well.

## 5.1 Full Cost Accounting

The full cost accounting (FCA) is a method of information collection and presentation for each obtainable alternative to facilitate an effective decision. This could be determined considering different effects such as economic, social, as well as environmental impacts. The main goals of FCA are to quantify, recognize, and allocate the associated cost to a product or process by considering in a suitable scenario, the social as well as environmental cost. Consequently, FCA can be exploited as an effective measure for financial assessment of PAYT systems [95–98].

It should be noted that, decision making is highly difficult and varies from one application scenario to the other. Taking Ireland as a case study, for 120 L of waste a week, the charges for collection and disposal range from €195 (Fingal) to €440 (Carlow) per annum. Also, taking Guimarães where 34% decrease in unsorted waste and 126% increase in recyclable

waste has been recorded as a case study in Portugal, the charges for different liters of bag is given in Table 5.1 [99, 100]. Figure 5.1 shows the per annum cost of 120 L black bin waste in different parts of Ireland [67]. Consequently, the variation in the charging systems calls for the implementation of FCA to ensure effective decision in respective application areas.

Table 5.1: Bag charges in Guimarães, Portugal [100].

| **Bag volume** | | | | | |
|---|---|---|---|---|---|
| **30 L** | | **50 L** | | **100 L** | |
| # of bag | price/bag (€) | # of bag | price/bag (€) | # of bag | price/bag (€) |
| 1-8 | 0.345 | 1-5 | 0.575 | 2 | 1.150 |
| 9-24 | 0.348 | 6-14 | 0.580 | 2-7 | 1.160 |
| 25-40 | 0.354 | 15-24 | 0.590 | 8-12 | 1.180 |
| >40 | 0.360 | >24 | 0.600 | >13 | 1.200 |

Furthermore, based on [95] , this thesis discusses the implementation of FCA for comparing various waste collection system and the associated charging schemes. This is achieved by comparing the waste services cost for the authority as well as the total waste charges that citizens are responsible to pay. This will help in recognizing a more profitable and appropriate scheme not only for the citizens but also for the authority.

## 5.2 Theoretical Approach

The implementation of FCA considering SWM at the municipal level offers the following to the municipal authorities [95, 96]:

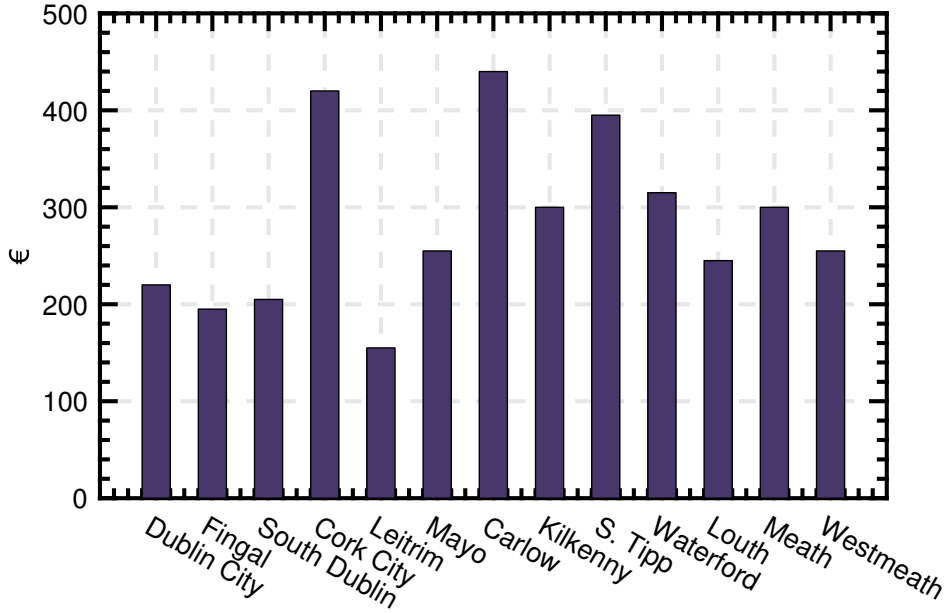


Figure 5.1: Per annum cost of 120 L black bin waste in Ireland [67].

*i)* A handy as well as effective tool for analyzing and planning the future budgets;

*ii)* An ability to detect a hidden cost;

*iii)* The competency to trace and restructure inadequacies of the scheme which will be even more effective provided that FCA is implemented yearly;

*iv)* The potential to estimate situations under financial viewpoint as well as possible influence on the quality and quantity of MSW;

*v)* The means of investigating the capability for applying innovative waste collection schemes and the associated charging systems whose objective is to give financial inducements to the citizens for cutting waste generation as envisaged by the PAYT systems.

Generally, based on the implementation of a PAYT system, FCA signifies, among other things, a suitable process for pricing/calculating the waste services fee-rate [66, 95].

Furthermore, the PAYT schemes result in a new viewpoint for municipal authorities regarding SWM. Usually, a PAYT scheme can be distinguished using factors such as the solid waste collection method, pricing, rate design and billing system. Besides, charging can be achieved with respect to the weight or volume of the waste generated. Furthermore, the volume-based system differs in accordance with the method employed or collection process as follows [95].:

*i)* Standardized prepaid bags;

*ii)* Bins of fixed or variant capacities;

*iii)* Common bags with standardized prepaid tags or stickers; and

*iv)* Frequency scheme, in a situation where charging is determined by collection frequency for an individual waste producer.

It should be noted that, though these systems are not operating in the same way, they are based on a common feature which is more residual waste production implies paying additional charges [63, 66, 82, 101].

In addition, bearing in mind the fact that municipalities vary in features such as size, governmental policies, and demographics, just to name a few, consequently, the evaluation of which PAYT scheme to be employed and the implementation procedure to be adopted have to be contingent on the local conditions as well as demands. Also, due attention should be paid to fundamental factors like the cost; nature of the rendered services; prospective contemporaneous programs; prerequisite administrative and managerial changes level; public support and participation level; instead of the citizens' hostility to the new program [82, 95, 102].

## 5.3 Practical Approach

This subsection focuses on the charges that citizens will be responsible for concerning the waste services in various PAYT implementation scenarios. The analysis can be grouped into the following on a practical level:

1. The MSW management (MSWM) cost ($C_T$), which relates to the authority that is employing the scheme and;

2. The level of charges, which relates primarily to the citizens.

### 5.3.1 Municipal Solid Waste Management Cost Analysis – Towards Authority

The fundamental measure in this method is to examine the existing condition such as (equipment, managerial structure, final disposal, transportation, collection, recycling, transfer, treatment, qualitative and quantitative data, responsible finances, authority, organizational frame, administrative structure, local regulations, national legislation, and demographic as well as geographical information, in the local SWM.

Moreover, the PAYT system's application accomplishment can be quantified by employing a number of conditions such as the $C_T$, fraction of commingled waste to be recycled and citizens' participation rate. It is remarkable that determination of targets is one of the most significant measures for a new program implementation. This centers on the evaluation as well as further investigation of the managerial requirements and municipality main concerns. Besides, target classifications are also essential, because, it is significant in the unit-pricing and rate-structure design selection.

In addition, the process can be accomplished by estimating the investment cost. Then, FCA can them be used for the $C_T$ assessment and computation. The $C_T$ can then be compared for different application settings which might be varied in line with the charging and collection process being employed. It should be noted that, FCA centers on the economic recourses flow and identifies costs as resources committed or else employed, irrespective of the time that the money is spent. Also, depending on the implementation scenario, the cost types may vary from one municipality to the other. The typical cost types that need consideration are:

*i)* The up-front costs: This is an initial investment floated for acquiring and launching technology and equipment that are highly essential. Besides, it a cost offered for public information campaign

*ii)* The operating costs.

Moreover, the yearly depreciated operating and up-front costs represent the annual waste management cost $C_T$ [€/yr]. also, the $C_T$ can be divided into fixed ($C_c$) and variable ($C_v$) components. As shown in Fig. 5.2, the $C_v$ includes waste collection, transportation and final disposal cost (tipping fees) as well as the procurement cost for stickers and bags. In general, the $C_v$ covers the entire costs which may vary in accordance with the collected waste. This is based on the assumption that municipal authority will not changes the personnel. Similarly, the $C_c$ consist of all remaining depreciated and operational investment costs.

The reduction in $C_T$ can be evaluated, which is due to likely citizens behavioral and attitudinal change concerning waste generation in addition to an individual SWM.

### 5.3.2 Waste Charges– Towards citizens

The charges that citizens will be responsible for concerning the waste services ($W_T$) in various PAYT implementation scenarios can be compared and evaluated. The SWM charges

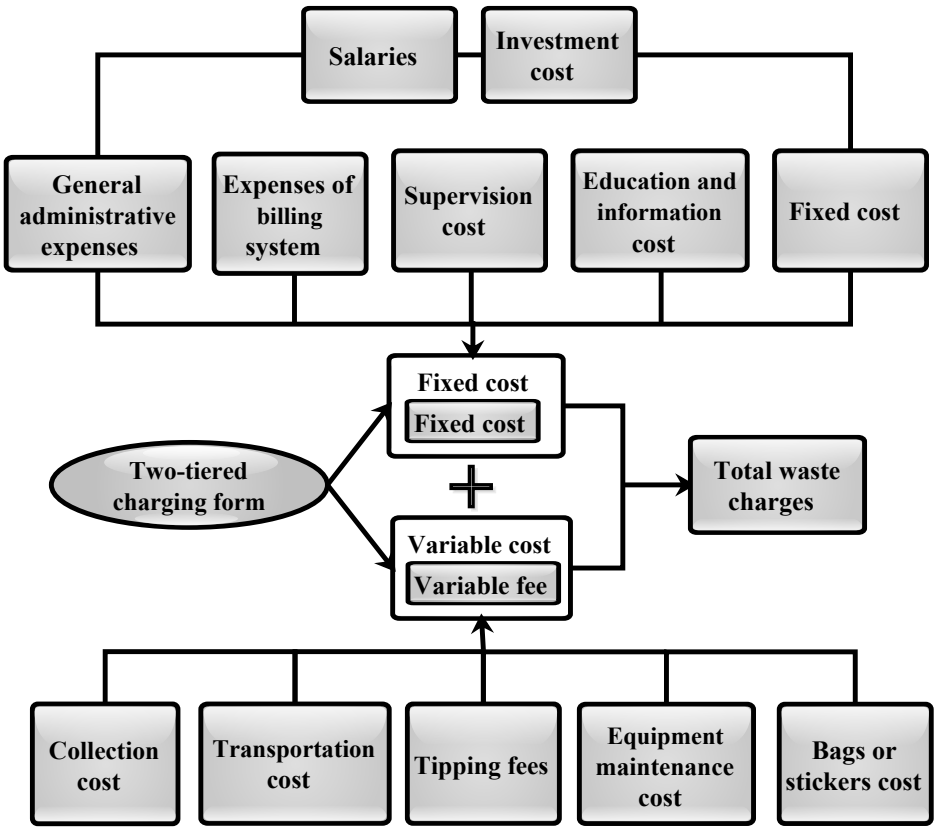


Figure 5.2: Total waste charges calculation based on two-tiered charging form (adapted from [95]. )

can be enforced by a flat-rate system. Using Panorama as a case study, the associated fee, the charging coefficient, is charged on a $m^2$-basis for the served area. The fee is controlled by the city councils on a yearly basis. A typical rate for Panorama municipality waste services pricing system in 2005 is illustrated in Table 5.2. The fee is normally collected via electricity bill. In some cases, according to the legislation, it might not only entail the MSW management (MSWM) costs recovery but also other charges such as street lighting cost.

In line with the existing pricing system, the municipal charge for respective estate can be evaluated on an annual basis by

$$M = C \times A \tag{5.1}$$

where $C$ denotes calculation coefficient [€/$m^2$.yr] that is related to a specified estate and $A$ represents the surface of the real estate [$m^2$].

In accordance with the PAYT charging systems, the total waste charges $W_T$ can be estimated using a two-tiered charging form as

$$W_T = W_c + W_v \tag{5.2}$$

where $W_T$ is the total waste charges [€/yr h], $W_c$ represents the fixed fee that is common for all households [€/yr h] and $W_v$ denotes the variable fee [€/yr h].

Table 5.2: Panorama municipality waste services pricing system in 2005 (adapted from [95].)

| **Charging method** | **Annual fee based on $m^2$ of the served property** |
|---|---|
| **Residential residual waste** | 2.34€/$m^2$ yr |
| **Commercial residual waste** | 3.99€/$m^2$ yr |
| **Residential source separated waste** | Free of charge |
| **Commercial source separated waste** | Free of charge |

Furthermore, when $W_c$ and $W_v$ that comprise $W_T$ are known, the four scenarios of PAYT programs can be distinguished by the charging method as follows [95, 102, 103]:

- weight-based scheme
- volume-based bin scheme
- volume-based bag scheme
- volume-based sticker scheme

## 5.4 Conclusion

The FCA has been presented as a tool that facilitates an effective decision on PAYT financial assessment in this chapter. FCA helps in quantifying, recognizing, and allocating the associated cost to the PAYT schemes by considering in an appropriate scenario, the social as well as environmental cost. So, FCA is a feasible means of addressing challenges and limiting factors of SWM policy development as well as decision making.

Chapter

# 6

# Survey Results of Different Countries

There are a number of positive impacts of PAYT that have been reported in the literature. The impact differs from municipalities to municipalities as well as countries to countries. For instance, in the US where over 20% of the population have access to PAYT system, waste reduction in the municipalities is evaluated to be approximately 16–17%. This corresponds to approximately 3.2% of the quantity of discharged residential waste. Furthermore, source reduction is evaluated to roughly 6%. Also, this corresponds to approximately 1.2% of the quantity of the discharged residential waste nationwide [73]. This chapter presents various effects of PAYT systems on waste reduction as well as source reduction.

## 6.1 Czech Municipalities Survey Results

In the Czech municipalities survey, Šauer et al. employed 157 municipalities with 2,672 inhabitants in the analysis [68]. Some samples were not processed due to incomplete or seemingly invalid data. The analysis are as discussed in the following subsection.

In order to analyzes the samples, the municipalities were classified into two groups based on the household waste scheme payment being employed. Moreover, the average quantities of total generated as well as mixed (residual) and separated waste per capita were determined for the groups. The results of the samples are presented in Table 6.1 on the following page. Similarly, fig. 6.1 on the next page depicts the mixed and separated waste percentage in the Czech municipalities [68].

With reference to Table 6.1 on the following page and fig. 6.1 on the next page, it can be deduced that municipalities that implements PAYT separate more and generate a lesser amount of mixed waste than those without PAYT. Furthermore, the statistic was verified using 5% level of significance. This enables the confirmation of the hypothesis which states that, municipalities that implement PAYT schemes have high tendency of reduction in the

Table 6.1: Average amount of municipal waste production per capita in kg and % in 2001 in municipalities with and without PAYT implementation (adapted from [68])

| Category | Number of municipalities | Number of inhabitants (in thousands) | Municipal waste | Separated waste | Mixed (residual) waste |
|---|---|---|---|---|---|
| **Municipalities with PAYT** | 92 | 1,540 | 240(100%) | 29(12.1%) | 211(87.9%) |
| **Municipalities without PAYT** | 65 | 1,132 | 260(100%) | 18(6.9%) | 242(93.1%) |
| **Total** | 157 | 2,672 | 244(100%) | 20(8.2%) | 224(91.8%) |


(a) (b)

Figure 6.1: Percentage of mixed and separated waste in the Czech municipalities for (a) municipalities with PAYT and (b) municipalities without PAYT (adapted from [68]).

production of mixed (residual) waste [34, 73]. Consequently, there is a substantial increase in the separated waste percentage. Furthermore, at equal level of significance, a considerable decrease in the total volume of municipal waste in municipalities with the implementation of PAYT was achieved compared to municipalities without PAYT implementation.

## 6.2 Japan Municipalities Survey Results

It is noteworthy that, in Japan, initiation of new PAYT systems climaxed in the early 1970s and for a second time in the 1990s. The 1970s boom was attributed to the improvement on the Waste Management Law in 1970. Moreover, the 1990s development was generally based on the communities were exploiting an amendment to the Waste Management Law in 1991 [73].

Moreover, as illustrated in Table 6.2 on the following page, the number of municipalities in Japan that have employed PAYT for residential combustible waste by 2003 was 954 (30.2%). Moreover, for the same period, 686 (21.7%) municipalities have implemented PAYT for residential incombustible waste. The aggregate populations of the municipalities that have employed PAYT for combustible waste were about 18M which signified around 14.4% of

Table 6.2: Effects of PAYT on waste in Japan (adapted from [73]).

| Category | Combustible waste | Incombustible waste |
|---|---|---|
| **Municipalities with PAYT** | 954 (30.2%) | 686 (21.7%) |
| **Municipalities' populations** | 18M (14.4%) | 13.6M (10.6%) |

the national population, while those that applied PAYT for incombustible waste were about 13.6M that indicated approximately 10.6% of the national population [73].

In addition, in the regions such as Kagawa, Gifu, Tottori, Hyogo, Saga, Oita, and Fukuoka, over 50% of municipalities have employed PAYT for combustible waste. However, in the regions like Kumamoto, Mie, Kanagawa, Kyoto, Aichi, and Iwate, less than 10% municipalities have implemented PAYT. From the analysis, over 50% of the population implemented PAYT Just in Saga and Shimane while below 10% of the population in Tokyo as well as other 17 regions is included in the PAYT programs [73].

## 6.3 Germany Municipalities Survey Results

There are some studies that are relating the condition in various European municipalities prior to and after the PAYT establishment. Since the PAYT systems are implemented to enable a change from mixed waste collection to source-separated collection, in Germany, households are expected to separate their domestic waste. This enables recycling rate to increase from approximately 10% in 1992 to more than 40% in 2007 [104]. Also, a rise of more than 70% has been reported for a source-separated waste material in the selective collection systems. The affected materials connect generally to kitchen waste, sales packaging and paper. These materials happen to be the traditional target of recycling programs and selective collection in Europe. However, considerable amount of these materials are still in the residual waste [34]. For instance, Germany has established packaging material collection on the national level since early 1990s via the supposed dual system. The system ensures packaging disposal payment by means of license fees. Therefore, selective collection was portrayed as a quasi-free collection service for the household.

It has been observed that, the closer the waste charge link to the generated residual waste and the real amount of residual waste services received, the greater the people's predisposition to participate in source separation as well as recycling efforts. The tendency can be perceived easily even when a little waste charge percentage is directly associated to the waste quantity and/or received service. Table 6.3 on page 65 illustrates the average waste amounts collected in German municipalities with the charging mechanism employed for residual waste services [34].

With reference to Table 6.3 on page 65, it is obvious that, fully variable charging implementation results in additional residual waste quantity reduction as well as increase in the separately collected recyclables. However, it can bring about illegal dumping which is a situation where people refuse to use the existing waste services and instead, engage in undesirable disposal practices. This menace can be addressed by the addition of either a fixed fee or compulsory minimum of payable services in the PAYT waste charge system. Moreover, positive

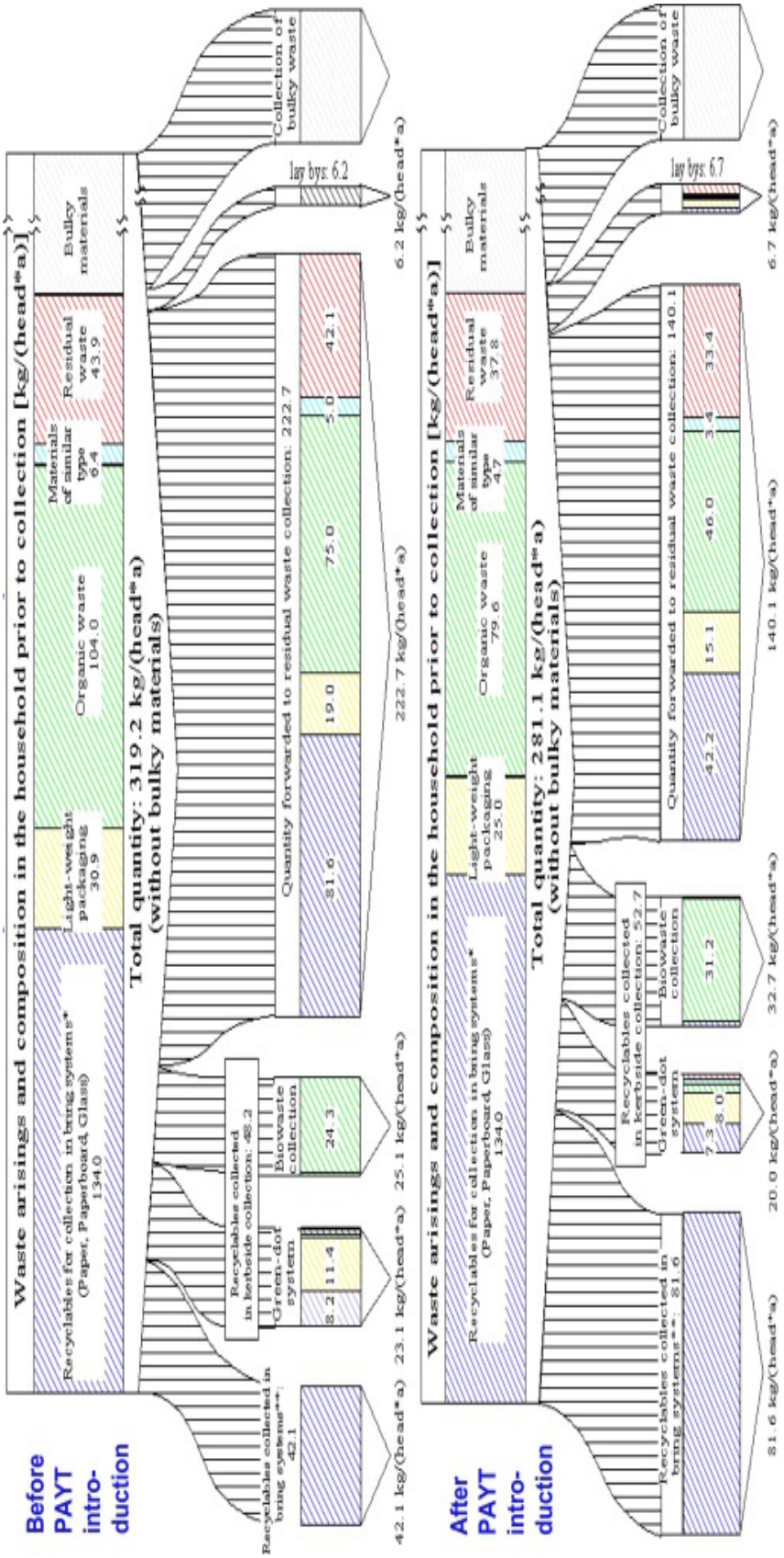


Figure 6.2: Waste flow developments due to the introduction of PAYT in a pilot area in the city of Dresden [34].

changes in the people's disposal behavior have been observed in a system with charges for the acquired residual waste services while recyclables collections are offered for a lesser or zero charge. Figure 6.2 on the previous page offers a suitable instance of the normal reaction of households. The illustrated waste flow study was performed in a pilot area of PAYT in the city of Dresden [34].

Additionally, initiation of practical solutions like chamber systems and locked bins for the PAYT implementation often occurs at the expense of a limited accessibility of large-sized objects to the waste containers. Consequently, materials of that category are usually dispatched to bulky-waste assembly systems. For instance, a minor rise in lay-bys from 6.2 to 6.7 kg per capita per year was witnessed. On the other hand, if container sites and locked bins are not employed and an area-wide PAYT coverage is provided, the condition might have been different. Hence, it is imperative to employ some technical measures with people awareness and sensitization on the consequences of wrongful conduct in the PAYT systems.

Moreover, the change in the aggregate amount of collected waste as well as drastic shift from the residual waste collection towards the systems that present source-separated recyclables is substantially discernable. A closer look shows 319 kg per person per year of collected household waste prior to the establishment of individual waste charges. However, within six months of introducing waste charges, collected household waste dropped by approximately 12% (i.e., to 281 kg per person per year). Furthermore, utmost reduction rate in the overall waste generation is shown by organic waste. The advancement can be attributed to the intense efforts for the organic wastes composting at home. Besides, in the total waste stream, there is a significant drop in the amount of waste components that are classified as non-recyclable residual materials. It should be noted that, to some extent, the perceived 14% drop surpasses the 8–12% margin that is usually recognized as the range of realizable avoidance for the waste category [34].

The analysis of PAYT progresses and the resulting advantages can be extended beyond the micro or pilot-scale level. The salient benefit can also be experienced on a territorial scale. For instance, area-wide PAYT dispersion can be seen in the Free State of Saxony where more than 90% of the municipalities are exploiting such measures in one way or another. Comparatively, about 60% and below 20% of the municipalities in the State of Baden-Wurttemberg and State of Hesse, respectively, are engaging in the schemes [34].

Moreover, an average of 470 kg, 400 kg and 366 kg per capita per year aggregate household waste collection are recorded in the State of Hesse, Baden-Wurttemberg and Saxony, respectively, in 2002. Also, the residual waste collection of 193 kg, 130 kg and 145 kg per

Table 6.3: Average waste amounts collected in German municipalities with the charging mechanism employed for residual waste services (adapted from [34])

| **Charging model applied to residual waste** | **Kilogram per capita per year** | |
|---|---|---|
| | **Collected residual waste** | **Collected recyclables** |
| Fixed or flat rate | 181.7 | 121.0 |
| Fixed rate charged on a number of pickups | 165.6 | 131.5 |
| Multi-component charge with variable part linked to the actual number of pickups | 159.9 | 137.6 |

capita per year were presented for the State of Hesse, Baden-Wurttemberg and Saxony respectively. Concerning the collection of various recyclable material per capita, the diversified outcome of the three states can be attributed to the disparities in the territorial as well as waste management infrastructures employed in each of them. Nevertheless, this is insufficient to substantiate the enormous disparities in the residual waste quantities as well as aggregate household waste generation. This is due to the fact that; the inner city areas people waste disposal behavior tends to be very similar to the ones that are living in the city outskirts as well as surroundings the moment a PAYT scheme is implemented [34].

## 6.4 Ireland Municipalities Survey Results

In Irish, about 1.75 million tonnes of the municipal waste was attributed to householders in 2005. Also, the household waste diversion in 2005 was 22.7%. This shows a positive step towards the 50% goal compared to the obtained values in 2004 and 2003 which were 19% and 13%, respectively. The estimate implies that in 2004, 1.19 million tonnes of household waste was moved to the landfill. This showed a slight reduction compared with the values obtained in 2004 and 2003 which were 1.21 million tonnes and 1.23 million tonnes, respectively. Furthermore, according to the European Environment Agency reports, Ireland has the highest municipal waste generation per capita. This could be due to the probability of the inclusion of commercial and other household related waste into the municipal waste figures by the Irish, while other countries data include only household waste. Figure 6.3 shows municipal waste generation per capita (kg/capita) in some countries [67].

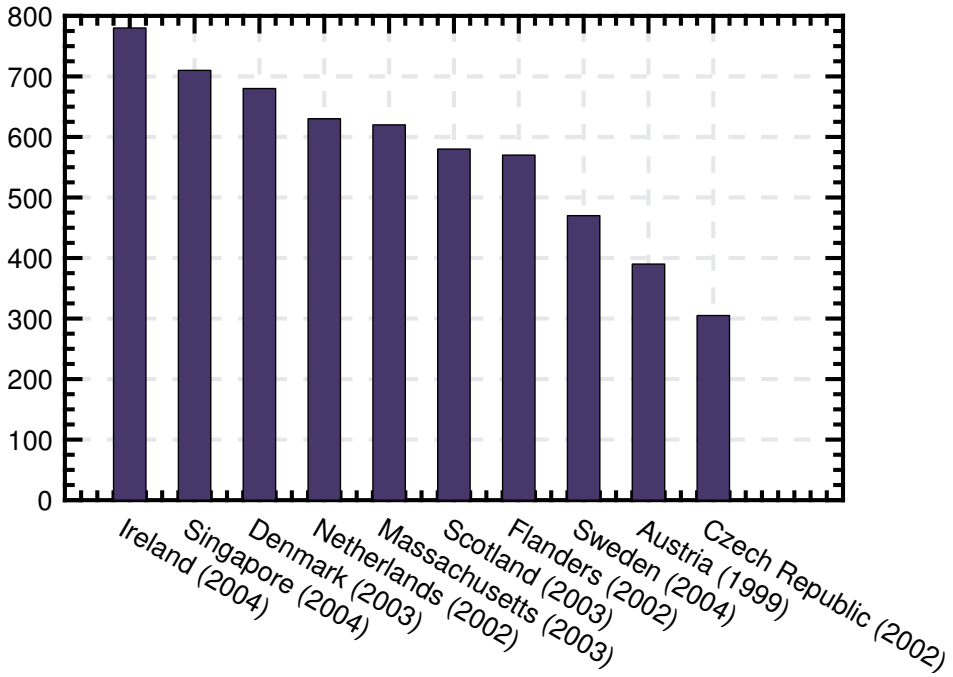


Figure 6.3: Municipal waste generation per capita (kg/capita) in some countries [67].

## 6.5 Spain Town Survey Results

The waste charge was a flat annual fee per household in 2002 in Torrelles de Llobregat which is a town in Spain. However, to address the unfairness of the flat rate as well as promote waste recycling and reduction, the council decided to employ variable waste charge systems. The related implementation commenced on the 14th of January 2003. The pay-per-can scheme is normally implemented for large commercial producers of bio-waste. In this scheme, they are allowed to choose bin(s) of any of sizes options for the ones provided by the council. Therefore, the charge depends on the size as well as the collection rate of the bin as illustrate in Table 6.4. Furthermore, as illustrated in Table 6.5 on the following page and Table 6.6 on the next page, PAYT Implementation changed waste flows considerably in the area. For instance, separate waste collection increased from 34% to 84% as depicted in Table 6.5 on the following page. Also, the overall recycling levels moved from 41% to 83% as shown in Table 6.6 on the next page [105].

## 6.6 South Korea Survey Results

The public anxiety about environmental difficulties caused by MSW has been recognized since the early 1990s in South Korea. This compelled the Korean government to exploit waste management strategy like a volume-based waste fee (VWF) system so as to reduce the generated MSW and increase recycling [106,107]. Based on this, the Ministry of Environment (MOE) performed a pilot test of VWF in several municipalities in 1994. When it was observed that the test was successful, VWF was embraced nationwide on January 1, 1995 [106, 108].

The waste bags price in Seoul typical ranges from 0.05 U.S. dollars (52 KRW) for a 2 l bag to 1.8 U.S. dollars (1840 KRW) for a 100 l bag [106]. The VWF happed to be highly effective in increasing recycling performance [27, 106]. According to the descriptive analysis results given in Table 6.7 on the following page, during pre-VWF period (1986-1994) the average MSW generated was estimated to be 72375.9 tons per day. After the application of VWF (1995-2012), the estimation of the average generated MSW was 48834.6 tons per day. This implies about 32.5% decreasing generated MSW. Regarding the recycled amount, an increase of more than 400% from 4409.9 to 23056.1 tons per day was observed. Consequently, the daily average recycling rate indicated a steep growth from 6.3% to 47% as well. In general, from the pre- and post-VWF phases, MSW generation decreased whereas the recycled MSW as well as recycling rates increased. Therefore, it can be inferred that VWF influenced the

Table 6.4: Charges for collection of biowaste bins in a Spanish city [105].

| **Container size (l)** | **Collections per week** | **Charge (€/year)** |
|---|---|---|
| 90 | 4 | 75.00 |
| 240 | 4 | 150.00 |
| 660 | 4 | 225.00 |
| 90 | 2 | 37.50 |
| 240 | 2 | 75.00 |
| 660 | 2 | 112.50 |

Table 6.5: Separate waste collection flows before and during the implementation of the PAYT scheme in a Spanish city [105].

| **Waste fraction** | **January–September 2002** | **January–September 2003** |
|---|---|---|
| Non-biowaste (refuse + packaging waste) | 1,147,860 | 178,410 |
| Biowaste | 204,740 | 267,570 |
| Paper | 88,400 | 64,680 |
| Glass | 24,880 | 52,790 |
| Bulky waste | 71,690 | 65,505 |
| Green waste | 17,535 | 36,490 |
| Recycling centre | 187,733 | 458,524 |
| Total | 1,742,838 | 1,123,969 |

Table 6.6: Final destination for waste flows before and during the implementation of the PAYT scheme in a Spanish city [105].

| **Waste fraction** | **January–September 2002** | **January–September 2003** |
|---|---|---|
| Composted biowaste | 234,088 | 361,695 |
| Recycled paper | 168,392 | 117,548 |
| Recycled glass | 53,633 | 93,307 |
| Recycled packaging | 59,749 | 41,086 |
| Recycled textiles | 7557 | 8843 |
| Recycled special wastes | 15,780 | 23,475 |
| Recycled others | 141,245 | 285,265 |
| Landfill | 993,954 | 185,258 |
| Total | 1,674,397 | 1,116,477 |

Table 6.7: Descriptive statistics of MSW variables in South Korea [106].

| **Order** | **MSW (generated)** | | **MSW (recycled)** | | **Recycling rate (%)** | |
|---|---|---|---|---|---|---|
| | *Mean* | *SD* | *Mean* | *SD* | *Mean* | *SD* |
| **Pre-VWF (1986–1994)** | 72375.9 | 11276.5 | 4409.9 | 2865.5 | 6.3 | 4.7 |
| **Post-VWF (1995–2012)** | 48834.6 | 1894.5 | 23056.1 | 6665.2 | 47.0 | 12.7 |

increase in recycled amount and rates [106].

## 6.7 Results of PAYT Analysis in Different Countries

In order to present a comprehensive examination of the collected date, this chapter analyze PAYT schemes in different countries focusing on factors such as type of PAYT implementation,

waste reduction, increase in separation and the associated fees. Table 6.8 presents PAYT analysis in different countries considering the aforementioned factors.

The average ($\bar{x}$) of the data that are expressed as

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{6.1}$$

where $\sum$ represents the summation expression, $\{x_1, x_2, x_3, \cdots, x_n\}$ represent the observed values of the sample items and $n$ denotes the number of observations in the sample.

Figure 6.4 and Figure 6.5 illustrate the sampled waste reduction and increase in separation analyses, , respectively.

The mean of waste reduction using Equation (6.1) is:

$$\bar{x}_{wr} = \frac{1}{16}\sum_{i=1}^{16} x_i, \tag{6.2a}$$

$$\bar{x}_{wr} = \frac{577}{16}, \tag{6.2b}$$

$$\bar{x}_{wr} = 36\%, \tag{6.2c}$$

Table 6.8: PAYT analysis in different countries

| | **Processes** | | | | | |
|---|---|---|---|---|---|---|
| **Country** | **PAYT Schemes** | **Type of PAYT implementation** | **Waste reduction** | **Increase in separation** | **Fee** | **Reference** |
| US | Pilot | Weight-based | 16–17% | 8–11% | | [67, 71, 72, 79] |
| Czech | Full | Volume-based | 22% | 12.1% | 10 €/person/yr | [68] |
| Japan | Full | Bags/sticker | 30.2% | | | [34, 71–73] |
| Germany | Full | Weight-based | 20% | 46% | 149.45€/4*person/yr | [47, 68, 109, 110] |
| Ireland | | Weight-based | 40% | 32%-40% | 195-440 €/yr | [34, 67] |
| Spain | | Unit-based | 38% | 83% | 75-112.50 €/yr | [47, 71, 72, 105, 111] |
| South Korea | Full | Volume-based | 32.5% | 47% | 0.05–1.8 U.S. dollars | [105–108] |
| Demark | | Weight-based | 59% | | 3.75 DKK/kg/waste | [109] |
| France | Pilot | | 35% | 25% | 76 €/person | [109, 112] |
| Greece | Pilot | Weight-based | 25.8% | 56% | | [113] |
| Portugal | Pilot | Bag-based | 34% | 126% | | [99, 100] |
| Italy | Pilot | Bags/tags | 18% | 50–75% | | [109] |
| Sweden | Pilot | Weight-based | 45% | 30% | 1,2–3,65 SEK/kg | [109] |
| Belgium | Pilot | Bag | 70% | 30% | 0.50 €(BEF 20)/bag | [47, 109] |
| Luxembourg | Pilot | Weight/volume | | 50% | | [109] |
| Switzerland | Pilot | Weight/volume | 53.5% | | | [47] |
| Netherlands | Pilot | Weight-based | 37% | | | [47] |

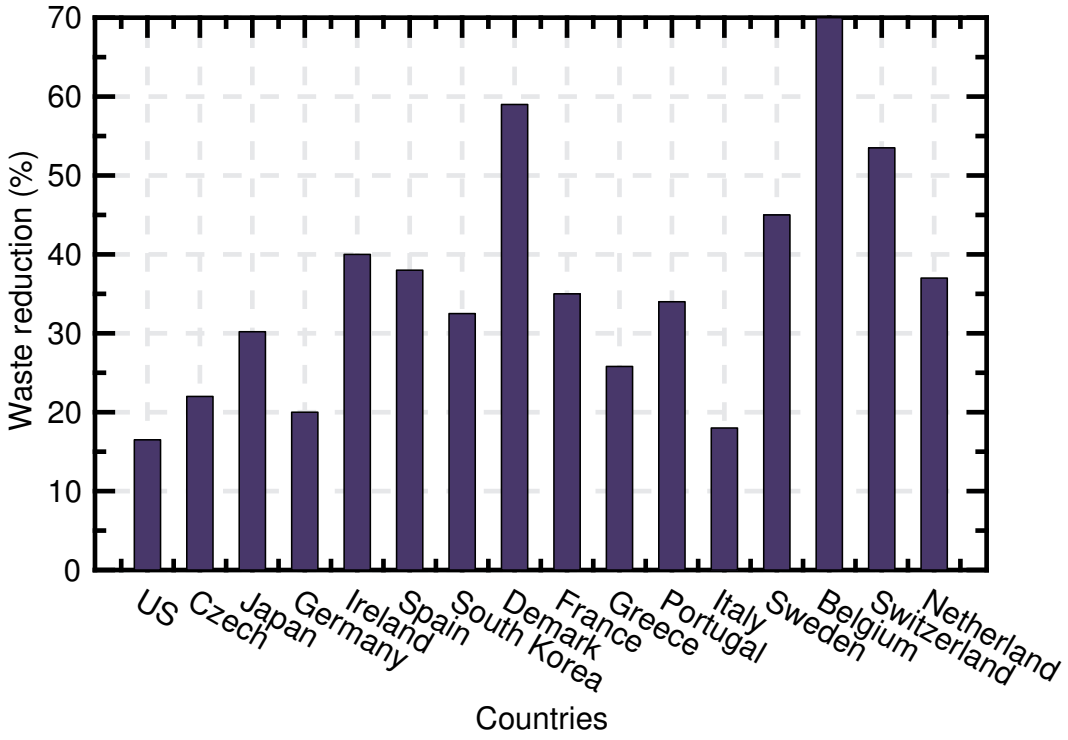


Figure 6.4: Sampled waste reduction analysis

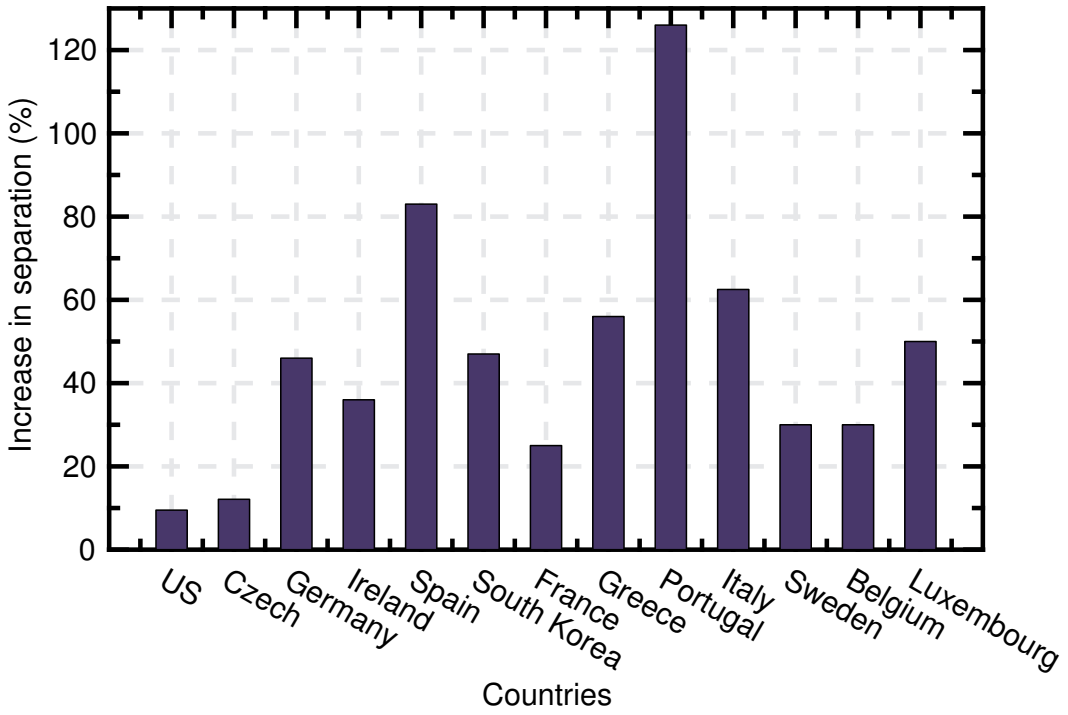


Figure 6.5: Sampled increase in separation analysis

Also, the mean of separation increase using Equation (6.1) on page 69 is:

$$\bar{x}_{si} = \frac{1}{13}\sum_{i=1}^{13} x_i, \tag{6.3a}$$

$$\bar{x}_{si} = \frac{613}{13}, \tag{6.3b}$$

$$\bar{x}_{si} = 47\%, \tag{6.3c}$$

The mean analysis using Equation (6.2) on page 69 and Equation (6.3) confirms the hypothesis that PATY systems implementation can result into 15–30% rise in recycling as well as a 30–40% reduction in waste to landfill [67, 70].

In addition, to study the deviation of percentage waste reduction and increase in separation from their means. The standard deviation of the sampled data can be expressed as

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{6.4}$$

where $\sigma$ denotes the standard deviation

Using Equation (6.4), the standard deviation of waste reduction and separation increase, respectfully, are:

$$\sigma_{wr} = 12, \tag{6.5a}$$

$$\sigma_{si} = 35. \tag{6.5b}$$

The results obtained from Equation (6.5) show that the former data set has a very small standard deviation ($\sigma = 12$) whereas the latter data set has a higher standard deviation ($\sigma = 35$). This indicates that there is a wide variation in the separation increase compared to waste reduction across the world.

## 6.8 Conclusion

This chapter has presented a survey results of associated effects of PAYT systems on waste reduction as well as source reduction in different countries. It was deduced that municipalities that implements PAYT separate more and generate a lesser amount of mixed waste than those without PAYT. Additionally, it was inferred that municipalities that implement PAYT schemes have high toward reduction in the production of mixed waste. Therefore, there is a significant increase in the separated waste percentage. Furthermore, using the PAYT results in different countries, the analysis carried out in this chapter confirms the hypothesis which states that PATY systems implementation can result into 15–30% rise in recycling as well as a 30–40% reduction in waste to landfill.

Chapter

# Conclusions

This thesis has presented different municipal waste treatment legislations that enable the implementation of PAYT schemes with the intention of encouraging household waste separation and recycling. Moreover, the thesis has shown that, implementation of PAYT schemes in the municipalities for running a waste treatment system enables the citizens in generating considerably less total municipal waste and less residual waste.

There are a lot of explanations for ensuring that waste charging is adjusted based on waste generation and diversion practices. Take for instance in countries such as the Netherlands and Germany, PAYT has been used for attending to citizens' needs for management in reaction to the perpetually growing charge burdens. Moreover, respective cost allocation for waste management services, offered with the utmost degree of transparency could be one of the most prominent drivers for a broader spreading of the European PAYT system in the future. Consequently, full-cost accounting has to be adopted in the individual countries for waste management. In addition, if waste financing can be one of the key subjects of an associated European-wide legislation, then, demands for full-cost recovery as well as promotion of recycling by economic instruments will be easy to realized. The judgment is established on the premise that, waste management financing is and will forever remain a politically sensitive matter. Hence, the principle of subsidiarity should be adopted so that preferences and local conditions can be given an appropriate consideration in the local waste management design.

Additionally, the PAYT acknowledgment as an efficient as well as entirely resourceful solution for adapting to the goal of a recycling-inclined society, is as well noticed in the European Commission's thematic strategy on waste recycling and prevention. It can also be seen in various encouraging applications as well as state-of-the-art systems that are in practice. So, implementation of PAYT has various advantages such as reduced waste quantities, transparent billing, in addition to increased diversion and recycling. Besides, it facilitates waste management logistics and offers a scalable and flexible on-demand services that assist in realizing savings that significantly offset capital expenditure (CAPEX). For instance, observations in several jurisdictions have shown that in certain conditions, weight-based waste collection charges can bring about substantial reductions in consumer waste. The charging

scheme offers the customer notable awareness of the need to control the waste generation. Also, they have a clear sense of direct control concerning how much they are charged and this enables them to be more responsive to the waste charges. In the current volume-based waste collection charges, the consumers are normally given additional charges for the use of a larger bin. Also, they can also buy tags that they have to attach to each bag or bin to be collected. These practices offer a considerable degree of inducement for waste reduction. Nevertheless, certain analyses have shown that, customers have the tendency of reacting by compressing their waste. This response has no environmental benefit since considerable waste has been compressed before landfilling and this even depends on the degree of compression.

Furthermore, in logistically expensive areas, large press-container schemes that contain chamber systems can be employed. An installation of this type can replace a huge amount of single containers and pickup operations. This has a tremendous cost saving advantages for final waste disposal. Technological approaches can also be adopted for waste monitoring and data transmission in order to address some of the related PAYT issues. Consequently, the PAYT schemes not only help in controlling the usually growing waste management costs but also permit people to benefit from the saved costs by being charged fairly or even at reduced rate. The discussed benefits of PAYT have been attracting people in dropping the conventional financing approaches and adopting the PAYT approaches in a growing manner. This is encouraging as it portrays a good tiding for more enhancement of PAYT concepts in the future. Furthermore, using the PAYT results in different countries, the analysis carried out in this chapter confirms the hypothesis which states that PATY systems implementation can result into 15–30% rise in recycling as well as a 30–40% reduction in waste to landfill.

# 7

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