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THE SOCIAL EFFICIENCY OF ALTERNATIVE FINANCIAL INCENTIVE SCHEMES FOR MUNICIPAL SOLID WASTE REDUCTION

Abstract: Efficient management of waste, especially at the urban level, is becoming more and more important in order to reduce negative externalities and achieve a sustainable society. Due to an increasing amount of waste, this goal is becoming more and more difficult; many solutions have been implemented, at different levels of the value chain. This research deals with different solutions for incentivising the reduction of municipal solid waste (MSW) through separation and recycling, applied by different municipalities in Switzerland. A cost-benefit analysis (CBA) is used to assess the social efficiency of different financial incentive schemes. Social efficiency is analysed as the difference between social costs and social benefits. Therefore not only economic but also environmental and social costs are taken into account. The results show how a pay-as-you-throw (PAYT) scheme can lead to a reduction of not only economic, but also environmental and social costs. It can therefore provide an important advantage to the social efficiency of a municipality.

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CHAPTER 1 – INTRODUCTION

1.1 INCREASED PRODUCTION OF WASTE AND RELATED EXTERNALITIES

In the last two decades, the world's population has grown from 5.5 billion in 1993 to 7.0 billion in 2012 (World Bank, 2012). In addition people's lifestyles have changed and as a result the consumption of products and services has increased (Carr et al, 2012). New challenges need to be faced, such as the efficient management of limited and scarce resources, the improvement of present and future generations' quality of life and the creation of sustainable communities (Pires et al, 2011).

Another consequence of the increased consumption of products and services is the increasing amount of waste which needs to be processed. Therefore waste management, especially at an urban level, is becoming more and more of a key challenge for cities in both developing and developed countries (Asease et al, 2009; Ferrara, 2008; Allers & Hoeben, 2010). As stated by Asease et al. (2009), Waste Management Systems (WMS) can help reduce negative externalities, but have not often succeeded in doing so. Already in 1969, externalities from Municipal Solid Waste (MSW[1]) management were recognised to have important negative effects on the environment (Ayres & Kneese, 1969 in Ulli-Beer et al, 2007). The negative effects of these externalities vary from soil, water and air pollution near dumping sites or incinerators, to accumulation of waste in urban areas, health-related problems and many others. Ferrara (2008) recognises that failures of the WMS are mainly due to the fact that the MSW collection and disposal is usually financed by a lump sum tax, and that no financial incentives for MSW reduction are applied. In this way, households are not charged for additional production of MSW and therefore are not encouraged to separate more and produce less waste (see Allers & Hoeben, 2010).

1.2 FINANCIAL INCENTIVES AS A SOLUTION

Municipalities are the primary actors responsible for coordinating and managing waste collection, disposal and recycling. Moreover, since they have coercive power, they can actively play a role in reducing the amount of waste produced, for example by applying financial incentives.

To solve the problems stated above, public actors adopt a variety of financial measures on different levels of the value chain. At the production level, public actors try to force producers to incorporate the costs of externalities of the products for the entire life cycle, thus also incorporating the externalities created when products and packaging are disposed. In this way, both the economic and environmental costs of collection and disposal are sustained by the producer rather than by the public actor, or by society. Producers are thus incentivised to design products and packaging using fewer resources and generating less waste. Other solutions are more focused on changing households' behaviour by introducing schemes that can incentivise the reduction of MSW. Financial incentive schemes for MSW reduction are defined as schemes that adopt the polluter-pays principle (PPP) and therefore include a tax which, unlike flat-rate or lump sum, increases as the quantities of waste presented for collection increase[2]. In the present research, this type of tax is referred to as a causal tax. This type of incentive is commonly known as pay-as-you-throw (PAYT)[3]. Two main PAYT schemes can be recognised: pay-by-weight (PBW) and pay-by-volume (PBV). Other types - such as frequency or hybrid systems - are less implemented. Within the research, a lump sum tax is considered a minimum financial incentive since it directly relates waste produced and money paid (see chapter 3.4).

Financial incentive schemes have a crucial role within the municipality's WMS. They provide a means to finance collection and disposal, and they are also an instrument to decrease the amount of MSW produced, to recycle more, and to incorporate externalities' costs of waste. In this regard, they may help to solve the problems related to the increasing amount of MSW. An important effect that financial incentive schemes for MSW reduction may have is the increase in waste separation and recycling. In fact, households subject to a causal tax on waste are incentivised to reduce their waste not only by purchasing more environmentally

[1] MSW is waste collected by the municipality that comes from households and commercial entities. MSW includes residual
[2] This can be proportional, variable or multi-tiered (see EPA, 1994, pp. 24-25).
[3] Also known as unit-based pricing, variable rate pricing and user pays fees.

friendly products (i.e., those with less packaging), but also by separating waste materials and bringing them to ecopoints or ecocentres.

Since the alternative financial incentive schemes considered in the research (see section 3.4) mainly target households and do not apply in the same way to businesses[4], the research will focus only on the waste produced by households. Other measures - for example moral or coercive incentives - or other stakeholders, such as businesses, are not taken into account.

Why are other incentives excluded, and why are only financial incentives to households analysed? Firstly, in order to perform feasible research within the resources available, the research objective had to be narrowed down. Only financial incentives are considered since these are recognised as one of the best instruments to encourage a specific behaviour (in this case, the reduction of MSW). In order to change their behaviour, households need to be financially incentivised in an explicit way; otherwise there is no reason for them to engage in costly action to reduce their waste production (Allers & Hoeben, 2010; Choe & Fraser, 1999 in Ulli-Beer et al, 2007; Zamboni, 2013). Moreover, only the household level is considered - and not the industry level. Changes in households' behaviour are fundamental to reduce the amount of waste processed, and therefore the impact on the environment (Fullerton & Wu, 1998 in Ulli-Beer et al, 2007). Personal interests and societal relevance are also important reasons for this specific focus. Since the researcher's background is in both economics and sustainable development, financial incentives constitute the best mixture of both economic and socio-environmental elements. By including households and their behaviour, it is also possible to account for various social mechanisms that would be disregarded if a focus on industries was to be adopted. Furthermore, by assisting first-hand with various public debates, the researcher's personal interest in financial incentives for the reduction of MSW grew. Many studies as described below (e.g., Allers & Hoeben, 2010) also recognised the need for more information on financial incentives for MSW reduction. This constituted a further motivation to focus particularly on financial incentives to households.

1.3 Criticism about costs and benefits of different financial incentives

Financial incentives can potentially be a useful instrument to reduce the amount of MSW produced, but they always come at a cost. The extent of these costs (as well as benefits) is often not clear and more insight on PAYT schemes are needed (Reichenbach, 2008; Bilitewski, 2008; Allers & Hoeben, 2010). The different financial incentive schemes have been much debated and criticised.

On the one hand, PAYT schemes are criticised as an additional burden for citizens; some argue that they do not justify the environmental benefits generated (Bilitewski, 2003; Dahlen & Lagerkvist, 2010). In fact, the waste related costs that a household must sustain are usually much higher, and it is argued to be inappropriate if compared to the real environmental benefit. Moreover, the reason why municipalities with PAYT schemes produce less waste is supposedly due to the fact that households dispose their waste in nearby municipalities that do not use PAYT schemes (waste tourism), or simply illegally dump it (Sakai et al, 2008; Economist's View, 2008; Puig-Ventosa, 2008, Price, 2001; Allers & Hoeben, 2010). These practices only transfer the costs from one municipality to another, and even increase the social costs because of the increased externalities. Kinnaman (2006) stated that, at least in the United States, the costs of PAYT schemes are higher than the benefits.

On the other hand, supporters of PAYT schemes claim that municipalities which adopt these produce significantly less MSW and have a higher percentage of recycling than non-PAYT municipalities (Bilitewski, 2003; 2008). PAYT schemes are also recognised as good instruments for increasing households' awareness. It is assumed that they will, through such schemes, pay more attention to what and how they consume, what can be recycled, how to reduce quantities of residual waste on which the causal tax is applied, and therefore have lower environmental costs. Moreover, it is claimed that PAYT schemes have a fairer allocation of costs within society (Batllevell & Hanf, 2008; Bilitewski, 2003; Dahlen & Lagerkvist, 2010).

[4] Businesses have different agreements and solutions for waste produced (lump sums, private collection and disposal, etc.). Pay-by-weight and pay-by-volume are usually applied only to households and small businesses.

The criticisms and uncertainties expressed about social costs and benefits of PAYT schemes are an obstacle for the decision-making process and without more information, it is difficult for a municipality to divert from the status quo. A cost-benefit analysis (CBA) gives the opportunity to take into account and calculate all costs and benefits, as well as to clarify the level of social efficiency (not only the effectiveness) of different schemes. In this way, the decision-making process is facilitated and social efficiency can be maximised.

1.4 Research objective and research question

The research objective is to **assess the level of social efficiency of alternative financial incentive schemes for MSW reduction in Switzerland by describing, evaluating and comparing their social costs and benefits**.

Firstly, in order to reach the objective of the research it is important to distinguish between effectiveness and efficiency, and to define what social efficiency is. An effective financial incentive scheme is a scheme appropriate to reach the goals and objectives set, and one which produces the expected outcomes. An efficient financial incentive scheme reaches the expected outcomes in the best possible manner and requires the least possible effort. Therefore, it is probable that municipalities that adopt financial incentive schemes such as PBV and PBW are the most effective in reducing the amount of MSW produced; are they also the most efficient? In order to answer this question, it is essential to research the social costs and benefits involved.

Social efficiency is defined in terms of profitability that financial incentive schemes yield to the society as a whole. Specifically in this case, the most efficient of the schemes will be the one that has the highest difference between social costs and social benefits, and therefore provides the highest net benefit or the lowest net loss to the entire society (Eijgenraam et al, 2000).

The research's objective has been translated into the following main question and sub-questions that will guide the research from here on in:

Which of the alternative financial incentive schemes for MSW reduction is the most efficient in terms of social costs and benefits?

- *Which social costs and benefits can be derived from scientific literature on PAYT?*
- *What are the current schemes adopted in canton Ticino?*
- *What is the actual level of efficiency of the schemes analysed, in terms of social costs and benefits?*
- *Which factors can explain the different levels of social efficiency of the schemes selected?*

Since a CBA is used, the data collected as well as the results produced are mainly quantitative in nature. Despite this, qualitative considerations are also made, especially in terms of the influence of exogenous variables in the results, and non-monetisable variables (i.e., PM-items). Since the main objective is to assess the level of social efficiency of the schemes selected, the majority of knowledge produced is evaluative (though descriptive knowledge is also produced). For example, the characteristics of the different schemes are described by different costs and benefits, and interviews will help to gain insight into the main features of each of these schemes.

1.5 Empirical focus: Switzerland

In order to carry out the research, four municipalities in Switzerland (in canton Ticino) are taken as an example. This region represents the perfect environment, since it provides the general (see section 1.1) and the specific (see section 1.3) problems, as well as a variety of financial incentive schemes (see section 3.4).

In canton Ticino, the amount of waste produced has also grown in the last decades (see table 1). Due to the growing amount of waste which needs to be collected and disposed, municipalities have begun to develop new systems and adopt new measures, in order to reduce the amount of MSW.

	Abitanti[1]	Totale rifiuti urbani		Rifiuti urbani non riciclabili[2]		Raccolte separate[3]		
		t	Kg./ab.	t	Kg./ab.	t	Kg./ab.	% sul totale
1981	269.666	100.719	373	100.719	373	...	...	...
1982	272.135	103.420	380	103.420	380	...	...	...
1983	272.940	104.338	382	104.338	382	...	...	...
1984	274.085	107.181	391	107.181	391	...	...	...
1985	275.777	117.149	425	117.149	425	...	...	...
1986	277.777	126.014	454	126.014	454	...	...	...
1987	278.917	135.916	487	135.916	487	...	...	...
1988	280.871	149.439	532	149.439	532	...	...	...
1989	283.130	167.569	592	141.138	498	26.431	93	15,8
1990	276.642	168.971	611	137.089	496	31.882	115	18,9
1991	290.000	179.159	618	138.780	479	40.379	139	22,5
1992	294.108	180.390	613	136.720	465	43.670	148	24,2
1993	297.955	173.495	582	130.223	437	42.946	144	24,7
1994	302.361	175.283	580	128.776	426	45.670	151	26,0
1995	304.104	173.175	570	125.348	412	47.827	157	27,6
1996	305.060	177.666	582	125.291	411	52.375	172	29,5
1997	304.469	178.683	587	125.058	411	53.625	176	30,0
1998	305.853	181.753	594	125.006	409	56.747	186	31,2
1999	308.646	190.839	618	130.626	423	60.213	195	31,5
2000	312.659	197.221	631	134.597	430	62.624	200	31,8
2001	313.570	200.436	639	133.446	426	66.990	214	33,4
2002	314.025	201.193	640	132.321	421	68.872	219	34,3
2003	319.544	198.905	622	128.591	402	70.314	220	35,4
2004	322.379	200.768	623	126.560	393	74.208	230	37,0

TABLE 1: TOTAL AMOUNT OF URBAN WASTE PRODUCED IN TICINO (1981-2004) ***(SOURCE: BAGGIO & ZULLIGER, 2005)***

General guidelines exist at a federal level, but municipalities are free to decide which solutions they prefer. Today, the way in which Swiss municipalities financially incentivise households to produce less waste is very heterogeneous. Despite this, it is possible to distinguish four main schemes: no financial incentive, lump sum tax, PBW and PBV. In 2010, a PAYT scheme was adopted in 2100 municipalities (out of a total of 2600) at federal level, while at a cantonal level (in Ticino), the percentage was much lower, with only 60 out of 170 municipalities applying such schemes (Okkio, 2011)[5].

The reason why in Canton Ticino PAYT schemes have not been adopted so widely is because there is uncertainty about the level of social efficiency of the different schemes. Moreover, PAYT schemes are not popular among households (since they increase costs) and are therefore avoided by politicians (e.g., for fear of referendum). The different schemes have been criticised and debated[6] in the popular, political and academic worlds for many years and clarity about costs and benefits of these schemes is needed.

Debates and criticisms concern the real effects that PAYT schemes have on the amount of waste produced and recycled, on the environmental benefits created, and on the role and extent of waste tourism and illegal dumping; they are accused to have higher or similar environmental costs when compared to other schemes. PAYT schemes have been already successfully implemented in different municipalities. For example, the city of Zug has the highest percentage of waste recycled (65%) - it was one of the first municipalities to introduce a PBV scheme in Switzerland (Baggio & Zulliger, 2005). Despite this, municipalities such as Lugano or Locarno, which do not apply PAYT, still have percentages of recycled waste of between 30% and 40%. This is a fairly good result considering that the average for waste recycling in Ticino is 44% (Repubblica e Cantone Ticino, 2011) and 50% in Switzerland as a whole (UFAM, 2013). By selecting four municipalities in Ticino with different schemes, it is possible to clarify different costs and benefits and to assess the social efficiency.

[5] For more information about demographic, political and economic variables and about the functioning of the WMS system in Switzerland and Ticino, please refer to Annex IV.

[6] See for example Lega dei Ticinesi (2013) and Ticino Libero (2012).

1.6 Reading Guide

In the next chapter, the research strategy, data sources and the three methods used in the research are explained in detail. Next, the identification of costs and benefits will follow; the theory of PAYT schemes is explained briefly and an impact model is built. This will answer the first sub-questions (together with chapter 4.2). The impact model will identify and explain the different effects of the introduction of a PAYT scheme.

After having established the theoretical and methodological basis, the impact of the schemes can be assessed. In order to do this, an impact assessment is carried out. Once assessed, the effects recognised previously are translated into costs and benefits. The methods through which different costs and benefits are monetised are also explained.

Next, the four case studies are presented. A brief introduction, an explanation of the infrastructures and collection systems, and the calculation of total costs and benefits are given for all four municipalities. Lugano is explained and assessed firstly, in order to provide a business-as-usual scenario. Secondly, Locarno is taken as a base case. Bellinzona, with a PBV scheme is the first alternative, and finally Caslano with a PBW scheme is the second alternative. These chapters, together with Annex IV, will answer the second and third sub-questions.

In chapter 9 all four schemes are compared in terms of their social efficiency. Here, the last sub-question and the main research question are finally answered. To finalise the research, some conclusive remarks are given.

CHAPTER 2 – METHODOLOGY

2.1 GENERAL RESEARCH STRATEGY

During the choice of a research strategy, the researcher must face several trade-offs: breadth versus depth; qualitative versus quantitative; empirical versus desk research (Verschuuren & Doorewaard, 2010).

Since the number of observations (or domain) is limited to four municipalities, the research strategy is clearly depth-oriented. The main research strategy selected is, in fact, a comparative case study. Therefore the aim is to gain as profound and complete insight as possible within the four cases selected. The different schemes selected are compared using the *hierarchic method*: in the first phase the four municipalities are individually assessed (chapters 5-8), and then the results of the individual analysis are compared (chapter 9). It is acknowledged that by using a small number of cases, the generalisation capacity and the external validity may be limited; therefore, consideration in this sense will be developed.

The research uses a systematic and quantitative approach in order to collect and analyse data. A social cost-benefit analysis (SCBA) (Eijgenraam et al, 2000) is applied to assess and compare the social efficiency of different schemes. The results are presented in tables that distinguish between different costs and benefits. These are monetised to give them the same unit of measure (CHF) - this allows an easy understanding and comparison of the results.

Since the research aims to assess the level of social efficiency of different municipalities' schemes for MSW reduction, and not to specifically fill a theoretical gap, the research is empirically-oriented; this is also visible by looking at the research questions, which aim to understand practical aspects of the problem. Moreover, since the schemes analysed are already implemented, the analysis will be *of* policy (i.e., ex-post).

The triangulation of methods and sources is also applied in order to increase the validity and reliability of the results. Firstly, three different methods are used to assess the impact of a PAYT scheme (see section 2.3). Secondly, multiple sources (general literature, specific local reports, interviews to municipals, surveys to households and personal experience) are used to collect data. Thirdly, the process of data collection and data generation have been recorded and reported throughout[7]. Thus, these three methods, as suggested by Lave and March (1975)[8], helped to improve the quality and reliability of the data; for example, exogenous variables have been taken from the literature but also the opinions of the municipalities have been recorded. Demographic variables of each municipality are taken from the Cantonal Office of Statistics (UStat), as well as measured by municipality interviews and household questionnaires. The extent of social issues was measured by asking both the municipalities and the households directly. The average distance to the ecocentre was calculated geographically, stated by the municipalities, and households were asked directly. The problems of illegal dumping and waste tourism were measured through municipalities' interviews, experience of households, questions to ecocentre employees and by personal experience gained from different zones of the municipalities. Moreover, data regarding quantities and costs of different types of waste were taken both from municipalities' interviews and from the cantonal census on waste (Repubblica e Cantone Ticino, 2011). The opinions of both the Azienda Cantonale dei Rifiuti (ACR) and the Okkio (Osservatiorio della gestione ecosostenibile dei rifiuti) are taken into account when measuring emissions from the incinerator, as well as operating costs and benefits from energy production[9].

2.2 DATA SOURCES AND DATA COLLECTION

In order to carry out the research, four main sources of data are used: scientific literature, publications, interviews and surveys. To build the theoretical basis (i.e., program theory, impact assessment and impact model), prior scientific research and governmental publications have been analysed. This step was particularly useful in order to recognise the potential effects of the introduction of a PAYT scheme, and therefore to identify the most important costs and benefits to measure.

[7] See section 2.2, and Annexes V and VI.
[8] See chapter 1, page 23-29.
[9] Further information on how data have been triangulated for each of the variables measured can be found in Annex II.

As stated by Rossi et al. (2004, p. 209), "*the most direct sources of information about these expected outcomes usually are the stated objectives, goals, and missions of the program"*. Therefore websites of both central[10] and regional governmental authorities[11], scientific studies (Bischof et al, 2003), publications and governmental communications (e.g., Rudin, 2010; DTB, 2013; Rapporto Mozione 3442, 2010; Bartoli, 2009; UFAM, 2003; UFAFP, 2004) are used to investigate governmental goals and objectives; they can reflect the local reality of what is expected as impacts from the implementation of PAYT schemes.

Next, prior research is examined. In order to select studies that more resemble the research developed here and therefore have more relevant and useful data, the research has been biased towards experiences on the adoption of PAYT and comparisons among PAYT and non-PAYT municipalities, mainly in Europe. Scientific (Omega, Scopus) and popular search engines have been particularly useful to select studies based on certain key terms[12]. The two main questions during this step were: *Which effects have been recognised and selected in prior studies? How have these effects been defined and calculated?*

For example, Hogg et al. (2002, 2006a, 2006b) provided an extensive description of multiple case studies on variable charging, all around Europe. Examples are the PBW and PBV in England and Germany, PBV in Belgium, PBW in Denmark, Italy's PBV, Luxembourg's Hybrid scheme (weight/volume), and many others. The British case (Hogg et al, 2006b) is particularly interesting, since it aims to assess the potential impact of volume- and weight-based schemes on England as a whole (from a social perspective). Šauer et al. (2008) shared their experience on the introduction of PAYT schemes in the Czech Republic, focusing on the impact that PAYT schemes have on separating and recycling efforts of municipalities and households. Dijgraaf & Gradus (2003) studied the effects and performance of weight, volume, bag and frequency-based schemes in the Netherlands. Moreover, Rogge & De Jaeger (2012) provided valuable information on the variable involved in measuring the cost-efficiency of municipalities with different PAYT schemes. Finally, despite being based in the U.S., several studies of Skumatz (2002 and 2008) are considered, since they provided fundamental information on how the impact and thus the effects of PAYT schemes are selected and measured. The high variety of financial incentive schemes studied is very useful for the identification of potential variations in the effects of PAYT schemes.

Prior literature is also the main source for identifying exogenous variables. Almost all studies focus their attention on exogenous variables - or at least take them into account and adjust their research accordingly. Often, these variables are related to socio-demographic characteristics of the municipalities (population density, income, and regional culture) and/or technical and political structure (other recycling programs, type of collection system used, etc.) (see section.3.6.3).

Local publications (especially statistics from public authorities) have been used in order to collect demographic, economic and other social variables of the different municipalities (e.g., UStat) and data related to the quantities and costs of MSW collections in Ticino and more specifically in each one of the municipalities selected.

Next, in order to collect quantitative data that was not available publicly within the sources specified previously, interviews to the responsible person for MSW management within the municipalities selected have been carried out (see Annex VI). The questions were aimed to measure specific costs and benefits. These interviews were also useful to collect qualitative data - opinions on, for example, illegal dumping and waste tourism, other specific problems perceived, motivations for introducing a PAYT scheme, strengths and weaknesses of the scheme. This helped to enrich the analysis and takes into account, only in a qualitative way, specific variables that may vary within municipalities (e.g., particular geographic, economic or social conditions). Therefore, four interviews have been carried out in each municipality. Ing. Di Gianfrancesco from the Ufficio Tecnico was the responsible person for the city of Lugano; Ing. Zamboni was the contact person and responsible for MSW management in Locarno; in Bellinzona, data were collected thanks to the help of Arch.

[10] Admin.ch.
[11] Ti.ch, lugano.ch, Locarno.ch, bellinzona.ch and caslano.ch.
[12] PAYT, unit-based pricing, variable charging, impact, effect, CBA, MSW, WMS, Illegal dumping, waste reduction, etc.

Baroni; and for Caslano, Sormani and Arch. Rossinelli were interviewed in order to collect data about their PBW scheme.

The monetisation of some costs and benefits (i.e., environmental costs of disposal and waste-to energy) required the collection of data directly from ACR, the organisation that is responsible for the management of the incinerator. The same data was also collected through Okkio, an organisation that looks critically at the activity of the incinerator.

Daniele Zulliger, from the cantonal office for MSW management, responsible for the publishing of the cantonal census on waste, was also interviewed for clarification about the classification of costs, estimation of illegal dumping and waste tourism, and the juridical system within Switzerland and Ticino.

Last but not least, some costs needed to be measured through direct questions to households (see Annex V). These included data about time and costs for separation, delivery and disposal of recyclable waste. In order to have a representative set of data, the sample selected must resemble - as far as possible - the entire population in all variables that influence household behaviour regarding waste activities (i.e., income, size, average age, race and education[13]). Data such as household income, size and education at a municipal level were not available; therefore it was not possible to exactly match the sample and the wider population. In order to overcome this problem - and assuming that households will have extra costs only when disposing separated waste in a different location than where also residual waste is disposed[14] - surveys were carried out in ecopoints and/or ecocentres, through directly approaching people who were about to dispose their garbage. Data from households were then organised in an excel database and presented in graphs and tables (see Annex III).

In general, there was a high willingness to collaborate - from municipalities, households and organisations. It was more problematic to collect data in a systematic way, since not all the municipalities registered costs and benefits in the same way and the availability of data varied greatly among municipalities.

2.3 Research methods

2.3.1 A cost-benefit analysis

As already stated in chapter 1, the research objective is to assess the level of social efficiency of alternative financial incentive schemes for MSW reduction in Switzerland by describing, evaluating and comparing their relative social costs and benefits. An SCBA is the main research method adopted in order to achieve this. Despite this, other complementary methods (i.e., Program Theory and Impact Assessment) are also used. As stated by Eijgenraam et al. (2000, p. IV), "*the CBA should be seen as the concluding stage of a large number of analyses*". In fact it is not possible to directly carry out a CBA, but some preliminary steps need to be followed in order to have a systematic and reliable assessment of a project or program's efficiency (see Eijgenraam et al, 2000, pp. 43-50).

An analysis of the problem, as in chapter 1, needs to be carried out in order to avoid focusing attention only on a narrow or technical problem. Before even starting any form of assessment, it is fundamental to establish an accounting perspective. This will fix the type of lens through which the effects are recognised, and costs and benefits measured. It is then important to define the program characteristics. This is done by reconstructing the **Program Theory** (PT) (section 3.5), by delineating the geographical boundaries and the time horizon. Moreover, four cases are explained and selected for comparison.

An adequate insight into the relationship among the various effects is required within an SCBA to prevent double-counting (Eijgenraam et al, 2000, p. 5 and Runhaar, 2011), therefore the effects of the proposed policy implementation are mapped in an impact model (see section 3.6). Once the different effects are recognised, they can be assessed. An **Impact Assessment** (IA) is used (see section 4.1) to assess the

[13] See for example Hogg et al. 2006b; Huang et al. 2011; Rogge & de Jaeger, 2012, Fullerton & Kinnaman, 1996 and Skumatz, 2008.

[14] If separated recyclable waste is disposed in ecopoints in which residuals are also disposed, there is no extra time for delivery, extra fuel consumption, tyre wear, etc. There is almost no difference, except for the time of separation, if garbage is disposed in the ecopoint in one bag or in separate bags.

introduction of PAYT scheme in a municipality. Within the IA, causality between the program and the effects first needs to be established, a control and an intervention group are recognised in order to isolate the program's effects. Only then can the two groups be compared in order to isolate the impact.

As described by Eijgenraam et al. (2000, p. 49), once all these steps have been performed, it is possible to begin with the actual CBA. This is done in two steps: total costs and benefits are measured and presented for each case; then, in chapter 9, the cases are compared.

2.3.2 Program Theory

As described by Rossi et al. (2004), a PT is "...the conception of what must be done to bring about the intended social benefits" (p. 134). In order to be able to assess program efficiency, it is important to look at the formulation of the PT and to see whether it includes a feasible and plausible process for improving social conditions of those targeted. Moreover, it is important to acknowledge that usually the PT is implicit and cannot be fully found in written form.

It is not the aim of this research to perform a complete Program Theory (PT) assessment, since many aspects are already included and explained in detail in section 3.6. Therefore, section 3.5 will briefly describe the theory at the base of the introduction of a PAYT scheme by looking at the program's assumptions, expectations, objectives, functions, important stakeholders, boundaries, and functional and operational characteristics. The PT is fundamental. It sets the theoretical basis needed to develop a solid impact model on which the other methods are based (see section 3.6).

2.3.3 Impact Assessment

Randomised versus quasi-randomised experiment

The goals of an IA is to make clear how a policy program changes the social conditions of a target group and to compare what the conditions of the target group could have been, had the policy program not taken place. For this reason, an IA is *"inherently comparative"* (Rossi et al, 2004, p. 236). In an ideal situation, the conditions of the target groups (control and intervention) would be exactly the same and the intervention would be the only different variable. By distinguishing the target groups in intervention and control groups (which receive no intervention), the impact of a policy program can be identified. In reality, an ideal situation that allows the two groups to be identical in all the important variables does not exist. The second best option is therefore to find a way to approximate this ideal situation by composing a control group that is as equivalent as possible to the intervention group.

An IA is thus concerned with two questions: whether a change in condition of the target group can be observed; and to what extent the change can be attributed to the policy programme at stake.

Rossi et al. (2004) recognise two valid options to identify the effect of an intervention. Firstly, there is the randomised field experiment. Participants are randomly assigned to two groups - in the control group there is no intervention, while in the intervention group the intervention is tested. Any differences in the effects can then be attributed to the intervention. Second, in a quasi-experiment, the intervention group is compared to a control group that is presumed to be significantly similar in characteristics to the intervention group. Generally, the randomised field experiment produces more valid results than the quasi-experiment, but it is often not easy or even possible to adopt.

In this research, a *quasi-randomised experiment* is used to measure the impact of the introduction of a PAYT scheme in a municipality. Although this is the second-best choice, a randomised experiment is not possible for several reasons. Firstly, since it is an ex-post analysis, control and intervention groups cannot be randomly built, but are already present - municipalities (and their households) with and without PAYT schemes. These groups are therefore self-selected since they must respond to the dichotomous variable of PAYT or non-PAYT. Secondly, considering the time and resources available, setting up a randomised experiment was deemed unrealistic.

Steps for assessing the impact

The first step required when performing an IA is to establish causality. This is done by looking at three different factors: asymmetry, covariance and non-spuriousness (see section 4.1.1). In order to have an exact measure of the cause-effect relation for the policy program, the covariance and correlation have been calculated for several variables. Since covariance it is not a standardised measure, it is very difficult to compare and analyse. For that reason, the Pearson correlation coefficient is used to show the relationship between PAYT and quantity or costs of different types of waste. The Pearson correlation coefficient divides the distance of the individual observations to the mean of the sample by the standard deviation (Laerhoven van, 2012).

$$r = \frac{Cov_{xy}}{s_x s_y} = \frac{\sum (x_i - \bar{x}) * (y_i - \bar{y})}{(N-1)\, s_x s_y}$$

Next, one must select a control and intervention group. As stated above, a quasi-experimental impact assessment has no randomly assigned groups. The two groups must resemble as much as possible in all important variables, in order to have a reasonable degree of confidence. Otherwise, differences between groups will lead to biased results. In the research, control and intervention groups are built using the "matching technique" (Rossi et al, 2004, p. 275), where the intervention group is specified first, then the control group is matched. Fundamental variables that need to be matched in order to reduce bias are taken from scientific literature[15] (examples include surface of the municipality, population, population density, income, age distribution[16]). Per capita measures are used to isolate the impact and limit the influence of exogenous variables (e.g., population size), and data regarding the variables has been taken directly from the cantonal office of statistics (UStat, 2013) or through interviews. Since only one municipality is taken for each group, the *individual matching* procedure is used in the research. Aggregate and average measures are considered and therefore the overall, and not individual, distribution is matched. For example, it was not possible to individually match the characteristics of each household in both municipalities and therefore the average demographic characteristics are used.

Next, it is fundamental to decide on the method to be used for measurement of the impact. By doing a simple pre-post program measure, many trends and exogenous variables that have an influence on the results are included and this may lead to an over- or underestimation of the intervention's effects. Before-after measures are good only if the IA is carried out for a very short program. In our case though, part of the reduction of MSW produced can be attributed to new regulations at a federal level, new prices for waste disposal and changes in the political structure of the municipality. A more appropriate design for the case is the *time series measurement*. This consists of several observations during the entire lifespan of the program. It is therefore a before, during and after measure[17]. With time series, the unit of analysis is highly aggregated, and therefore the aggregated matching group procedure used fits perfectly.

In order to build credible time series, a lot of data needs to be available for each one of the measurable variables. For this purpose, the cantonal census on waste (Repubblica e Cantone Ticino, 2011) is used for the collection of data about quantities and costs of different types of waste. The census provides ready-to-use data, measured over several years. The variables selected have been measured for the period 2004-2011. In this way, the year of introduction of the PAYT falls exactly in the middle of the time period selected, thus giving a good overview of before, during and after effects of the policy intervention. Preliminary descriptive statistics are applied on the longitudinal data for each of the two groups separately. Averages and standard deviations are calculated before and after 2007 in order to have a better comparison between municipalities. Data is first presented in tables and then re-elaborated in graphs.

After having specified and collected data, the intervention and control groups are compared with the use of two methods: a simple *numerical difference*[18] of the means before, during and after the introduction of

[15] See section 3.6.3.
[16] See section 4.1.2.
[17] To be precise, the policy program (the introduction of a PAYT scheme) does not have an established end date. Therefore there is no possibility of an after measure. In the research the term before/during measure is used with the same meaning as what is defined by Rossi et al. (2004) as a before, during and after measure.
[18] Average value of Bellinzona minus the correspondent average value of Lugano.

a PAYT is given in order to provide a general overview of the performances and differences of the two groups; also, a statistical effect size measure is used to increase the comparability, robustness and validity of the results. The method selected is the *standardised mean difference*. This measure expresses the mean effect differences in standard deviations. The standardised mean difference is the most used statistical measure to express numerically an effect size (Rossi et al, 2004, p. 304), and since it is particularly *"…appropriate for representing intervention effects found on continuous outcome measures"* (p. 304), it fits particularly well with the type of data collected (i.e., time series). As shown by figure 1, the standardised mean difference of a specific variable is calculated as the difference between the mean score of the intervention and control group for that variable, divided by the pooled standard deviation of the intervention and control group. The fact that the pooled standard deviation of both groups is used helps to adjust for different scales, precisions of measurement and populations.

$$\frac{\bar{X}_i - \bar{X}_c}{sd_p}$$

where $\bar{X}_i$ = the mean score for the intervention group,

$\bar{X}_c$ = the mean score for the control group, and

sd_p = the pooled standard deviations of the intervention (sd_i) and control (sd_c) group scores, specifically: $\sqrt{((n_i - 1)sd_i^2 + (n_c - 1)sd_c^2))/(n_i + n_c - 2)}$ n_c with n_i and n_c the sample sizes of the intervention and control groups, respectively.

FIGURE 1: FORMULA OF STANDARDIZED MEAN DIFFERENCE (SOURCE: ROSSI ET AL, 2004, P. 305)

Sources of bias

With a quasi-randomised experiment, the level of certainty and confidence is lower than in a randomised experiment. Moreover, different sources of bias must be considered in order to reduce the influence on the results and therefore to give more credibility and confidence. The bias will eventually lead to over- or underestimated program effects that do not correspond to the "true" effects. It is possible to have bias occurring at several points during the assessment of the program's impact. For example, while building the two groups; while measuring the effects of the program and the policy design; or while estimating effects without program. The main sources of bias that must be taken into account are outlined below.

Bias from measuring and estimating effects: As suggested by Rossi et al. (2004) bias on program effects directly measured is easy to avoid, by simply using indicators and variables that are valid and responsive to all effect levels expected to appear among the target groups. Per capita measures are used in the research, to reduce bias coming from different exogenous variables. Second and more complex method to solve bias lies in the estimation of effects without the program intervention. Usually, the effects without intervention on a targeted group cannot be observed; they are therefore estimated and compared with the group with the intervention. It is therefore clear that the results will depend on both measured and estimated data. Since this is a special case that adopts two different and matched municipalities as intervention and control groups, the effects without intervention can be measured with the exact same procedure used to measure the effects with intervention. Thus, estimation bias is not relevant within the research.

Selection bias: Since the two groups have not been randomly assigned, but instead a quasi-randomised experiment is used, it is not possible to assume with a high degree of confidence that if both the municipalities selected did not receive the intervention (i.e., a PAYT scheme was not applied), they would have had the same quantities and costs of waste. Therefore, as stated by Rossi et al. (2004, p. 269), *"…equivalence on outcome, absent program exposure, cannot necessarily be assumed"*. Every municipality is unique and by using two different municipalities, it is practically impossible to perfectly obtain the same effects with the same program. Moreover, this assumption is also limited by the fact that neighbouring municipalities and their schemes have great influence on costs and quantities of the municipalities selected as intervention and control groups (e.g., if - and how many - neighbouring municipalities have PAYT schemes, and the extent of waste tourism). For all these reasons, selection bias is an important factor to be considered in the research. Both the fact that the groups have been self-selected and that the two municipalities have different demographic, cultural, political and economic variables may influence the final results; both are therefore accounted as source of selection

bias. In order to reduce this type of bias, as stated above, the two municipalities have been selected with exogenous variables as similar as possible (see table 8). Moreover, qualitative reflections are made if it is assumed that exogenous variables influenced the results.

Another potential source of bias is *attrition*; this may occur when targets of either control or intervention groups leave the group and cannot be reached, or are unwilling to cooperate in the effects' measurements. Although this was a possibility to take into account, during the research there has been no attrition. Therefore, it is not a relevant source of bias in this case. In order to avoid this, all the stakeholders from whom data was to be collected were contacted before the official start of the research, to ensure their willingness to collaborate and avoid attrition.

Other sources of bias: Biases arise not only during the selection process of the two groups, but in fact also during the program intervention. Different groups may be subject to different events and experiences during the intervention time. Other sources of bias account for the environment and all exogenous variables that influence the results of the program, and therefore may increase or decrease the effects measured. This influence is almost inevitable, especially when social programs are assessed. For example, households may reduce their waste production simply because they have become more aware of sustainable development and environmental practices - not only because they were forced to by the PAYT scheme. Therefore, even without the PAYT scheme, a net reduction of MSW could have been measured. Three types of external trends can be recognised:

- *Secular trends:* long-term trends that may result in an under- or overestimation of the program effects. A global demographic trend that is also reflected in this region is population growth and the reversal of the population pyramid. While it is clear that an increase in population leads to an increase in MSW produced, the relationship between age and MSW produced is less clear[19].
- *Interfering events:* short-term events that may bias the estimation of the effects. For example, the reduction of price per ton disposed due to the commissioning of the incinerator of Giubiasco in 2010 (costs of disposal fell from 285 CHF/ton to 175 CHF/ton). Some municipalities in Ticino also lowered their taxes on waste, and this could be responsible for an increase in residual and bulky waste produced after 2010 (DFE, 2010).
- *Maturation:* the influence of maturational and developmental processes (Rossi et al, p. 273). As stated above, the fact that in the beginning of the 90s, the concept of sustainable development and the environmentalism in general grew in popularity may have influenced the tendency to reduce MSW, or increase separation of waste. At the same time, today's households may be more prone to separate waste and companies may be more active in recycling and using recyclable materials. This incentivises the positive change in households' behaviour even more starkly.

[19] See for example Fullerton & Kinnaman (1996) and Rogge & De Jaeger (2012).

CHAPTER 3 - IDENTIFICATION OF COSTS AND BENEFITS

3.1 ACCOUNTING PERSPECTIVE

The first important step in developing a CBA is to establish which **accounting perspective** should be adopted. To avoid confused specifications and overlapping or double-counting, it is important to use a single perspective to define costs and benefits (Rossi et al, 2004, p. 345). An accounting perspective is a point of view through which costs and benefits are recognised, measured and monetised. Rossi et al. (2004) recognise three key accounting perspectives: individual target, program sponsor and communal. The individual target perspective takes into account the point of view of the population targeted to receive the program intervention; the program sponsor represents the source of the program intervention. In our case the municipality, the source of intervention, applies a PAYT scheme in order to reduce MSW produced by households - thus the population targeted. The communal perspective[20] takes into account the point of view of the society as a whole. As suggested by Rossi et al. (2004), this is usually measured in terms of total income. This perspective does not only merge the program target and sponsor point of view, but it also requires extra effort to recognise indirect and distributional effects. In the same way, Eijgenraam et al. (2000) recognise that a SCBA includes both direct and indirect effects, priced and non-priced. The author points out the importance for a SCBA of distinguishing between redistribution of welfare and net welfare increase. In fact, some of the costs sustained by municipalities and households may compensate each other (Rossi et al, 2004, p. 349). For example, the revenues that municipalities perceive from selling the bags or applying other taxes are reflected as costs for the households. These costs and benefits are redistributions, not net increases in welfare and thus should not be taken into account during the realisation of a SCBA. A SCBA is much more complex to perform due to its comprehensiveness. In fact, much data on the effects, costs and benefits must be collected from different sources and in this specific case, the fact that the SCBA is of an ex-post nature reduces the complexity, and thus allows this type of research.

Why is it important to use a social perspective in the research?

Firstly, it is important to recall that the research is embedded in an academic context, in which Sustainable Development is the underlying theme. It is therefore not possible to carry out a CBA merely from the financial point of view of one stakeholder - as would be the case if it were carried out by the municipality itself or by a financial institution - but the three pillars of sustainability (environment, economy and society) and different stakeholders must be involved. Furthermore, it is clear that since the objective of the research is to assess the *social efficiency* of alternative financial incentive schemes, the only possible choice is to use a social perspective. Since the social perspective does not take the side of only one stakeholder, it is generally considered the most politically neutral (Rossi et al, 2004). Of course, objectivity and neutrality are important factors in any academic research.

The effects on MSW management cannot be isolated; they involve many stakeholders who are often influenced indirectly. Individual target and program sponsor perspectives are limited to the efficiency of only one of the stakeholders - this would result in an underestimation of the effects and thus lower or higher social efficiency.

3.2 GEOGRAPHICAL DELINEATION

Another important step is to establish the **geographical boundaries**, since different geographical boundaries may lead to different effects and thus levels of social efficiency. This is even more important when a social perspective is used (and thus indirect and distributional effects are taken into account). Eijgenraam et al. (2000) recognise that the effects of major projects often cover large areas; cross-border or cross-regional effects are possible. Therefore it is important to clearly show the distribution of costs and benefits among regions (or nations, if that is the case). For example, the effects of MSW's disposal may affect the

[20] In the research the term social perspective is used instead of communal or comprehensive perspective.

environmental quality not only of people living next to incinerators or landfills, and not only people of the municipality, or even of Switzerland, but may reflect also on other (neighbouring) nations. In the same way, the reduction of MSW may affect private companies which manage waste collection and disposal. These effects can vary according to the location of these companies and the geographical boundaries set within the research. If the private companies are within the boundaries chosen, the effects are taken into account. On the contrary, if the companies are outside the geographical boundaries set, the effects are as a result excluded from the efficiency's measure.

Rossi et al. (2004) explain the possibility of defining the boundaries of a program as a catchment area - the geographical area being served by the program. If this definition is applied to this specific case, the catchment area for a PAYT scheme is the boundary of the municipality where the scheme is introduced. Therefore the geographical boundaries of the municipality under study are taken as the boundaries of the SCBA within which costs and benefits are measured. In order to assess the social efficiency, only costs of the specific municipality are taken into account. Despite the fact that environmental costs may have an effect on the entire region (i.e., Canton Ticino) and not only inside the municipality itself, these are calculated on the basis of the emissions created only by the quantities of waste that the specific municipality sent to the incinerator. The only partial exception made is for costs related to waste tourism. In order to measure this, costs and quantities of other municipalities' MSW are considered, and the major/minor costs sustained by a municipality because of waste tourism from neighbouring municipalities are subtracted/summed.

3.3 TIME HORIZON AND RISK DISCOUNTING

Eijgenraam et al. (2000) and Rossi et al. (2004) underline the importance of accounting for time and risk while a program unravels itself, when assessing program efficiency. To take these factors into account, a technique called **discounting** is used.

Time Horizon: if time is not considered, the evaluation of costs and benefits is restricted only to the specific moment at which data are collected. In order to set a time horizon, it is necessary to consider the time span in which most of the costs and benefits occur. Often, social programs do not produce costs and benefits immediately after their introduction; they are instead spread across time. Costs may therefore decrease over time and benefits increase - or the other way around. For example, costs of the introduction of a PAYT scheme may be much higher at first due to investment in various equipment and infrastructure (bags, underground containers, etc.), and due to the fact that people must adapt to the new scheme. Environmental costs and benefits may also be reflected only after a certain amount of time. In this specific case, it appears that households adapt and change their habits quite fast and therefore quantities of MSW decrease and recyclable materials increase within one or two years of the scheme's introduction. Especially in social programs, benefits also persist throughout the participants' lifetime. For example, the changes in households' behaviour regarding waste habits will probably persist, or even augment, through the generations. In order to define the **time horizon** of the alternatives, their characteristics must be analysed in depth. If only the equipment's technical lifespan of the alternatives is considered, it is possible to understand that the PBV has an unlimited lifespan. In fact, the introduction of a PBV scheme does not necessarily require irreversible investments in infrastructure or specific adjustment in the collection system. On the contrary; for the PBW scheme, it is necessary to purchase specific scales for trucks (if kerbside collection) or containers (if centralised). In this case, the lifespan can be calculated as the lifespan of the equipment purchased. Despite this, the time horizon of the program itself can be seen as unlimited - after its introduction the scheme will continue, and no end date is officially fixed as in, for example, social requalification programs.

For all these reasons the research will consider a unique standard time horizon of 100 years to include technical lifespan and pay-back-time; therefore this research is not in danger of underestimating costs and benefits. Moreover a 100-year lifespan is also appropriate, since it can be considered that after 100 years the PAYT scheme will probably be obsolete and new solutions will be available.

Risk and discounting: as recognised by Eijgenraam et al. (2000), quantifying risk is a very difficult task. In order to do this, again the characteristics of the two alternatives are fundamental. The two alternatives can be

classed as risk-free investments since, compared to large infrastructural projects, the investments needed to set up a PAYT scheme are much lower. Despite this, we must consider that the PBW may also bare higher risk since it requires higher, irreversible initial investments when compared to the PBV.

An example of such risk comes from the municipality of Caslano. After the introduction of the PBW scheme, which required the purchase of a specific scaling system and prepaid cards, the citizens started a referendum in order force the municipality to change the newly installed system. The reasons for this were the citizens' concern for the high price per kg fixed by the municipality, and the technical issues related to the underground containers. The referendum was in fact rejected, but it is clear that if this had been accepted, the municipality would have lost a substantial amount of its investment.

Eijgenraam et al. (2000) prescribe a rate of 4% for a risk-free project. This should also take into account the lower value of benefits arising in the future, as compared to current benefits. The highest costs and benefits of the introduction of a PAYT scheme arise immediately, in the same year of introduction - at the most, one or two years after. Therefore, it is not necessary to discount costs or benefits for future value. Moreover, not all costs sustained for the introduction of the PAYT scheme can be subjected to discounting; these costs would have also been sustained without a PAYT scheme since collection and disposal of waste is a basic service that the municipality needs to provide to the population. Therefore, the discount rate is applied only to specific investment in infrastructure and equipment strictly related to the introduction of PAYT scheme and not to all costs related to collection and disposal of waste. For these reasons, a discount rate of 4% and 5% is applied respectively to the cases of Bellinzona (PBV) and Caslano (PBW).

3.4 Four Cases

In order to carry out the research, and because of the comparative nature of the method used (i.e. SCBA), different cases need to be selected and compared. As described by Eijgenraam et al. (2000) and the European Union (2008), it is possible to distinguish between several cases: business-as-usual scenario, base case and several alternatives.

The first case is the *business-as-usual* (BAU), which describe the situation in the current state without any intervention (this is also known as the 'do-nothing' scenario). As stated by Eijgenraam et al. (2000), program effects are the differences between the development with (base case and alternatives) and without (BAU) the implementation of the program. Therefore the BAU is fundamental to evaluate the impact of a PAYT scheme and to measure the net costs and benefits of the other cases. In fact, the difference of costs and benefits between the cases and the BAU scenario will result in the measure of net effects of the introduction of different financial incentive schemes. Eventually, the highest positive difference will represent the most socially efficient scheme (see chapter 9). The second case is the *base case*. This is not "doing nothing" or current situation, as in the BAU, but it is a combination of the best alternative application of the available investment resources, in case the program is not realised. This best alternative is usually the smallest possible intervention, investment or measure adoptable. The base case is as important as the BAU or the alternatives, since it is used to recognise all the deviations of the PAYT schemes from the minimum investment (i.e., the extra effects). Moreover, at least one alternative must be selected in order to represent the intervention.

In this research, four different municipalities in the south of canton Ticino, Switzerland, have been selected. The selection of the four cases is based on two principles: representativeness and similarity. Firstly, the municipalities selected need to represent the variety of schemes present in the region. These schemes vary in terms of the extent to which they incentivise households to reduce MSW. In order to be comparable, the municipalities selected also need to be as similar as possible in all the exogenous variables that may influence quantities and costs of MSW (see section 3.6.3). Therefore the biggest municipalities within their scheme's category have been selected. This also helped in the inherent higher availability of data. Since it was not always possible to match the four municipalities exactly in all the variables, questions aimed to measure these variables were included in the interviews. Qualitative considerations about the possibility of over- or underestimation of costs and benefits due to these variables are made when necessary. Lastly, in an ideal situation, the cases selected must also represent all other municipalities with the same scheme in order to

have a good degree of generalisability of the results. This was more difficult to achieve due to the wide variety of demographic and economic variables among the municipalities in Ticino. The level of generalisability is therefore not very high and will vary from case to case.

Usually when setting up a CBA to decide about an infrastructural investment or about the adoption of a social program, different alternative cases are built around a single unit or case (i.e., municipality). In this research, four distinct municipalities (i.e., cases) are considered. This is mainly due to the fact that the analysis is *of policy (ex-post*), and social costs and benefits cannot be estimated; they must instead be measured 'in the field' in order to assess the real level of social efficiency, and therefore answer to the research questions. It is acknowledged that by using multiple cases, exogenous variables and specific characteristics of the municipalities may influence the comparability and therefore the results. The four cases are structured as follows:

- **Business-as-usual:** The municipality of Lugano is taken as the BAU scenario, since it does not apply any direct tax and thus there is no incentive on households. Instead, Lugano finances the WMS with a general income tax. Also, it does not provide a systematic kerbside collection for residual, bulky or recyclable waste.
- **Base case:** Locarno applies a lump sum tax on waste based on the number of people living in the household and therefore is considered as the base case, or case with *minimum intervention.* The taxes on households vary from 126 CHF a year to 402 CHF a year. Here, it is assumed that a lump sum tax gives a minimum incentive to households, since they can directly associate the money paid with the waste produced (they know what they pay for). The calculation of lump sum taxes is often based on the costs of collection and disposal. Therefore, a household may consider reducing the quantities of MSW produced in order to decrease the costs for the municipality, and therefore pay lower taxes in the following years. Locarno also provides a kerbside collection for paper, organic and residual waste.
- **Alternative 1:** Bellinzona is the first of the PAYT cases - it applies a *pay-by-volume* (PBV) scheme in combination with a lump sum. In order to present their garbage for collection, households and small businesses must purchase specific coloured and tagged bags. The households must pay a fixed tax of 50 CHF a year, and the price for a bag varies according to its size (between 9 CHF for 10 bags of 17l and 28 CHF for 10 bags of 60l).
- **Alternative 2:** The last case is the municipality of Caslano, which adopts a *pay-by-weight (PBW)* scheme in combination with a lump sum. The citizens, at the moment of depositing waste, must weigh their bags and the relative amount of money is deducted from a prepaid card.

3.5 Program Theory

3.5.1 Program Impact Theory

A program impact theory includes all the assumptions about the social changes that the introduction of a PAYT scheme may bring to the targeted society.

The following figure shows the main causal relationships that form the introduction of a PAYT scheme. As direct consequence of the introduction of a PAYT scheme, the unit price paid for non-recyclable waste will increase. This is seen as a financial incentive because - in order to minimise the costs related to waste disposal - households must maximise separation of recyclable waste and minimise the amount of MSW produced. Thus, household behaviour towards waste production will change: higher quantities of waste will be separated and recycled and lower quantities of non-recyclable will be disposed. This in turn will eventually lead to lower costs for the municipality, better financial performance (less problematic for the municipality to finance MSW's collection and disposal) and lower externalities from WMS.

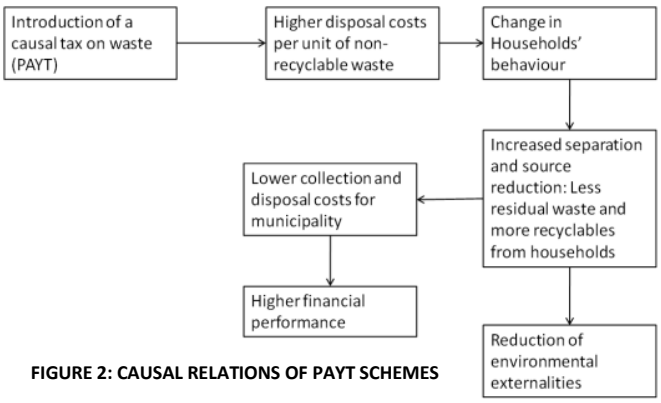


FIGURE 2: CAUSAL RELATIONS OF PAYT SCHEMES

3.5.2 Program Boundaries

The definition of the boundaries of a PAYT scheme may seem straight forward. In fact, these boundaries can be considered simply as the physical boundaries of the municipality that introduced such a scheme, since all households in the municipality are targeted. Despite this, though, it is important to account that some secondary and negative aspects, such as illegal dumping and waste tourism, cross the boundaries; it is also important to take into account neighbouring municipalities when assessing the social efficiency of a PAYT scheme. For example, a PAYT municipality that is surrounded by non-PAYT municipalities will probably have a higher percentage of waste diverted by waste tourism, and therefore the reduction of MSW produced showed will also include a higher degree of reduction due to waste tourism, not due to households' source reduction or more separation. This is especially true during the early years of introduction, especially if the fees that must be paid with the newly introduced PAYT scheme are much higher if compared to the old scheme and to neighbouring municipalities. On the contrary, a PAYT municipality that is surrounded by other PAYT municipalities will have a lower influence of waste tourism in its reduction of waste (e.g., Bellinzona). In the last case, data about MSW reduction are more representative of the real impact of the PAYT scheme.

3.5.3 Explicating Program Theory

Goals and Objectives

The main goals of the environmental laws introduced at federal and cantonal level[21], and therefore of the introduction of a PAYT scheme in a municipality, are twofold; partially merely economic and partially environmental. Due to the increasing amount of MSW, it is increasingly difficult for the municipalities to finance their WMS. The introduction of a PAYT scheme does not aim to increase the amount of money available by the municipality; on the contrary, it is to lower management, collection and disposal costs and therefore increase the financial performance of the municipality.

The reduction of costs is directly linked to the environmental objective, which refers to the reduction of MSW and related externalities, and the improvement of environmental quality.

It is assumed that, thanks to the financial incentive, households will change their behaviour and separate more in order to save money. By separating more, the amount of residual waste disposed in the incinerator is reduced, more is recycled, less virgin materials are used and as a consequence less pollutants are emitted into the air or soil. The central and main goal of PAYT schemes is the **change in households' behaviour**. This is the turning point that determines the success of the PAYT scheme.

Stakeholders

The two main stakeholders that interact within the program are the municipality (the program's initiator) and the households (the targeted population). Within the municipality, the city council play an important role, especially during the evaluation and introduction of the PAYT scheme. It has the decisional power and can accept or refuse the scheme. As also stated by Zamboni (2013), political will is the main determinant of the introduction of a PAYT scheme. If the city council is against the introduction of a PAYT scheme - as is the case in Locarno and Lugano - the scheme has no chance of being introduced. Later, after the introduction, the department and people responsible for the WMS are the most important stakeholders within the municipality. They have the power of deciding on the organisational activities that involve waste collection and disposal, therefore the performance of the scheme may also depend on the ability of these individuals.

Neighbouring municipalities must also be noted as a secondary external stakeholder. As stated above, the schemes of neighbouring municipalities may have an important role in determining the extent of illegal dumping and waste tourism within the municipality.

Households are another fundamental stakeholder, since the main goal of the program is to change household behaviour regarding the separation and recycling of MSW. Households are thus the key stakeholder and have great influence on the performance of the program. Households can either accept and use the PAYT

[21] See Annex IV for more information about legislation.

scheme or divert their waste to illegal dumping or waste tourism; they can also have the power of changing the scheme's fees and structure, through a referendum. Potential issues are often found to be related with large families with babies, low-income families or the elderly.

Moreover, cantonal and federal authorities and their organs (e.g., the federal tribunal) also have the power to influence the decisions of municipalities about PAYT schemes, and they are able to pass directives and suggestions on how to manage MSW (e.g., which waste to separate and recycle).

Another secondary stakeholder is businesses. For example, municipalities which also collect waste from businesses are in a disadvantaged position, if many businesses operate there[22]. Businesses may not be subject to a PAYT scheme, but their waste quantities are - at least in part - accounted with those collected from households. In fact, many businesses dispose their waste in underground containers with households. The number of businesses in a municipality is therefore an important variable to account when assessing the performance of a PAYT scheme.

Functions, Components and Activities

The first important step before actually introducing the PAYT scheme is to understand how it is perceived by the population and city council. The biggest threat for the introduction of a PAYT scheme in Ticino is in fact the referendum, which may have the power of eliminating the PAYT scheme and returning to the old scheme. Moreover, it is also important to look at neighbouring municipalities and assess how these may affect the performance of the scheme. For example, if all the other municipalities introduced a PAYT scheme, it may be a good idea to proceed in that direction; otherwise, the result may be a huge increase in waste tourism towards the municipality. Furthermore, it is also important to assess the current related infrastructure and calculate costs related to modernisation and adaptation. As stated above, usually ecocentres and ecopoints are built and/or modified in order to fit with the new scheme. These operations usually require large investments. The last preliminary step before introducing a PAYT scheme is to determine the fees that will apply with the new scheme. This may be, for example, the costs for bags of different sizes (PBV), the cost for one kilo of different waste (PBW); or if the households are charged only with causal tax, or also with a lump sum tax.

After the city council and citizens have approved the estimated budget and the fees are established, it is possible to proceed with the actual introduction. Some opt to introduce the scheme only in a small area of the city, as a trial. All households near the test site start to use the new scheme with new infrastructures and equipment, on a small scale, while all the other households remain with the old scheme. During this time, the municipality can collect feedback from the households and adapt the infrastructure, equipment and fees. If the test was met with a positive response, the new scheme can be applied across the entire municipality. This is the moment in which the investment costs are at the highest point and are irreversible. Ecopoints are modified, expanded or newly built. Ecocentre are built or improved and parallel infrastructures - such as places to buy bags, tags, containers or to charge magnetic cards in the case of the PBW scheme - must be arranged. All these activities and functions require an extra administrative effort, and the municipality may need to hire additional employees to run the ecocentre, to sell the necessary equipment, etc. The work for the municipality does not end when the scheme is finally introduced, but especially at first it must pay attention to the needs of the household and look at potential negative effects such as illegal dumping. Feedback from households and experts must always be taken into account, and the scheme may be adapted during the entire lifetime and not only in the beginning.

3.5.4 Objective assessment

In general, there are no guidelines on how to carry out the program. Functions, activities, resources and capabilities are different depending on the scheme adopted (i.e., volume, weight, frequency or hybrid).

[22] This is the case of Grancia, which has the highest per capita residual waste production of all Canton Ticino. This is justified by the fact that Grancia is the biggest commercial location in Ticino where shipping malls, industries and other economic activities are concentrated.

There are no ready-to-use instructions on how to implement the PAYT scheme; it is up to the municipality to decide on and establish all the aspects mentioned above. Federal and Cantonal Laws only state the need of financing the WMS following the PPP, but do not restrict the choice of the municipality in any way. This is typical of a multi-level government - as is the case in Switzerland.

Are the policy objectives well-defined?

The stated objectives are very simple in the form in which they are defined. For example, no guidelines on the expected or required percentage reduction in costs are stated. The same applies for the increase of separation and reduction of residual waste. The objectives are easy to understand and uniform within all the official and non-official documents analysed.

Are the goals feasible and plausible?

Financial incentives are commonly known to be a good instrument used to change behaviours. Usually, people try to minimise their costs. In this case, since the unit costs for disposal of MSW increase, people will automatically try to separate more in order to reduce the weight or volume of their residual waste. For this reason, the assumption of an increase in separation, recycling and reduction of residual waste is both plausible and feasible. Moreover, the results of a survey to households made in the two PAYT municipalities showed that households in general recognise a PAYT scheme as a good incentive to separate and recycle more, especially because money is directly involved. The reduction of costs related to collection and disposal is also a feasible goal, closely related to the first goal. In fact, if the amount of residual waste is reduced, for example directly from source reduction, MSW must be collected less frequently - further reducing the collection costs. Moreover, since lower quantities of non-recyclable waste are sent to the incinerator, the costs for disposal are lower. It is also important to consider that municipalities usually make profits from recyclable waste. Therefore, if households separate more, more recyclables can be sold thus increasing the profits. For all the reasons above, the goals set with the introduction of a PAYT scheme are both feasible and plausible.

3.6 IMPACT MODEL

In this chapter, all the effects that can be attributed to the implementation of PAYT schemes are recognised and described. A detailed explanation of the sources used to recognise the effects and motivations for including such effects in the research are also given. Finally, these effects have been linked in a causal way in order to form an impact model that graphically shows the impact of the introduction of PAYT schemes.

The development of an impact model is very important within a CBA. The aim of a CBA is to evaluate the effects of a policy program in monetary terms (Runhaar, 2011) - in this case the introduction of a PAYT scheme. As stated by Rossi et al. (2004), especially for an ex-post analysis, a CBA should be considered an extension of, rather than an alternative to, impact evaluation. It is logical that, before even starting to assess the effects that can be attributed to the policy program, these must first be identified. The first step in an impact assessment is in fact to determine the variables (i.e., effects) that need to be measured.

Moreover, a difficult point to overcome during the realisation of a CBA is how to prevent double-counting. By setting up an impact model, a causal chain of events that begins with program implementation and ends with changed social conditions is established. It is thus possible to recognise eventual double-counting errors and therefore avoid them.

A distinction must be made between the **output and outcome** of a program. Output describes the actions performed during the implementation of the program, while outcome is the effect of a program on society. In this specific case, the output consists of all the actions performed in order to implement a PAYT scheme in the municipality (see section 3.5.3). The outcomes are all the effects on the society that can be attributed to the implementation of a PAYT scheme. Such effects are, for example, changes in the amount of waste produced, recycled and composted, changes in the level of environmental externalities, etc.

Rossi et al. (2004) define the effect of a policy as the change in the policy outcome (difference in outcome with and without the policy intervention). The effect of a PAYT scheme is, therefore, the difference in the outcomes of municipalities with and without PAYT.

In order to explain how the effects are recognised, it is fundamental to recall that a **social perspective** is used to assess cost and benefits. This is important because it has great influence on the type of effects that are included in the impact model and in the calculation of social efficiency. For example, a social perspective requires an extra effort to recognise indirect and distributional effects.

Many types of effects can be recognised when developing a SCBA. For example, Eijgenraam et al. (2000) underline the importance of distinguishing among: regional vs. national vs. international (cross-border effects); direct vs. indirect; priced vs. non-priced; efficiency vs. redistribution[23]. For practical reasons, all the effects have been organised in two main categories - direct and indirect. Despite this, all the other types described in Annex I have been recognised.

3.6.1 Direct effects

The literature review made clear that the main direct effect of the introduction of PAYT schemes is the **reduction in MSW produced by households**. This effect has impact mainly within the boundaries considered, affects all the stakeholders involved and can be priced (e.g., using market prices). More importantly, it constitutes an important efficiency effect since it may increase the social net welfare both financially (fewer costs) and environmentally (fewer externalities).

Even so, it is not always clear what the definition and composition of waste reduction is; there isn't uniformity in the way it is measured. Often, studies simply define waste reduction as the reduction of waste send to landfills (Hallas & Halstead, 2004) or simply as the reduction in MSW disposed (Huang et al, 2011; Šauer et al, 2008). Moreover, Bischof et al. (2003) and Dijkgraaf & Gradus (2003) measured the reduction in terms of waste collected by the municipality. Some authors have been more precise in defining waste reduction and its composition. Taylor (2000) recognises that waste minimisation can be attributed to source reduction and waste diversion (through recycling, composting, etc.). Hogg et al. (2006a, 2006b) used the general term "waste prevention" and recognised three main causes: source reduction (e.g., buying more durable and less packaged goods), avoidance (e.g., preventing delivery of unwanted mail or not purchasing unnecessary goods) and product reuse (e.g. donating goods to charity, reusing goods).

Therefore in this research, three main sources of MSW reduction are recognised: waste diverted to **recycling**, diverted to **composting** and **source reduction**[24].

All studies found positive impacts on the reduction of MSW produced[25] and on the increase in recycling and composting[26] after the introduction of PAYT schemes. Despite this, the positive effects vary greatly among studies, a fact which can be attributed to different definitions of MSW reduction but also to different and uncertain measurements of waste produced, collected and disposed, different PAYT considerations (weight, volume, bag, etc.), different operating environments and different methods and variables used for the analysis (Taylor, 2000 and Skumatz, 2008). It is possible to estimate that, on average, the effect of a PAYT on the amount of MSW produced is a reduction of 30% (Bischof et al, 2003; UFAM, 2003). Studies have shown reductions from 10% up to 74% (Hogg, 2006a, 2006b; Huang et al, 2011). The amount attributed to source reduction varies from 5 to 7% (on a total MSW reduction of 16%) (Hogg et al, 2006b; Skumatz, 2008). Figure 3 presents the results about the effect on total amount of MSW produced, obtained by Bischof et al. (2003) from a comparison among 13 Swiss municipalities with and without bag schemes.

[23] For more information about the classification framework used in order to recognise the effects, see Annex I.
[24] This includes also avoidance and product reuse.
[25] See Hypothesis 1, Hogg et al. (2006b), p. iii (7).
[26] See Hypothesis 1, Hogg et al. (2006b), p. iv (8).

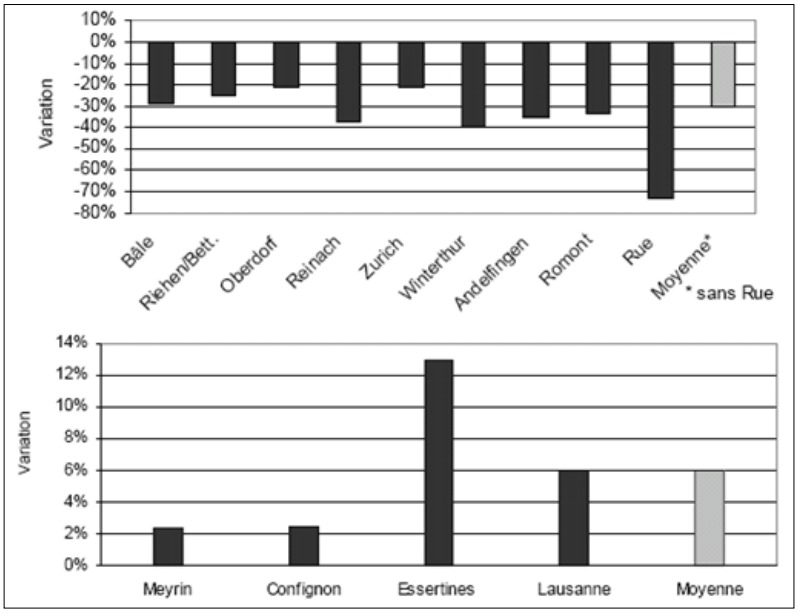


FIGURE 3: VARIATION IN RESIDUAL WASTE PRODUCED BY HOUSEHOLDS IN MUNICIPALITIES WITH AND WITHOUT BAG SCHEME (SOURCE: BISCHOF ET AL, 2003)

Even more variation is found in the studies regarding the effect of PAYT on recycling. For example, Taylor (2000) found that the increase in recycling among several studies (in municipalities in U.S.A.) ranged between 3% and more than 150%. Part of this impact and variation can be explained by different levels of parallel recycling programs in place.

A third element of MSW reduction is composting. Studies agree that there is a positive impact on the amount of composting performed by household; but clear data are not always presented. This can be explained by the fact that since composting usually takes place in private gardens, it is very difficult to measure. Dijgraaf & Gradus (2003) estimated the impact of different PAYT schemes on composting by measuring the reduction of organic waste's quantities in the residual waste presented for collection (p. 359). The reduction was estimated between 14% and 60%, depending on the PAYT scheme used. Moreover, it is often difficult to isolate the impact on composting, since it is often merged with recycling or other effects.

Another important direct effect recognised within the literature review is the increase in **illegal dumping**, **waste tourism**, littering, and other forms of illegal or uncontrolled waste diversion. This is in fact the main fear for municipalities that want to introduce a PAYT scheme. In the study of Skumatz (2008), 20% of the municipalities investigated cited big problems of illegal dumping. Results on the effects of illegal dumping are mixed. Some studies show no presence or no relevance of illegal dumping on the reduction of MSW (Dijkgraaf & Gradus, 2004); other studies show a limited impact, consisting in only 1-2% of the total amount of MSW (Bischof et al, 2003 and UFAM, 2003); some measured a large influence of illegal dumping on the total amount of waste decreased (Skumatz, 2002), in some cases 28-43% (Fullerton & Kinnaman, 1996). This variety in results may be due to different cultural and geographical characteristics. For example, there may be more chance for illegal dumping in rural areas or in developing countries than in developed or urban areas (because of geographical and political structures). Moreover, as explained by Dijkgraaf & Gradus (2003), waste tourism may depend a lot on the distance between municipalities with and without PAYT, and if municipalities without PAYT are surrounded by PAYT municipalities.

As can be seen from figure 4, the "Dipartimento del territorio" (Zulliger, 2013) compared production of residual and recycling waste in 56 municipalities in Canton Ticino before and after the introduction of a PAYT scheme. They found that, on average, 5.6% of MSW reduction cannot be attributed to reduction of residual waste or increase of recyclable waste. This 5.6% is a combination of three positive effects - source reduction, more composting in the garden, direct disposal of businesses - and three negative effects - waste tourism, disposal in fireplaces and disposal in

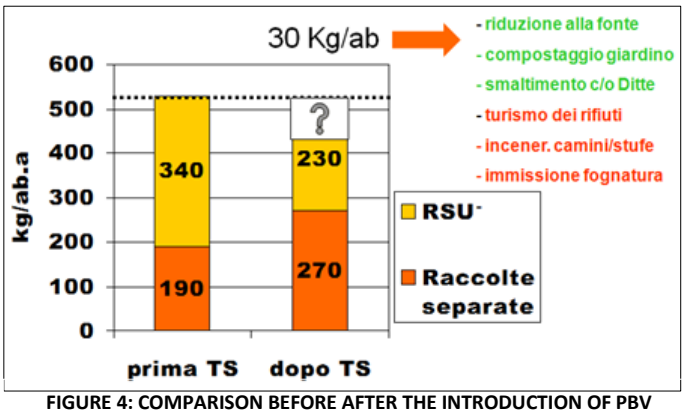


FIGURE 4: COMPARISON BEFORE AFTER THE INTRODUCTION OF PBV SCHEME IN 56 MUNICIPALITIES (SOURCE: ZULLIGER 2013)

sewers. As stated above, the single effect of illegal dumping and disposal has been calculated on average to be 2% of the total MSW produced.

Another negative, direct and priced effect that derives from the introduction of PAYT schemes is the possibility of an **increase in administrative costs, equipment costs** and efforts. This is a possibility since, at least during the time of introduction, the WMS must be adjusted, staff must be trained, bags must be purchased, old containers and other equipment must be modified or new purchased, eventually leading to more maintenance (Skumatz, 2002 and 2008). For example Rogge & De Jaeger (2012) recognised an increase in administrative costs of 8 Euros per household after the introduction of the id-chip scheme in Belgium. In the CBA of Fullerton & Kinnaman (1996), the results presented in table 2 showed that social benefits (second column[27]) were less than the additional administrative costs (third column[28]) in either situation, i.e., both with (DUMP1 and DUMP 2) and without illegal dumping (No dumping). These results are partially criticised by Hogg et al. (2006a) because of the limits in the way costs and benefits were taken into account (p. 47).

Assumption	Benefits (per person per year)	Threshold Administrative, Enforcement and Compliance Costs (per bag)	Estimated Administrative Costs to Government (per bag)
No minimum:			
No dumping	3.59	0.149	0.193
DUMP1[a]	2.67	0.111	0.193
DUMP2[b]	2.17	0.090	0.193
One-bag minimum			
No dumping	2.54	0.105	0.193
DUMP1[a]	2.38	0.099	0.193
DUMP2[b]	1.95	0.081	0.193

TABLE 2: COST-BENEFIT COMPARISON FOR CHARLOTTESVILLE, VIRGINIA (SOURCE: FULLERTON & KINNAMAN, 1996)

Despite the increase in administrative costs having a negative impact on the social efficiency, the total costs sustained by the municipality are found to be lower or the same, at worst (Skumatz, 2008).

Moreover an important and positive direct, non-priced effect of the application of schemes conforming to the PPP is that these are considered to be fair - they **enhance equity among the population**. This is due to the fact that those who produce more waste, and thus use a larger part of the service, must pay more. For example Hogg et al. (2006a, p. 125), by analysing previous reports (BDA Group and EconSearch), stated that user charges on waste have been introduced for a number of reasons, including for improved equity in waste charges. In the U.S., too, municipalities have introduced PAYT schemes to reduce MSW: they aim to begin *"...increasing recycling and promoting equity in paying for the service"* (Huang et al, 2011, p. 1). Skumatz (2002) also recognised equity as one of the advantages of PAYT schemes. The same author recognised from a survey on households after a PAYT scheme implementation that, because of the equity that these schemes provide, they are preferred by the 95-98% of the households (Skumatz, 2008, p. 2782). Of the same opinion are also other authors such as Taylor (2000) and Bartoli (2009).

3.6.2 Indirect effects

On the other hand, an important indirect, priced and efficiency effect of the introduction of PAYT can be recognised. This is defined as indirect, because it derives directly from source reduction, recycling and composting. The assumption is that - since the amount of waste that needs to be collected and disposed is reduced - the costs for MSW management decrease.

Reduced costs for MSW management: all studies recognised a positive effect on costs for MSW management. Hallas & Halstead (2004) measured that municipalities with PAYT can save 0.06$ per household per day, due to the reduced amount of waste that needs to be treated. The following figure by Hogg et al. (2006b) shows how potential savings, up to £18, can be achieved by a combined weight/frequency scheme.

[27] Benefits per capita per year are translated into benefits per bag in the second column. The threshold represents the cost that would make the social profit equal to zero.

[28] These include the cost of purchasing the bags and paying the employees and exclude costs for enforcement and compliance.

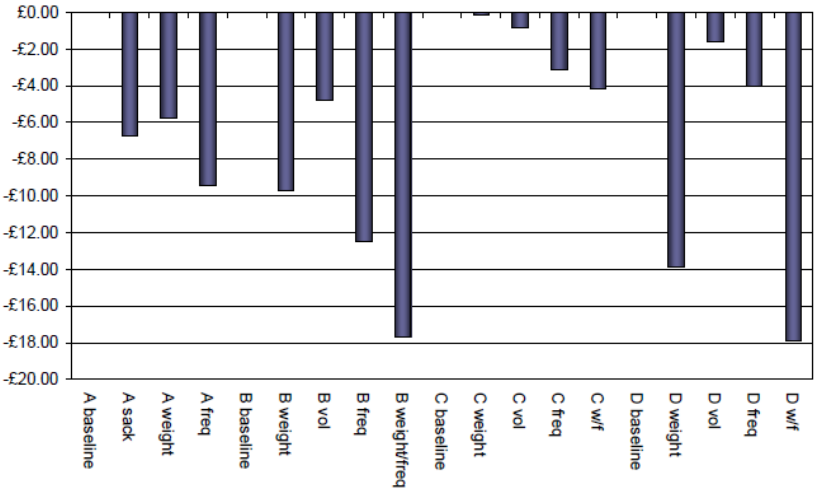


FIGURE 5: TOTAL COSTS OF SYSTEMS RELATIVE TO AUTHORITY BASELINE (SOURCE: HOGG ET AL, 2006B)

Skumatz (2002 and 2008) obtained the same positive results in a study among U.S. municipalities and found that 66% had the same or lower costs after the introduction of a PAYT scheme. The author also pointed out the importance of operating environment and the choice of the appropriate scheme (to fit the infrastructure already in place) for determining the total municipality costs for MSW management. Moreover, Rudin (2010) recognised that, with only the effect of reduced waste to dispose, the municipality of Lugano can save up to two million Swiss francs per year. Finally Bischof et al. (2003) recognised an average decrease in costs for MSW management among 13 Swiss municipalities of 20%. This can be explained by the difference in costs for disposing non-recyclable waste. Since residual waste decreases and recyclables increase, and the costs to dispose recyclable are lower than those for residual waste, the total costs for the MSW management will be lower (Rapporto Mozione 3442, 2010). It is therefore clear that the reduction of costs related to the MSW management constitute one of the most important efficiency improvements.

Another negative and priced effect related to the decrease of MSW is the reduced contribution to electricity production. In fact with lower quantities burned in the incinerator of Giubiasco less waste is converted into electricity thus decreasing the profits.

One of the most important indirect effects used to sustain and incentivise the introduction of PAYT schemes is the **increased environmental quality.** This is clearly a non-priced, efficiency effect that may influence all the stakeholders, but especially households living next to incinerators and landfills. The reduction of waste produced has also the potential to result in lower externalities from MSW management, and can therefore lead to higher **environmental quality**. Firstly, less waste is burned or disposed, thus reducing hazardous emissions of CO_2 and other greenhouse gases from incinerators and landfills. Since the totality of residual and bulky waste in Ticino is disposed in the incinerator of Giubiasco, emissions from landfills can be excluded. Emissions from incineration of residual and bulky waste are dioxin, furan, CO_2 and other gases such as sulphur dioxides, nitrogen oxides and heavy metals (e.g., mercury). The different gases emitted have different impacts on the environment, for example, mercury is considered more hazardous than CO_2 (IPCC, 2000; Beychok, 1987; Chang et al, 2003; Themelis, 2003). This, in turn, makes it more difficult to exactly estimate the impact on the environment and thus to quantify environmental effects on social efficiency. Moreover, less collection and transportation of MSW leads to **fewer emissions** from trucks and other collection vehicles. Fewer emissions from MSW management will in turn increase the environmental quality of air, soil and water. Consequently, these positive effects (both from disposal and collection) can lead to improved health of the population (e.g., less respiratory problems for people living close to incinerators or landfills). As described by Hogg et al. (2006b), important savings in CO_2 emissions are possible thanks to the increase in recycling and decrease in landfill waste (see figure 6). This will eventually lead to better performance in climate change mitigation (p. 108). These effects can be economically evaluated in order to measure the extent of the environmental damages or benefits, for example, by applying a price of £65 per ton of CO_2, based on previous studies[29]. Skumatz (2008) also described a positive effect on the reduction of greenhouse gases emissions (p. 2782). Of the same opinion are Huang et al. (2011), who recognise the potential for households in reducing their environmental footprint through the reduction of MSW (p. 5).

[29] See Watkiss et al. (2005), in Hogg (2006b).

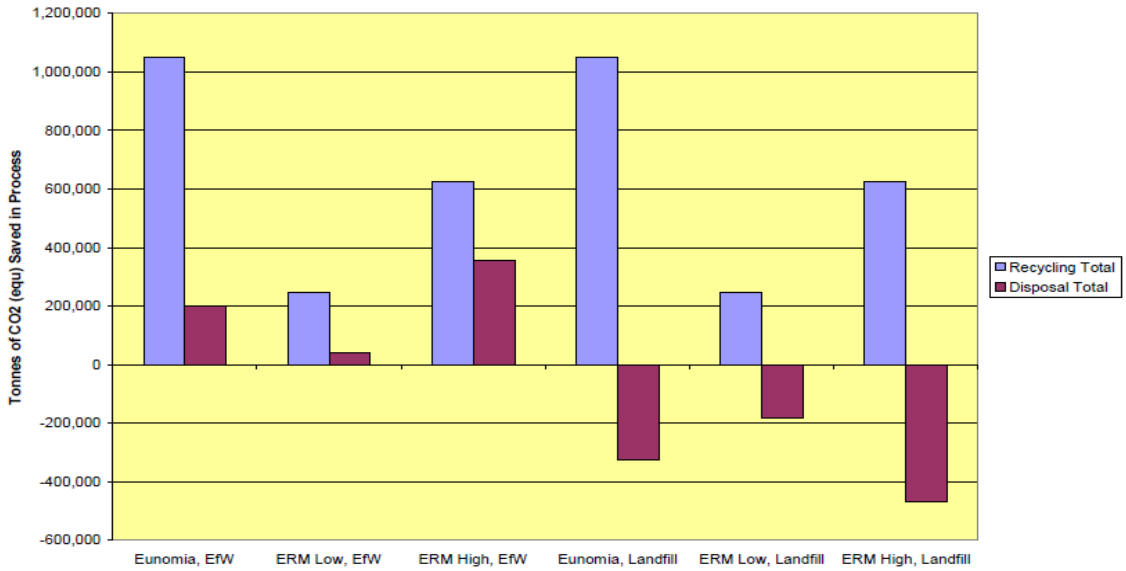


FIGURE 6: IMPACTS OF RECYCLING ASSOCIATED WITH PAYT SCHEMES AND AVOIDED DISPOSAL (SAVINGS IN TONS OF CO2) (SOURCE: HOGG ET AL, 2006B)

Other authors also recognise lower environmental burdens and more efficient use of resources as positive effects of PAYT schemes, but do not measure or explain them in detail (Šauer et al, 2008; Skumatz 2002, 2008; Bartoli 2009; Rudin 2010). Hogg et al. (2006a, p. 67) recognise potential positive health effects but state the difficulty in estimating the effect of hazardous pollutants on human health. Hogg et al. (2006a) also explain how these effects can be measured in terms of avoided externality-related costs, for example, those associated to composting[30].

Although the positive indirect effect, on the environment, of the reduction of MSW collected and disposed is clear and noted in all studies, it is important to take into account that illegal dumping and waste tourism may have two negative indirect effects, one priced and one non-priced. The non-priced effect refers to the negative impact that burning waste or dumping it into the wood can have on environment. The priced effect refers to the fact that, to solve the problem of illegal dumping, the studies suggest different types of enforcement actions, such as raising awareness about environmental damage (Hogg et al, 2006a, 2006b), visible enforcement with fines (Skumatz, 2002), the introduction of command-control regulations (Taylor, 2000), and many others. This in turn will lead to an indirect, priced effect, namely **increase in enforcement costs** (Hogg et al, 2006b, p. xii). It is important to take these two effects into consideration in order to balance the social welfare arising from the introduction of PAYT schemes.

Another important indirect, non-priced effect refers to **distributive issues**. More precisely, it is recognised that the application of PAYT schemes leads to important disadvantages and inequities for **large families (with babies), low-income and elderly**[31]. As stated by Skumatz (2008), municipalities are concerned with possible negative effects of PAYT on large families. The problem for large families is found to be not important since they pay more for water, groceries and other products; in the same way, they pay more for waste management (PPP). Moreover, large families usually buy in bulk thus reducing the amount of packaging purchased and presented for collection (see Huang et al, 2011). Families with babies will experience a disadvantage in being subject to PAYT schemes since they have higher amounts of waste, especially diapers, etc. Diaper disposal can also pose a problem for elders. Low-income families simply cannot afford to pay a higher price for the waste they produce. Regional publications and studies (Rudin, 2010; Bartoli, 2009; Rapporto Mozione 3442, 2010) also expressed concerns for the negative effects on low-income and families with babies. The solutions suggested vary, from ad-hoc solutions such as providing a fixed number of free bags (Rudin, 2010 and Rapporto Mozione 3442, 2010) or discounts on garbage fees (Skumatz, 2008). These solutions are not taken into account in the SCBA, since they are distributional effects from the municipality to the households, compensated from the social welfare point of view (i.e., there is no change in net welfare).

[30] Danish EPA (2003) and Sundqvist et al. (2002), in Hogg (2006a).
[31] See Skumatz 2002, 2008 and Hogg 2002, 2006a,b.

Another negative indirect, priced effect linked to increased recycling rates can be recognised. Since ecocentres are very often centralised, households must spent time and money to load their cars with recyclables and reach the ecocentres (e.g., costs of gas and opportunity costs) (Hogg et al, 2006a). This leads to an **increase in households' time and costs for delivering recyclable materials**. For example, Dijkgraaf & Gradus focus mainly on the time spent by households to deliver recyclables, while Taylor (2000) recognises both an extra institutional and personal effort for delivering recyclables. Moreover Fullerton & Kinnaman (1996) recognise not only an increase in time and costs for delivery the recyclables but also to buy bags or adapt to the new scheme.

3.6.3 Exogenous Variables

Last but not least, a series of exogenous variables that may play a role in influencing the effects described above and in turn the social efficiency of WMS is now presented. It is important to correct for these variables because they may lead to under- or overestimating results. It is possible to consider these variables as components of the complex system by which a PAYT scheme is introduced.

As mentioned above there is great variety in the results in terms of the influence of PAYT schemes on increasing recycling rates. As explained by several studies, this can be attributed to the fact that changes almost never occur in isolation, but many internal and external factors play a role. In fact, as stated by Skumatz (2008, p. 2781), *"changes in PAYT are usually accompanied by concurrent modifications in **recycling programs**, yard waste programs, outreach, or other changes."* Other authors such as Hallas & Halstead (2004), Hogg et al. (2006a, b), Huang et al. (2011), and Skumatz (2002) also note that the effect of PAYT on recycling can be overestimated due to parallel recycling programs. For this reason, other recycling programs must be taken into account as an exogenous variable that may influence the impact of PAYT.

Collection systems (kerbside or centralised, separated or non-separated, frequency of collection, etc.) are important external factors to be considered when analysing PAYT schemes' impact. Bischof et al. (2003), Hallas & Halstead (2004), Hogg et al. (2006a,b), Huang et al. (2011), Rogge & De Jaeger (2012), Šauer et al. (2008) and Skumatz (2008) all recognise the influence of collection system adopted by the municipality on the amount of MSW produced. Hogg et al. (2006a) noticed an influence in the amount of waste reduced, recycled and separated. Huang et al. (2011) showed how the presence of kerbside collection may reduce the costs for households (in terms of time and effort to dispose their garbage) thus increasing the amount of MSW produced. Rogge & De Jaeger (2012) saw not only the influence of frequency of collection and the collection method, but also the level of outsourcing of the collection service as important variables influencing MSW production. Šauer et al. (2008) also acknowledged technical conditions (levels of separation in the kitchen) and container distance (kerbside or centralised) as variables playing a role in the determination of the amount of MSW produced.

Demographic variables seem to be the preferred factors through which the studies are adjusted**.** Household income, size and age are the most used.

Little evidence has been found for a link between households' income and the amount of waste generated, and the results in the studies are mixed (see Hogg et al, 2006b). For example Hallas & Halstead (2004) found that influence of income was not statistically significant. On the contrary, Rogge & De Jaeger (2012) found *"…that municipalities with citizens having a lower median income are on average more cost efficient that the municipalities with citizens having a higher median income"* (p. 661).

Household size seems to be a more solid variable (Hogg et al, 2006b). As already mentioned above, household size has a significant negative relationship with the amount of waste produced per inhabitant (Huang et al, 2011). Dijkgraaf & Gradus (2003) also found that *"an increase in household size of one standard deviation reduces collected waste per inhabitant by 5%"* (p. 360).

Consumption patterns vary according to ages. Therefore also the amount of waste produced is influenced by the age composition of a municipality's population (see for example Rogge & De Jaeger, 2012).

Other variables such as education (Fullerton & Kinnaman, 1996; Hogg et al, 2006b), race/nationality (Fullerton & Kinnaman, 1996; Dijkgraaf & Gradus, 2003) and urban vs. rural municipalities (Rogge & De Jaeger,

2012; Skumatz, 2008) have also been considered. For example, Dijkgraaf & Gradus (2003) found that, in municipalities with a large population of elderly people (over 65) and a small population of foreigners, waste per capita (also compostable waste) was larger.

Linked to the rural vs. urban municipality, the number of businesses within a municipality may also affect the amount of waste collected (Di Gianfrancesco, 2013).

Regional culture may also influence the performance of PAYT schemes. Dijkgraaf & Gradus' (2003) results showed that in municipalities with higher "environmental activism", the amount of waste produced is 7% lower. Therefore, it is possible that some of the effect of PAYT scheme in reducing the amount of MSW is actually due to higher environmental activism.

Figure 7 presents an example of exogenous variables in the measure of municipal waste costs.

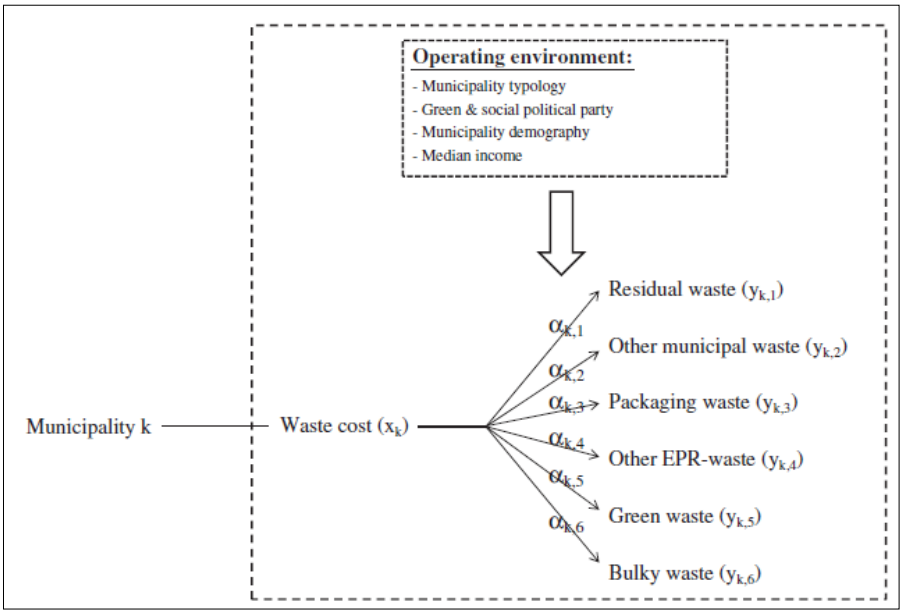


FIGURE 7: EXAMPLE OF VARIABLES FOR MUNICIPAL WASTE COSTS (SOURCE: ROGGE & DE JAEGER, 2012).

These variables affect the representativeness and comparability of the different municipalities as well as explaining different quantities and costs of MSW. Therefore, when assessing the impact of PAYT scheme, the different municipalities must be corrected and/or matched according to these variables as much as possible. Exogenous variables are taken into account both in a quantitative and in a qualitative way. The presence of other recycling programs, the collection system in use, the regional culture and other socio-demographic variables are investigated in the four municipalities selected. The data obtained are compared to the results in the literature, and qualitative and quantitative results on the extent of their influence are given when necessary.

Besides exogenous variables, other methods are also used to isolate the effects of the introduction of a PAYT scheme. As explained in the next chapter within the IA, time series have been analysed in order to assess the effects of a PAYT scheme on MSW quantities and costs. Moreover, in chapter 9, the base case, and the two alternative cases are adjusted to the BAU scenario in order to recognise and assess the relative efficiency.

The following impact model presents in a schematic way all the effects and their relations explained above. For the explanation of the excluded effects, refer to Annex II.

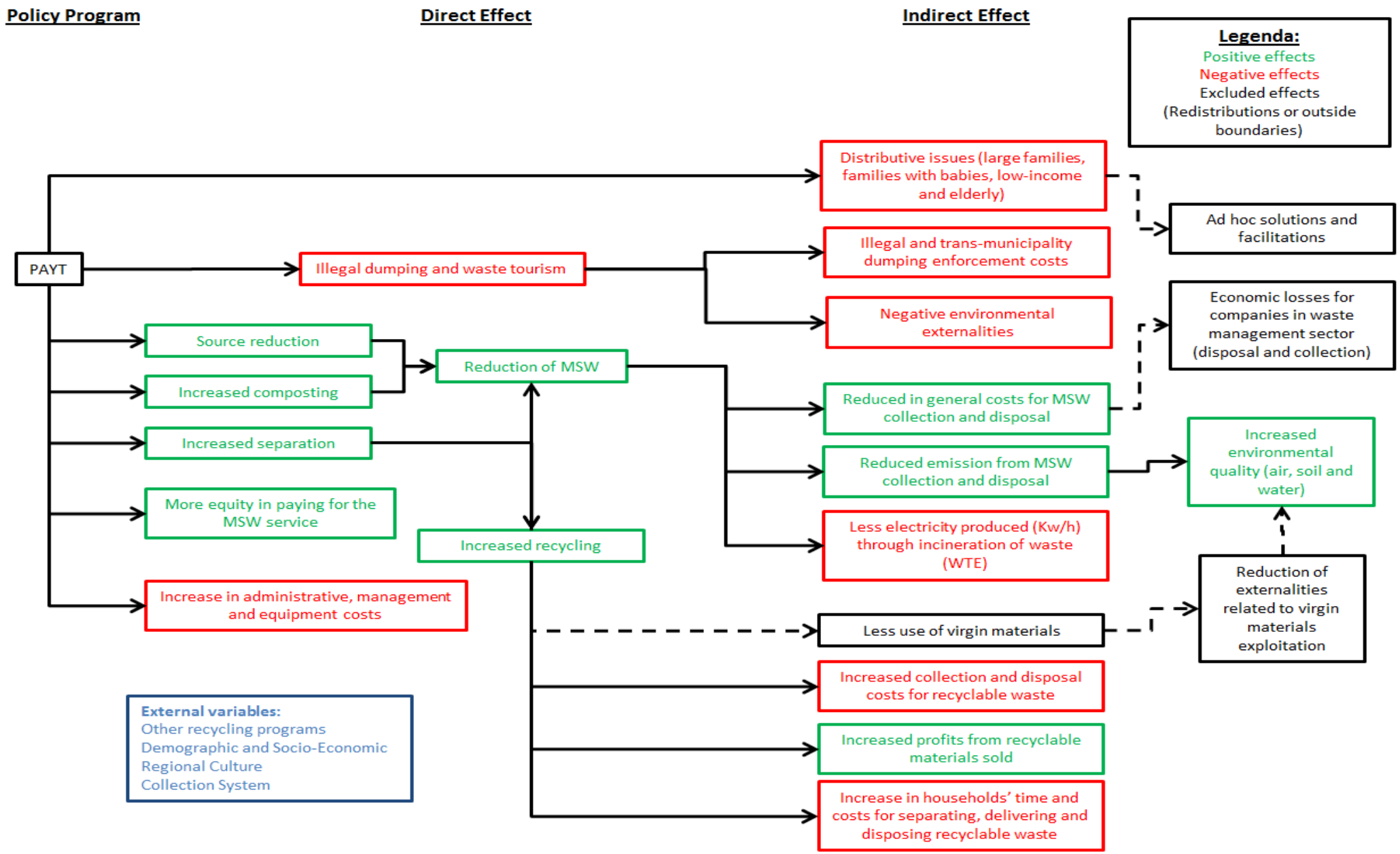


FIGURE 8: IMPACT MODEL

CHAPTER 4 - ASSESSMENT AND MONETISATION OF COSTS AND BENEFITS

4.1 IMPACT ASSESSMENT

Before beginning with the actual measure of costs and benefits, and that of social efficiency, it is important to recognise the effects that can be attributed to the program under study and assess its impact. In this specific case, the impact is assessed for the introduction of a PAYT scheme in a municipality in canton Ticino.

The first step that needs to be carried out to be able to assess the impact of a policy program is the recognition of the different effects. The following table recalls in a schematic way the effects that have been described in the previous chapter.

Direct Effects	Indirect Effects
Reduced quantities of MSW by means of: - Source reduction - Increased separation and recycling - Increased composting	Reduced costs for MSW collection and disposal
Increased administrative, management and equipment costs	Increased recyclables' collection and disposal costs
Increased equity in paying for the service	Increased profits from recyclable waste sold
Increased illegal dumping and waste tourism	Externalities and enforcement costs related to illegal dumping and waste tourism
	Increased environmental quality (reduced emissions from MSW collection and disposal)
	Less electricity produced (WTE)
	Increased households' time and costs for separating, delivering and disposing recyclable waste
	Distributive issue on large families, families with babies, low income, elderly

TABLE 3: DIRECT AND INDIRECT EFFECTS OF THE INTRODUCTION OF PAYT SCHEME

As will become clear later on, the Impact Assessment (IA) focuses only on assessing two main direct and indirect effects (quantities and costs of different types of waste). Other effects that have been included in the impact model and that will be measured as costs and benefits in the CBA are not assessed here, primarily because of a lack of time and reliable longitudinal data. Despite this, evidence about the effects was provided in section 3.6.

For example, if after the introduction of a PAYT scheme, the municipality produces and disposes less waste to the incinerator, the municipality will be responsible for fewer emissions into the air and water, and therefore to lower environmental costs and degradation. Isolating and measuring this impact is practically impossible. This, however, does not necessarily mean that the environmental quality improvement will impact directly upon the municipality. This depends upon where the incinerator is situated, and other geographical and meteorological factors (presence of mountains, winds, etc.). Moreover, in this specific case, the fact that in 2010 a new incinerator was built in Ticino (previously, all waste had been burned in other cantons across the Alps) may have actually made the environment of the region or of the municipality worse, and improved the environment of the region where waste was disposed before 2010. The only factor that can be accounted and measured as an environmental improvement is that less waste will lead to more infrequent collections and therefore fewer emissions from collection vehicles. Unfortunately, there is no information about the type of vehicles used in previous years, especially the fuel consumed and number of kilometres travelled. These data could be estimated using data from 2011. Kilometres travelled and fuel consumption can be divided by the amount of waste produced in 2011 in order to obtain a measure of the kilometres travelled and fuel consumed per ton of waste collected. Knowing the total amount of waste produced in previous years, it is possible to estimate previous fuel consumption and kilometres travelled. The problem here is that this estimation does not take into account changes in the efficiency in collecting waste (e.g., fleet, truck consumption and places of collection). Changes in the technology, leading to reduced emission from trucks, may actually have a higher impact on the environment than the reduction in frequency itself. Moreover, taking into account that when introducing a PAYT scheme, often new infrastructures (ecopoints) are built, this assumption is even weaker. Last but not least, the exact contribution of the

incinerator to regional pollution and environmental quality is not known exactly. Throughout the years, the environmental quality may be improved, but only because of reduced emissions from industry or less traffic in the region. Because of all these factors, assessing the impact on the basis of these estimations will produce very biased and inexact results.

Similar problems have been found for other variables. Administrative costs are often counted together with the costs for collection and disposal; therefore the impact is reflected together with those variables. The production of electricity is proportional to the quantities of residual and bulky waste sent to the incinerator, therefore this effect is partially expressed within the measure of these quantities (i.e., an increase in the quantities will increase the production of electricity). Moreover, from 2010, non-recyclable waste is sent to a different incinerator, so measuring this effect with longitudinal data will account for two different incinerators, thus biasing the results. Profits from recyclable waste were not accounted for in the cantonal census or systematically by the municipalities, and the tariffs paid for the different materials vary greatly over time depending on the demand for each material. Illegal dumping and waste tourism have never been estimated exactly in the region and data are lacking, even for the current year. To estimate the impact of PAYT on households, costs and time data for the evolution of distances, time and habits during several years are needed. This kind of detailed data was also unavailable. Last but not least, distributive issues and increased equity are accounted for in the CBA as PM-items and here, again, longitudinal data was not available because of the difficulty in estimating or measuring the two effects.

4.1.1 Establishing causality

The first step of the assessment of a program's impact is to establish causality between variables. In this case, the dependent variables are the quantities and costs of non-recyclable and recyclable waste; the independent variable is dichotomous - whether a municipality has or does not have a PAYT scheme. The causal relation that must be established refers to the link between quantities, costs and the introduction of a PAYT scheme. Therefore the main question is: *is it really possible to consider the introduction of a PAYT as the cause of MSW reduction, increase of separation and recycling and general reduction of costs?* In order to assess this, it is important to use longitudinal data that track the same variables for the same subject over a period of time (Rossi et al, 2004), so in order to establish causality only one municipality (i.e., Bellinzona) is selected and the variables are measured before and during the program intervention, in order to isolate the cause-effect relations. Bellinzona was chosen because of its ability to represent other municipalities in all of the important variables (exogenous, dependent and independent). Moreover, it was the municipality with the most complete data available. This improves the generalisability of the results. The time span - from 2004 until 2011 - was chosen in order to have a similar number of years before and after the introduction of PAYT schemes.

In order to establish causality between variables, three factors are considered: asymmetry, covariance and non-spuriousness (see Laerhoven van , 2012).

- **Asymmetry:** this factor refers to the temporal order in which the variables present themselves. As logic suggests, the cause must precede the effect, so in this case, in order to have asymmetry, the reduction of quantities and costs must follow the introduction of the PAYT scheme in a logical, temporal order. The causal claim stated in section 3.5.3 seems to have a logical temporal order. In fact, after the introduction of a PAYT scheme, the household should change its behaviour to reduce quantities and costs of MSW. The effects of the introduction of a PAYT are visible immediately: for example, as can be seen from the case of Bellinzona in table 4 and figures 10 and 11, quantities and costs of residual waste started to decrease significantly only after the introduction of the PAYT scheme in 2007. The same result is found for the increase in recyclable materials collected. These effects have the highest impacts in the first years after introduction and they stabilise as time passes. Therefore, the data suggest that the first parameter for establishing causality is met.

- **Covariance[32]:** using before/during measures in the municipality of Bellinzona, it is possible to show if (and how) the cause (introduction of a PAYT scheme) is related to the effects.

Table 4 presents the data relative to quantities and costs for different types of waste during different years in the city of Bellinzona. The dichotomous variable PAYT express the presence of the PAYT scheme when 1, and the absence of such a scheme when 0.

Year	2004	2005	2006	2007	2008	2009	2010	2011
PAYT	0	0	0	1	1	1	1	1
Quantity Residual	313.3	310.9	319.2	251.5	179	177	187	185
Quantity Recyclables	244.1	262.7	250.3	318.3	316.1	352	312	303
Quantity Bulky	32.9	32	32.4	30.1	30	28	23	17
PAYT	0	0	0	1	1	1	1	1
Costs Residual	132.9	134.2	136.3	110.8	84.2	85	70	68
Costs Recyclables	32.4	41.9	35.2	37.1	72.5	66	65	64
Costs Bulky	17.1	15.6	20.2	22.5	20.6	23	15	15

TABLE 4: COSTS AND QUANTITIES RELATED TO PAYT SCHEME IN BELLINZONA (SOURCE: REPUBBLICA E CANTONE TICINO, 2011)

Even without any statistical measure - looking solely at the raw data - it is possible to see that somehow costs and quantities covariate and are correlated to the presence or absence of a PAYT scheme.

As already stated in section 2.3.3, the Pearson correlation coefficient is used in order to standardise results of the covariance. First, the relationship between PAYT/quantities is analysed. As seen from table 5, and considering that a value of 1 represents a perfect correlation, the following can be said:

- The strongest correlation is found to be between quantities of residuals and the PAYT scheme. This negative value of -0.93 express the fact that with the introduction of a PAYT scheme, residual waste will decrease immediately and significantly.
- Another strong relationship - but this time positive - of 0.92 is found between PAYT and recyclable waste. Therefore the quantities of recyclable waste will increase as a consequence of the introduction of a PAYT scheme.
- The introduction of a PAYT scheme has also a negative effect on quantities of bulky waste disposed. Although less important, the correlation of PAYT and reduction of bulky waste is also confirmed.
- There is a clear and strong negative relationship between the quantities of residual and recyclable waste. This means a decrease of residual waste of one ton corresponds to an increase in recyclable waste of 0.88 tons.

Correlation Bellinzona	*PAYT*	*Quantity Residual*	*Quantity Recyclables*	*Quantity Bulky*
PAYT	1			
Quantity Residual	-0.93	1		
Quantity Recyclables	0.92	-0.88	1	
Quantity Bulky	-0.64	0.69	-0.44	1

TABLE 5: COVARIANCE AND CORRELATION PAYT/QUANTITIES IN BELLINZONA (DATA FROM TABLE 4)

Next, table 6 explains the casual relationship between costs and PAYT:

- Again, a strong correlation is found between PAYT and decrease of costs related to collection and disposal of residual waste.
- Costs for recyclable waste increase as a consequence of the introduction of a PAYT scheme.
- As is seen, raw costs for bulky waste are positively correlated with the introduction of a PAYT scheme. Although this may seem strange, considering that the quantity of waste has a negative relationship, it

[32] Details about data used and calculations can be found in the Annex III.

must be taken into account that some fixed costs exist and therefore - after a certain threshold of quantity reduction - the costs won't be any lower[33].

Correlation Bellinzona	*PAYT*	*Costs Residual*	*Costs Recyclables*	*Costs Bulky*
PAYT	1			
Costs Residual	-0.89	1		
Costs Recyclables	0.76	-0.90	1	
Costs Bulky	0.24	0.10	-0.03	1

TABLE 6: COVARIANCE AND CORRELATION PAYT/COSTS IN BELLINZONA (DATA FROM TABLE 4)

Last but not least, it is important to consider if (and how) quantities and costs are related (table 7). It seems legitimate to say that lower quantities of waste for collection and disposal, correspond to lower costs. This is not always true since both variables and fixed costs come into play in the WMS.

Correlation Bellinzona	*Quantity Residual*	*Costs Residual*
Quantity Residual	1	
Costs Residual	0.97	1
	Quantity Recyclables	*Costs Recyclables*
Quantity Recyclables	1	
Costs Recyclables	0.74	1
	Quantity Bulky	*Costs Bulky*
Quantity Bulky	1	
Costs Bulky	0.44	1

TABLE 7: COVARIANCE AND CORRELATION BETWEEN QUANTITIES AND COSTS IN BELLINZONA (DATA FROM TABLE 4)

Residual waste is the type of waste that shows the strongest correlation between costs and quantities. If the quantities decrease by one unit, the costs decrease by 0.97 units. Recyclable waste also has a fairly strong correlation of 0.74. This means that if the quantities of recyclable waste increase the costs of recyclable waste will increase as well - although less than proportionally. The lowest covariance and correlation is found for bulky waste. As already shown above, the relationship between quantities and costs for bulky waste are not as straightforward as for the other types of waste. In fact, the correlation shows a ratio of 0.44. This means that costs will follow only slightly variation change of quantities.

Moreover it is also important to remember that, in 2010, the fees for residual and bulky waste incinerated were lowered from 285 CHF/ton to 175 CHF/ton; this may have played also an important role in the variation of costs and quantities after 2010[34].

- **Non-spuriousness:** this parameter refers to the fact that no other plausible explanation other than the cause can be found to explain the effects. For this reason, it is very important to stress again the importance of considering waste tourism and illegal dumping as factors for the reduction of waste quantities. In fact, part of the effect of reduction of quantities (and therefore costs) can be caused by households disposing their waste in other municipalities. The plausibility of this hypothesis of course depends on the neighbouring municipalities' schemes. In order to reduce this influence, the city of Bellinzona is taken as an example since it is surrounded only by PAYT municipalities; this makes it more difficult for households to dispose their waste elsewhere, therefore limiting the effect of waste tourism on MSW's reduction. For this reason, it is possible to assume that the effects showed above are not influenced (or only to a very limited extent) by waste tourism. Illegal dumping could also be an external reason for the reduction in quantities. As the research showed, this is a weak assumption, since illegal dumping in Switzerland is very limited or absent. Moreover, variations over time in the

[33] Other factors, such as changes in the composition of bulky waste or changes in the tariffs paid for different types of bulky waste may as well influence the relation between quantity and costs.
[34] More Information about the introduction of new prices for disposal in 2010 are given in Annex IV.

exogenous variables stated in section 3.6.3 may also partly explain the effect. For example, changes in the demographic composition (e.g., age, education, environmental awareness or average salary) may result in changes in waste composition, thus further influencing quantities and costs.

4.1.2 Intervention and control groups

In this section, the two municipalities selected for the IA are selected and described. Bellinzona and Lugano have been chosen respectively as the intervention and control groups. Lugano in this case represents the counterfactual or, in other words, the situation in terms of costs and quantities if the PAYT scheme had not been introduced (see Laerhoven van, 2012; Lave and March, 1975, pp. 75-114). Despite the two municipalities being similar in many of the exogenous variables that have been recognised to have an influence in waste generation in section 3.6.3, some differences are also seen.

Variable	Bellinzona	Lugano
Typology	Urban	Urban
Surface	19.15 km^2	32.09 km^2
Population	17,373	54,667
Population density	907.21	1,703.55
Percentage (male - female)	47.1% - 52.9%	47.6% - 52.4%
Percentage (Swiss - foreign)	70.7% - 29.3%	62.2% - 37.8%
Unemployed (registered)	440 (2.5%)	1,685 (3%)
Percentage pop:		
- 0-19	- 18.2%	- 17.9%
- 20-64	- 61.4%	- 61.2%
- More than 65	- 20.4%	- 20.9%
Households:	7,294	24,160
- 1 person	- 36.5%	- 42.6%
- Couples without children	- 22.7%	- 21.5%
- 1 parent families	- 6.8%	- 6.8%
- Couples with children	- 30.3%	- 25.0%
- Others	- 3.6%	- 4.1%
Type of building:	2,551	5,487
- Single household	- 58.4%	- 51.1%
- Multiple households	- 41.6%	- 48.9%
Houses Size:	8,455	28,798
- 1-2 rooms	- 20.8%	- 29.4%
- 3-4 rooms	- 64.4%	- 56.8%
- 5 or more rooms	- 14.8%	- 13.8%
Businesses	1,248	4,904
- in tertiary sector	- 88.9%	- 90.1%

TABLE 8: MATCHING VARIABLES FOR INTERVENTION AND CONTROL GROUPS (SOURCE: USTAT, 2013)

Lugano and Bellinzona are the first and second largest municipalities in Ticino. Both are urbanised municipalities with a high percentage of businesses in the tertiary sector. Lugano is spread over a bigger surface, has a higher population and its density is almost double that of Bellinzona. It is possible to see (Figure 9) that the two municipalities have very similar population structures. As confirmed also by table 8, Lugano has a slightly older population and a higher percentage of foreign people. Moreover, the household composition is similar except for couples with children and single persons, which, in Lugano, are lower and higher respectively. The composition of political parties in the city council is also similar except for the social party (PS) and the right wing party (LEGA) - respectively much higher and much lower in Bellinzona. The label "Altri" includes also the Green Party that seems to be present in the same way in both municipalities. It is important to acknowledge that some of the differences described above may actually influence the generation of waste, and therefore bias to a certain extent the results[35]. Considerations in this sense are taken into account. For example, a higher elderly and foreign population may result in more waste produced (see Dijkgraaf & Gradus, 2003; Skumatz, 2008; Rogge & De Jaeger, 2012). This may be partially balanced by the fact that Lugano has a lower average household size and therefore potentially lower waste production (see Huang et al, 2011; Fullerton & Kinnaman, 1996).

No better match for Bellinzona could have been selected as a control group, since only two municipalities in Ticino can act as a BAU scenario. One is Lugano, and the other is Stabio, which has a very small population and even bigger differences in the exogenous variables presented below.

[35] The same IA has been carried out with the municipality of Locarno as control group, which is more similar in endogenous and exogenous variables if compared to Lugano, in order to have a second indicative measure of the validity of the results obtained (see Annex III).

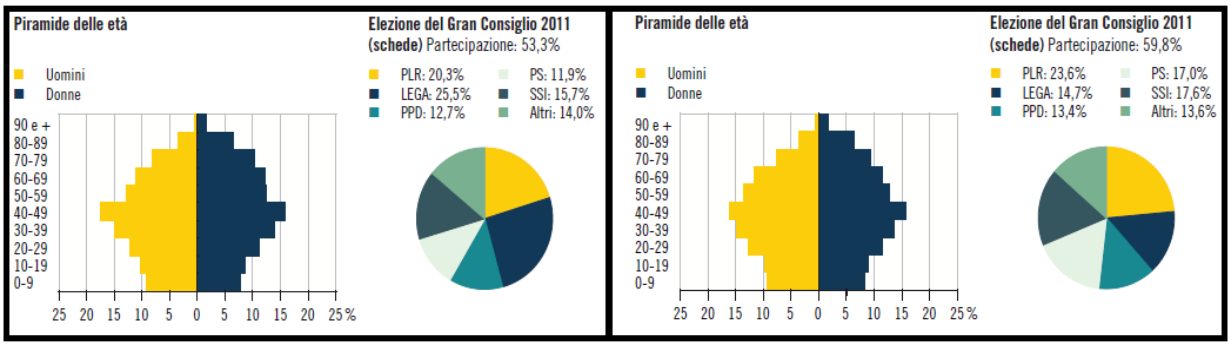


FIGURE 9: POPULATION AND POLITICAL COMPOSITION IN LUGANO AND BELLINZONA (SOURCE: USTAT, 2013)

4.1.3 Time series[36]

After having selected the two municipalities to compare, longitudinal data must be collected. For each of the municipalities, data on different variables is first presented in tables for 2004-2011. These data are then shown in different graphs and descriptive statistics are applied.

Table 9 presents costs and quantities of residual, bulky and recyclable waste. Distinct data about collection and disposal costs were available for residuals and bulky waste, while for recyclable waste only aggregated costs were available. The variable *QRec/TotMSW(%)* expresses the ratio between total MSW and recyclable waste. The variable *Organic* refers to all the "green waste" - both from garden and kitchen - that is collected by the municipality. Quantities and costs of recyclable waste already include organic waste, but this is presented separately in order to see potential effects on composting.

Bellinzona

	2004	2005	2006	2007	2008	2009	2010	2011
Quantity Residual	313.3	310.9	319.2	251.5	179.0	177	187	185
Total Costs Residual	132.9	134.2	136.3	110.8	84.2	85	70	68
- Collection	45.1	47.1	46.9	40.3	33.3	34	35	34
- Disposal	87.8	87.1	89.4	70.5	50.9	51	35	34
Quantity Recyclables	244.1	262.7	250.3	318.3	316.1	352	312	303
QRec/TotMSW(%)	41.3	43.4	41.6	53.1	60.2	63.1	59.8	60
Costs Recyclables	32.4	41.9	35.2	37.1	72.5	66	65	64
Quantity Bulky	32.9	32	32.4	30.1	30	28	23	17
Total Costs Bulky	17.1	15.6	20.2	22.5	20.6	23	15	15
- Collection	6.9	6	6.8	7.4	5.8	6	6	6
- Disposal	10.2	9.6	13.4	15.1	14.8	17	9	9
Quantity Organic	114.3	112.7	110.2	123.6	124.4	140	111	105
Costs Organic	18	22.3	20.9	21.2	22.2	15	24	22

TABLE 9: TIME SERIES FOR QUANTITIES AND COSTS PER CAPITA OF DIFFERENT TYPES OF WASTE IN BELLINZONA (SOURCE: REPUBBLICA E CANTONE TICINO, 2011)

[36] A complete overview of time series from all four municipalities and descriptive statistics can be found in the Annex III.

The following table present the descriptive statistics for the data presented above, within the two periods considered.

Variables	Average before 2007	Average after 2007	Total average	Standard deviation before 2007	Standard deviation after 2007	Total standard deviation
Quantity Residual	314.5	195.9	240.4	4.3	31.3	65.8
Total Costs Residual	134.5	83.6	102.7	1.7	17.1	29.3
- Collection	46.4	35.3	39.5	1.1	2.8	6.1
- Disposal	88.1	48.3	63.2	1.2	14.9	23.5
Quantity Recyclables	252.4	320.2	294.8	9.5	18.9	38.2
QRec/TotMSW(%)	42.1	59.2	52.8	1.1	3.7	9.3
Costs Recyclables	36.5	60.9	51.8	4.9	13.7	16.6
Quantity Bulky	32.4	25.7	28.2	0.5	5.6	5.5
Total Costs Bulky	17.6	19.2	18.6	2.3	4.0	3.3
- Collection	6.6	6.2	6.4	0.5	0.7	0.6
- Disposal	11.1	13.0	12.3	2.0	3.7	3.2
Quantity Organic	112.4	120.7	117.6	2.1	13.7	11.3
Costs Organic	20.4	20.9	20.7	2.2	3.4	2.9

TABLE 10: DESCRIPTIVE STATISTICS FOR DIFFERNET VARIABLES IN BELLINZONA DIVIDED IN BEFORE AND AFTER 2007

It is immediately clear that there is much variation in all variables between the two periods. As can be seen from figure 10, residual waste quantities decreased significantly after 2007. Between 2006 and 2007 the municipality experienced a decrease in quantities of 67.7 kg/capita (21.2%); again between 2007 and 2008 a further reduction of 72.5 kg/capita was seen (28.8%).

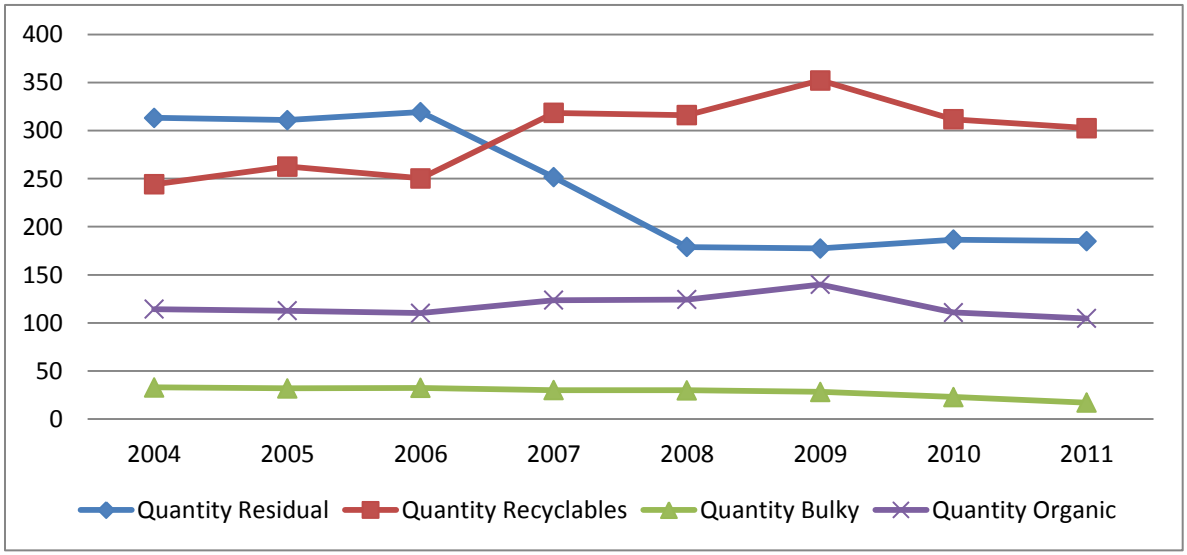


FIGURE 10: EVOLUTION OF QUANTITIES OF DIFFERENT TYPES OF WASTE IN BELLINZONA

Quantities stabilised then at around 180 tons per capita, except for a slight increase in 2010. The same downward trend, but less steep, was experienced for bulky waste. These did not decrease immediately after the introduction of the PBV scheme, but only after 2009. At the same time, recyclable waste followed the opposite trend: a steady increase in quantities from 2006 to 2007 (68 kg/capita or 27.2%).

As stated in section 4.1.1, there is strong correlation between quantities and costs, especially for residual waste. In fact, the evolution of costs follows closely the trends described above for quantities. Collection and disposal costs for residual waste decreased between 2006 and 2008, from 136.6 CHF/capita to 84.2 CHF/capita (42.7%). Part of the reduction of residual collection costs may be also due to the fact that, with the introduction of the PBV scheme, residual waste is no longer collected at the kerbside, but households must bring the garbage to one of the five ecopoints. Costs for recyclable waste were less responsive to quantity variation and increased only after 2007. Costs for recyclable waste almost doubled in one year, increasing from 37.1 CHF/capita in 2007 to 72.5 CHF/capita per capita in 2008. Bulky and organic waste costs remained more or less stable and fluctuated at roughly 20 CHF/capita.

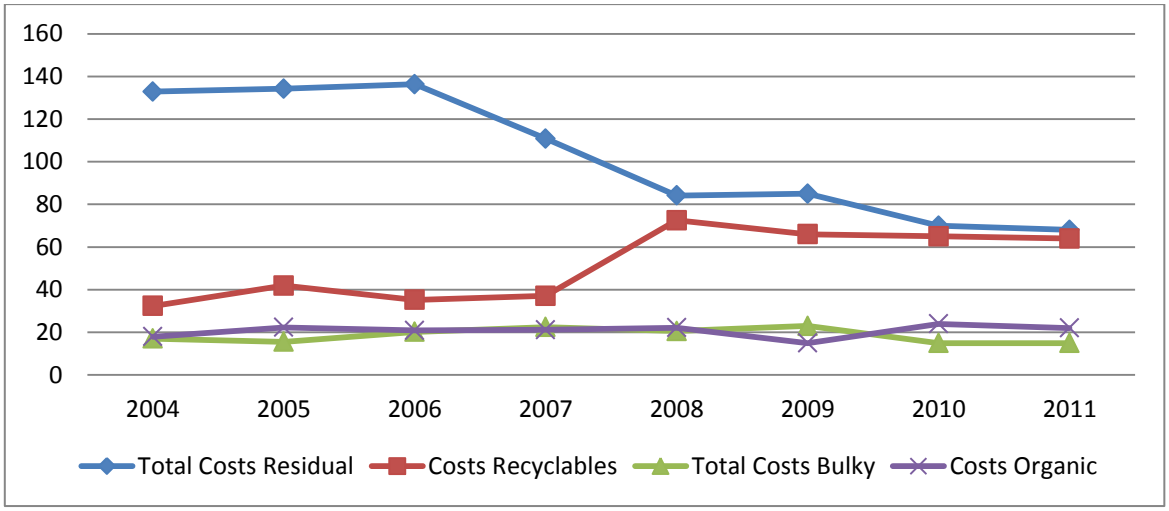


FIGURE 11: EVOLUTION OF COSTS FOR DIFFERENT TYPES OF WASTE IN BELLINZONA

It is interesting to see how Bellinzona increased its percentage of waste recycled from 2004 until 2011. The greater increase was experienced between 2007 and 2009. After 2009, the percentage stabilised at around 60%. This is a phenomenal result if we consider that the cantonal average is around 44%.

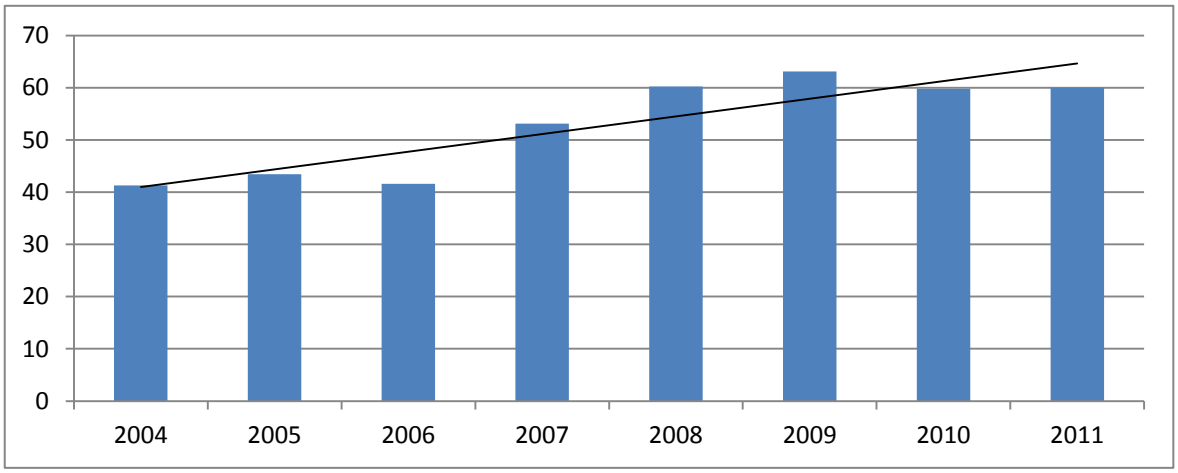


FIGURE 12: PERCENTAGE OF RECYCLABLE MATERIAL ON TOTAL MSW COLLECTED BY THE MUNICIPALITY OF LUGANO

Lugano

	2004	2005	2006	2007	2008	2009	2010	2011
Quantity Residual	356.7	348.3	336.3	334.2	343.7	338	344	338
Total Costs Residual	128.5	135.4	130.7	129.9	135.6	132	105	103
- Collection	39	38.2	36.5	36.3	39	37	40	39
- Disposal	89.5	97.2	94.2	93.6	96.6	95	65	64
Quantity Recyclables	194.1	213.6	210.3	217.8	240.2	240	239	257
QRec/TotMSW(%)	33.8	36.3	36.8	37.5	38.8	39.4	39.3	41
Costs Recyclables	23.7	26	24.6	25.5	22.9	18	19	21
Quantity Bulky	23.1	26.8	24.6	29.1	35.6	31	26	28
Total Costs Bulky	11	13.7	9.7	11.3	13.5	16	10	12
- Collection	5.3	6.2	2.8	2.6	3.1	6	5	7
- Disposal	5.7	7.5	6.9	8.7	10.4	10	5	5
Quantity Organic	66.4	87	81.6	77.4	81.2	76	66	86
Costs Organic	7.5	4.8	5.6	7.1	7	7	4	7

TABLE 11: TIME SERIES FOR QUANTITIES AND COSTS PER CAPITA OF DIFFERENT TYPES OF WASTE IN LUGANO (SOURCE: REPUBBLICA E CANTONE TICINO, 2011)

Even from the descriptive statistics, it is possible to recognise little variation between the two periods here, when compared to the municipality of Bellinzona.

Variables	Average before 2007	Average after 2007	Total average	Standard deviation before 2007	Standard deviation after 2007	Total standard deviation
Quantity Residual	347.1	339.4	342.3	10.3	4.1	7.5
Total Costs Residual	131.5	121.1	125.0	3.5	15.7	13.2
- Collection	37.9	38.3	38.1	1.3	1.5	1.4
- Disposal	93.6	82.8	86.9	3.9	16.8	14
Quantity Recyclables	206.0	238.8	226.5	10.4	14	20.8
QRec/TotMSW(%)	35.6	39.2	37.9	1.6	1.2	2.2
Costs Recyclables	24.8	21.3	22.6	1.2	3	3
Quantity Bulky	24.8	29.8	28.0	1.9	3.8	4
Total Costs Bulky	11.5	12.6	12.2	2.0	2.3	2.1
- Collection	4.8	4.7	4.8	1.8	1.9	1.7
- Disposal	6.7	7.8	7.4	0.9	2.6	2.1
Quantity Organic	78.3	77.4	77.8	10.7	7.5	8
Costs Organic	6.0	6.4	6.3	1.4	1.3	1.3

TABLE 12: DESCRIPTIVE STATISTICS FOR DIFFERNET VARIABLES IN LUGANO DIVIDED IN BEFORE AND AFTER 2007

Excluding the drop in disposal costs for residual waste in 2010[37], during the period(s) considered, quantities and costs did not change significantly in the municipality of Lugano. Quantities of residual waste had an average reduction from the previous year of 2.4 kg/capita (-0.7%), recyclable waste increased 9.5 kg/capita (4.2%), bulky increased 1 kg/capita (3.9%) and lastly, organic waste increased 4 kg/capita (5.1%). Bulky and organic waste's quantities and costs have a high volatility. For example, in 2008 bulky waste increase by 6.5 kg/capita (22.3%) and in 2009 decreased by 4.6 kg/capita (13.2%). While costs for bulky and organic waste in general increased (0.56 CHF/capita or 4.6% and 0.34 CHF/capita or 5.5%), the opposite can be said for residual and recyclable waste (-3.5 CHF/capita or -2.8% and -0.24 CHF/capita or -1.1%)[38]. Moreover, the fact that in both Bellinzona and Lugano the relationship between quantities and costs of organic waste is not constant is due to changes in the composition over the years (e.g., more wood from garden and less waste from kitchens). In fact, weight and costs may vary a lot according to the type of organic waste collected and disposed.

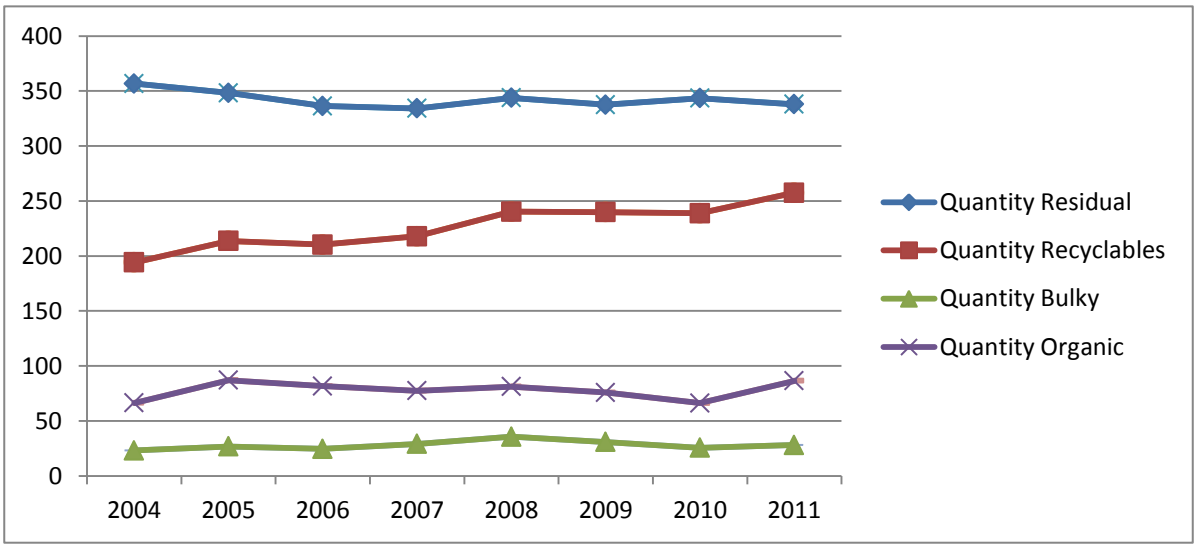


FIGURE 13: EVOLUTION OF QUANTITIES OF DIFFERENT TYPES OF WASTE IN LUGANO

Costs for waste collection and disposal in Lugano have also remained quite stable. Again the biggest variation is related to residual waste that, on average, decreased by -3.5 CHF/capita (-2.8%) from the previous year, mainly because of a reduction of 27 tons/capita (20.5%) in 2010.

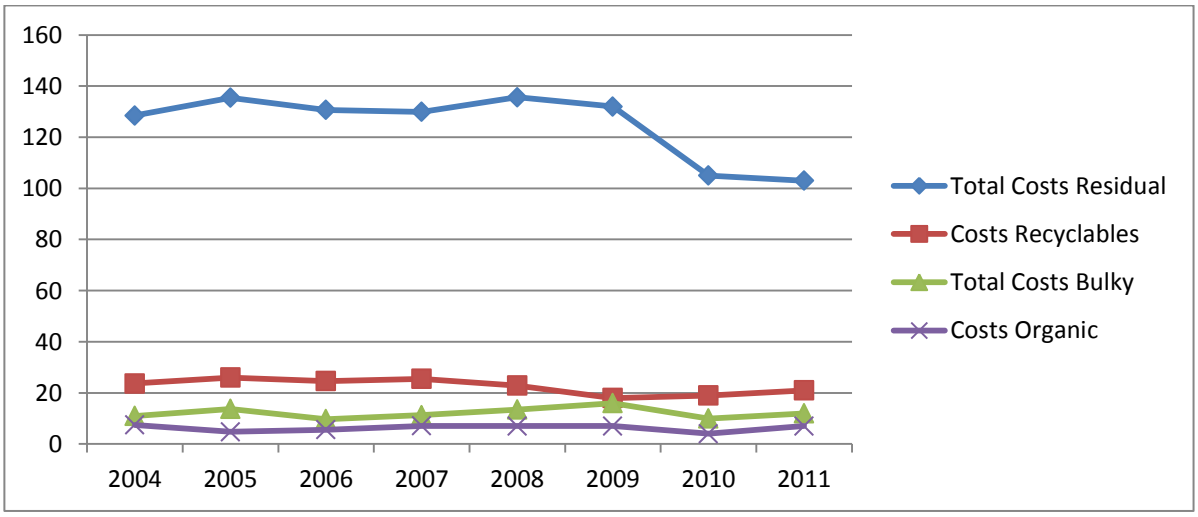


FIGURE 14: EVOLUTION OF COSTS FOR DIFFERENT TYPES OF WASTE IN LUGANO

[37] This is due to the fact that the new incinerator built applied much lower fees for waste disposal (see Annex IV).
[38] Detailed information about the percentage of variation and its calculation can be found in the Annex III.

The percentage of waste recycled out of the total amount of waste increased slightly over the years. This is clearly shown by the trend line in figure 15. This increase is explained by the improvement in the collection system, as well as the introduction of the new ecopoints and ecocentres. From 2004 until 2011 Lugano had an average percentage of waste recycled of 37.9%, with a peak of 41% in 2011.

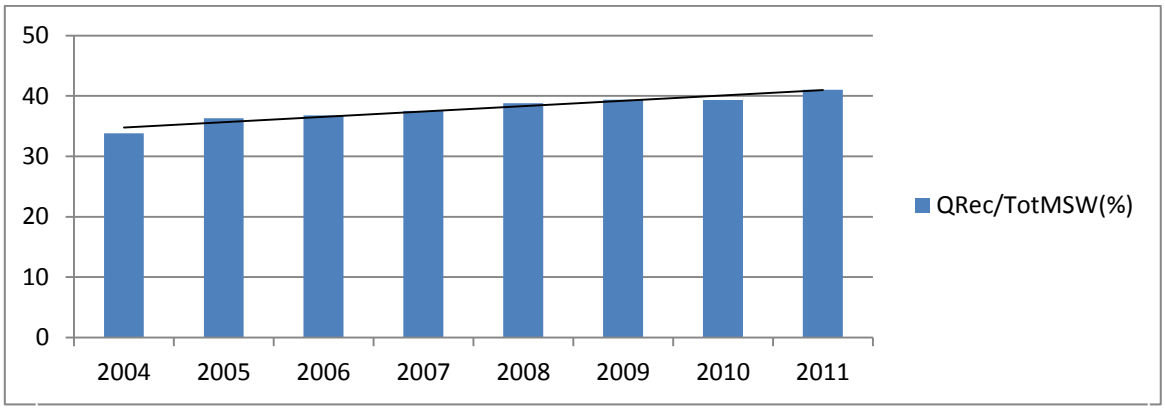


FIGURE 15: PERCENTAGE OF RECYCLABLE MATERIAL ON TOTAL MSW COLLECTED BY THE MUNICIPALITY OF LUGANO

4.1.4 Measuring program effects

The ultimate goal of an IA is to measure the effects of the policy program analysed. After having presented and described the two groups individually, the intervention and control groups are now compared in order to measure the effects of the introduction of a PAYT scheme.

As explained in section 2.3.3, two measures are used:

Numerical difference

Table 13 represents the difference in average values between Lugano and Bellinzona. It is possible to see that, before the introduction of a PAYT scheme in 2007, the two municipalities had very similar quantities and costs for residual waste; some differences in the other variables were also already present. For example, Bellinzona already had 46.4 kg/capita of recyclable waste more than Lugano. Since quantities and costs have a good correlation, costs of recyclables are also 11.7 CHF/capita higher in Bellinzona. With lower residual and higher recyclable wastes, Bellinzona had a higher percentage of recyclable waste out of the total MSW (35.6% against 42.1%) before 2007. This may reflect specific political views, differences in population characteristics or the availability of infrastructure. Last but not least, Bellinzona before 2007 had higher per capita quantities and costs of bulky and much higher for organic waste when compared to Lugano. The difference in bulky waste costs between Bellinzona and Lugano may be due to different collection systems (e.g., kerbside collection in Bellinzona) and different compositions. The higher quantities of organic waste in Bellinzona may be due to the fact that a less densely populated area has more land availability, and the houses also have gardens, which produce organic waste (see De Jaeger & Eyckmans, 2009).

After the introduction of the PAYT scheme, the more noticeable result is the significant increase in the difference of quantities and costs of residual waste. Before 2007, Bellinzona produced on average 32.6 kg/capita (10.4%) less residual waste; while after 2007, the difference raised to 143.5 kg/capita (73.3%). Another interesting result is that before the introduction of the PAYT scheme Bellinzona actually had slightly higher costs for residual waste (3 CHF/capita more), while after 2007, the costs were 37.5 CHF/capita less than Lugano, a reduction of 40.5 CHF/capita. Moreover, the already important difference of quantities of recyclable waste became even bigger - from 46.4 kg/capita to 81.4 kg/capita more. This of course leads to an even higher difference in the rates of recycling waste (20% more in Bellinzona). A negative point is the related increase in costs. If quantities almost doubled, the difference in recycling costs is now almost four times (from 11.7 CHF/capita more, to 39.6 CHF/capita).

Before 2007, Bellinzona had higher quantities of bulky waste (7.6 kg/capita); after 2007, this decreased, especially in 2010 and 2011. Despite this, the costs for bulky waste actually increased (0.5

CHF/capita). This may be explained by the fact that for bulky waste there are high fixed costs and therefore the response of costs to the quantities is inelastic. This is also partially confirmed in section 4.1.1 and in Bellinzona (2012).

	Before 2007		After 2007	
Effect	Absolute difference (kg/capita or CHF/capita)	Percentage Difference	Absolute difference (kg/capita or CHF/capita)	Percentage Difference
Quantity Residual Waste	32.6	10.4	143.5	73.3
Total costs Residual	-3.0	-2.2	37.5	44.9
Quantity Recyclable Waste	-46.4	-18.4	-81.4	-25.4
Total costs Recyclable Waste	-11.7	-32.1	-39.6	-65.0
Percentage of Recyclable on total MSW	-6.5	-15.4	-20.0	-33.8
Quantity Bulky Waste	-7.6	-23.5	4.1	16.0
Total costs Bulky waste	-6.1	-34.8	-6.6	-34.4
Quantity Organic waste	-34.1	-30.3	-43.3	-35.9
Total costs organic waste	-14.4	-70.6	-14.5	-69.3

TABLE 13: COMPARISION OF VARIATIONS BEFORE AND AFTER THE PAYT SCHEME

Standardised Mean Difference

Table 14 presents the results of the standardised mean difference for the two groups. The results represent the attitude of the intervention group (Bellinzona) compared to the control group (Lugano) in the different variable chosen. A positive value means that the intervention group was more efficient than the control group in the case of a positive variable (e.g., quantity of recyclable or organic), or less efficient in the case of a negative variable (e.g., costs). On the contrary, a negative value indicates that the intervention group is more efficient in the case of a negative variable and less efficient in a positive variable.

	Standardised Mean Difference after 2007
Quantity Residual	-3.2
Total Costs Residual	-0.6
- Collection	-1
- Disposal	-0.5
Quantity Recyclables	1.3
QRec/TotMSW(%)	6.5
Costs Recyclables	2.3
Quantity Bulky	-0.4
Total Costs Bulky	1.4
- Collection	0.78
- Disposal	0.98
Quantity Organic	1.4
Costs Organic	4.7

TABLE 14: STANDARDISED MEAN DIFFERENCE IN BELLINZONA AND LUGANO AFTER THE PAYT SCHEME

Bellinzona has negative attitude respect quantities and costs of residual waste: -3.2 and -0.6 standard deviations, respectively. Therefore Bellinzona is more efficient than Lugano in reducing and managing residual waste. Bellinzona has also a better attitude towards recyclable waste quantities (1.3 standard deviations), 6.5 standard deviations more in the ratio of recycled waste on total MSW, but 2.3 standard deviations more in costs related to recycling waste. Positive results on quantities of bulky waste, -0.4 standard deviations, and organic waste, 1.4 standard deviations, are also found for Bellinzona, when compared to Lugano. Negative results are seen for costs of bulky and organic waste, 1.4 and 4.7 standard deviations respectively.

Considering all the results shown above, it can be concluded with a good degree of certainty that the introduction of a PAYT scheme has the following effects:

- Large decrease in quantities of residual waste collected and disposed;
- Reduction of costs related to residual waste, especially collection costs;
- Increase in quantities of recycled waste;

- Large increase in the ratio of recycled waste out of the total amount of waste collected and disposed;
- Increase in recycling costs;
- Increase in quantities and costs of organic waste.

The effect on bulky waste is unclear and may depend more upon technical, infrastructural and organisational conditions within the municipalities than upon the introduction of a PAYT scheme.

4.2 Monetisation of costs and benefits

In this section, each one of the effects presented in section 3.6 is translated into costs and benefits that may influence the social efficiency of the cases.

It is important to consider that the low number of benefits presented in table 16 is due to two factors. Firstly, some of the benefits that can be attributed to the introduction of alternative 1 and 2 are actually reductions in costs. For example, as stated above, the introduction of a PAYT scheme may have the benefit of decreasing the total costs for WMS. This benefit is not shown in the benefit column but is reflected in lower costs for collection and disposal of MSW. Moreover, since less MSW is collected and disposed with a PAYT scheme, the environmental quality increases. This benefit is not stated as an environmental benefit but as a reduced environmental cost. The second factor that might explain the low number of benefits presented is related to the program's nature. In fact, the collection and disposal of MSW is a public service. This usually present more costs than benefits and rarely leads to a positive balance. The main source of income in all the municipalities is the taxes paid (either on MSW or general income). These are not taken into account, since they are a redistribution between the municipality and its households, not a net increase in welfare.

The following tables summarise the costs and benefits identified and the methods used for their monetisation. An extensive explanation of the monetisation of costs and benefits can be found in Annex II.

Costs	Measure	Monetisation	Data source
MSW collection costs: residual, bulky and recyclable waste	Direct money measurement	Monetised by the municipality (market prices)	Municipalities' interviews + Repubblica e Cantone Ticino (2011)
MSW disposal costs: residual, bulky and recyclable waste	Direct money measurement	Monetised by the municipality (market prices) (price of disposal per ton depending on the material)	Municipalities' interviews + Repubblica e Cantone Ticino (2011)
Administrative, management and equipment costs	Direct money measurement	Monetised by the municipality (market prices)	Municipalities' interviews + Repubblica e Cantone Ticino (2011)
Environmental costs: from collection	Shadow prices (emissions damage impact)	Total emissions from collection vehicles X shadow prices	Municipalities' interviews + Volvo Trucks (2013) + de Bruyn et al. (2010)
Environmental costs: from disposal (incineration)	Shadow prices (emissions damage impact)	Total emissions from waste sent to incinerator X shadow prices	Municipality interview + ACR interview + de Bruyn et al. (2010)
Illegal dumping	Proxies from literature + shadow prices for emissions damage impact (environmental costs) + Direct money measurement (enforcement costs)	(0.5-2% X total MSW) X emissions per ton X shadow prices + enforcement costs (market prices)	Municipalities' interviews + literature[47]+ de Bruyn et al. (2010)
Waste tourism	Proxy from literature + Direct money measurement (enforcement)	4-5% of total MSW (13-17% of total reduction) + enforcement costs (market prices)	Linderhof et al. (2001) + Municipalities' interviews
Households time and cost for recyclable separation, delivery and disposal	Hypothetical questions	Average stated costs for recyclable deliver + (time for separation and delivery of recyclable waste X WTP)	Households' interviews

Distributive issues: families with babies, low-income and elderly (Alt 1 e 2) (PM-)	PM-item	PM-item	Municipalities' and households' interviews
Discounting	Direct money measurement + proxies from literature	4% (PBV) and 5% (PBW) of risk and time discounting applied on investment costs (Market Prices) (see section 3.3)	Eijgenraam et al. (2000) + municipalities' interviews + local publications
Other costs	Direct money measurement	Market prices for parallel programs, awareness rising, information to households about the WMS, etc.	Municipalities' interviews

TABLE 15: OVERVIEW OF COSTS' MONETISATION METHODS AND SOURCES

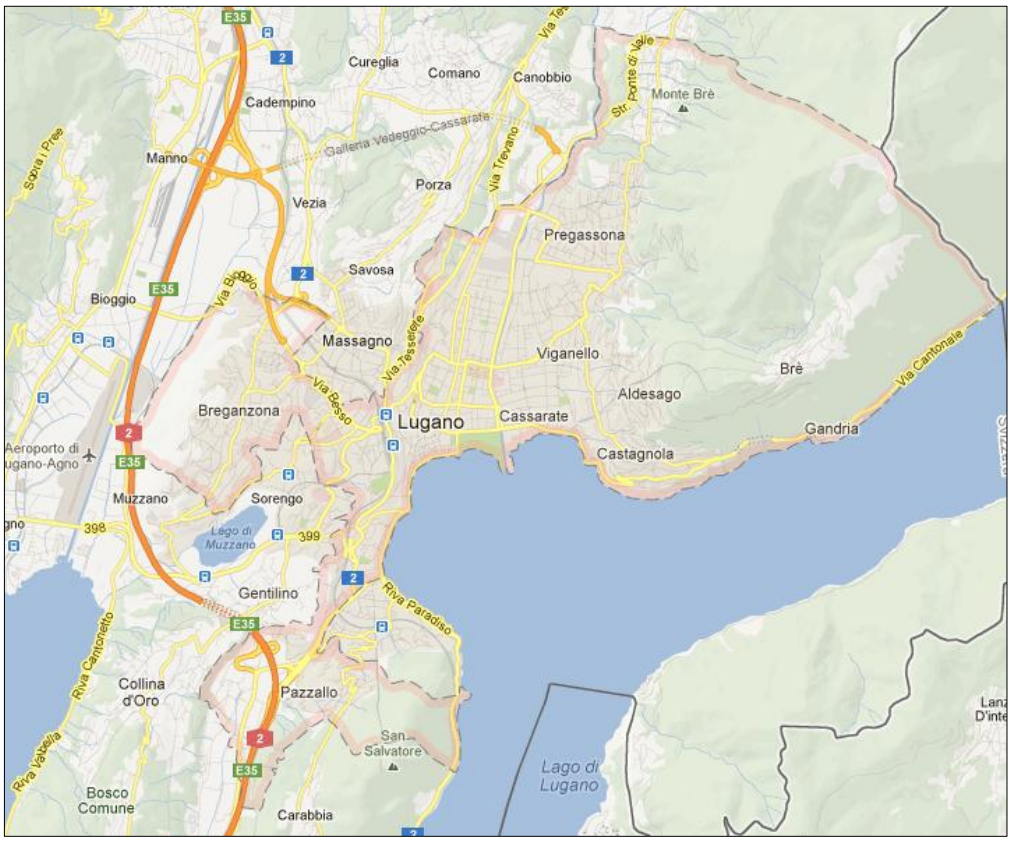
Benefits	**Measure**	**Monetisation**	**Data source**
Waste-to-energy (WTE)	Market value	Net profits from electricity produced [(quantities of Kw/h produced X selling prices) - costs of production)]	Municipalities' interviews + ACR interview + literature review
Profits from recyclable waste	Direct monetary measure	Quantity of material X selling price	Municipalities' interviews
Increased equity (Alt 1 e 2) (PM+)	PM-Item	PM-item	Municipalities' and households' interviews

TABLE 16: OVERVIEW OF BENEFITS' MONETISATION METHODS AND SOURCES

CHAPTER 5 - BUSINESS-AS-USUAL: LUGANO

5.1 INTRODUCTION

Lugano is situated in the south of canton Ticino at 273 meters above sea level; it faces the gulf of "lago Ceresio" and it is surrounded by the mountains of Lugano Prealps. Lugano, with a population of 54,667, is the biggest city in Ticino. It has around 38,000 more inhabitants than the second largest city, Bellinzona. With an area of 32.09 square kilometres, it has a population density of 1,703.55 people per square kilometre.



In line with the average municipality in Ticino it has 47.6% men and 52.4% women. The average age in Lugano is 46, and more than 20,000 foreigners live in Lugano (37.8% of the population) (Ustat, 2013). This is higher than the cantonal average of 26%. Lugano is also the biggest financial centre in Ticino, the third in Switzerland only after Zurich and Geneva and within the top ten off-shore financial centres in the world (Swissinfo, 2013b). It has about 5,000 businesses, 90.1% of which operate in the tertiary sector. Only 3% of the population is registered as unemployed. There are about 11 people for every business in the city. The level of environmental awareness in Lugano is considered to be average. Around 12% of the city councillors are from the social party and 6% from the green party (Di Gianfrancesco, 2013b).

From the 70s, Lugano passed through a long aggregation process that aimed to incorporate several neighbouring municipalities. In 1972, the first two municipalities (Aldesago and Bre) were incorporated into Lugano. The second and third wave of aggregations took place in 2004 and 2008, when 15[39] more municipalities merged. Nowadays, Lugano is organised into 17 distinct neighbourhoods. These neighbourhoods maintained their identity (name, boundaries, etc.), but share the same political organisation and they are formally recognised as one municipality (i.e., the same postcode is used) (Lugano.ch, 2013).

[39] These are: Barbengo, Besso, Breganzona, Carabbia, Castagnola-Cassarate, Cureggia, Davesco-Soragno, Gandria, Loreto, Molino Nuovo, Pambio-Noranco, Pazzallo, Pregassona, Viganello and Villa Luganese.

5.2 INFRASTRUCTURE AND COLLECTION SYSTEM

Lugano in 2011 produced 34,373 tons of MSW, 41% of which was diverted to recycling. Taking into account that the average recycling rate in canton Ticino is 46%, Lugano is only slightly below average, although it does not apply any form of financial incentive scheme (Repubblica e Cantone Ticino, 2011).

Lugano does not apply any type of direct tax on MSW, neither lump sum nor a PAYT. The WMS is financed through general income taxes. As already stated above, both at federal and cantonal level, specific laws exist that require a municipality to finance at least 80% of the expenses related to WMS with a causal tax[40]. According to these laws, Lugano is in a situation of illegality.

The collection system in Lugano is mainly based on two levels, ecopoints and ecocentres. Lugano also provides kerbside collection for different types of waste, but only to a very limited extent[41]. The level of technology, availability and number of ecopoints and ecocentres is different within neighbourhoods. The most advanced situation presents underground containers for residuals and ecopoints with underground containers for both residuals and recyclables (PET, aluminium, glass and batteries). Other neighbourhoods still use old containers. In addition, there are 4 ecocentres, in the neighbourhoods of Breganzona, Molino Nuovo, Pambio-Noranco and Pregassona. These are open from Monday until Saturday, usually from 09:00 until 17:30, and all sorts of recyclable and non-recyclable waste, including bulky waste, can be disposed. The access to the ecocentres is granted only with the specific ecocard which is provided by the municipality to all citizens of Lugano. This is a way to avoid, or at least limit, waste tourism within the ecocentres and to collect data about the utilisation of these centres. The annual costs of maintenance of the ecopoints, ecocentres and public garbage are around 150,000 CHF (in 2011, Di Gianfrancesco, 2013b). These costs are included within the general costs of the WMS, and are measured as an alternative and indicative measure of the efficiency of the municipality's WMS.

Typology	Urban
Surface	32.09 km^2
Population	54,667
Population density	1,703.55 capita/km^2
Percentage (male - female)	47.6% - 52.4%
Percentage (Swiss - foreign)	62.2% - 37.8%
Unemployed (registered)	1,685 (3%)
Percentage pop.: - 0-19 - 20-64 - More than 65	 - 17.9% - 61.2% - 20.9%
Households: - 1 person - Couples without children - 1 parent families - Couples with children - Others	 24,160 - 42.6% - 21.5% - 6.8% - 25% - 4.1%
Type of building: - Single household - Multiple households	5,487 - 51.1% - 48.9%
Houses Size: - 1-2 rooms - 3-4 rooms - 5 or more rooms	28,798 - 29.4% - 56.8% - 13.8%
Businesses	4,904

TABLE 17: SUMMARY OF GEOGRAPHIC AND DEMOGRAPHIC VARIABLES FOR THE CITY OF LUGANO (DATA 2010) (SOURCE: USTAT, 2013)

The frequency of collection depends upon the area, for example, in the city centre MSW is collected every day, while in peripheral areas only once a week. On average, MSW is collected two or three times a week. The collection service is 65% directly managed by the municipality itself and 35% outsourced to private companies, which mostly take care of MSW collection in peripheral areas. Lugano collaborates with many neighbouring municipalities for the collection of MSW but only to a limited extent and in special situations. Often, it is more efficient for Lugano to collect MSW from other municipalities in those streets that are partially shared, since the other municipality does not have sufficient capacity or would require an extra trip thus increasing the costs of collection (Di Gianfrancesco, 2013b).

As for the majority of the municipalities in Ticino, Lugano is also responsible for the collection of residual waste from businesses[42]. These quantities are included in the total MSW collected, and the same goes for waste from public garbage bins. Since Lugano is a very attractive city for tourism the quantities of waste collected increase in summer, both from public garbage bins and from businesses such as restaurants, bars.

[40] Art. 18 e 28 della LaLPAmb e l'art. 11 RLaLPAmb.
[41] Depending on and not in every neighborhood, for example bulky waste 5 times a year and for paper once a month.
[42] Only to the ecopoints. Businesses are not allowed to deposit any type of waste in the ecocentres.

Only for what concerns the collection service provided by the municipality itself (i.e., excluding the service provided by private companies), ten vehicles are used. Five trucks are used to collect MSW from underground containers (cutting-edge technology trucks with a EURO 5 standard emission). Three trucks are used to collect MSW from old containers and kerbside, and two roll-off trucks are used to transport MSW from the ecocentre to the private companies responsible for disposal. Average annual costs of maintenance for trucks and other vehicles dedicated to collection of waste are 4,340.25 CHF per truck (Di Gianfrancesco, 2013b). These maintenance costs are not included within the general costs of collection and disposal. After collection, MSW is delivered to different private companies for disposal. Residual and bulky waste is disposed through the ACR in the Giubiasco's incinerator, as it is for all the municipalities in Ticino. Glass, aluminium and other metals are disposed through Vismara and Ochsner. Paper and wood is delivered to Fratelli Maffi, electronics is taken over by Swico and Sens. Last but not least, organic waste is given to Bizzini company or disposed in the landfill owned by Lugano and managed by Brenchino company (Di Gianfrancesco, 2013).

5.3 TOTAL COSTS AND BENEFITS[43]

Collection and disposal costs

Data about collection and disposal costs have been taken from the cantonal census (Repubblica e Cantone Ticino, 2011) and were identical to those stated by Di Gianfrancesco (2013b) during the interview.

In 2011, the municipality of Lugano produced 18,652 tons of residual waste. The total costs for collection and disposal of residual waste in the municipality were 2,131,134 CHF and 3,526,154 CHF respectively. With 1,526 tons of bulky waste produced, the collection and disposal costs were 377,177 CHF and 288,321 CHF respectively. For recyclables, 14,195 tons were produced and the costs of collection and disposal were 1,178,205 CHF in total.

Environmental costs

Environmental costs of collection: the ten trucks used travel on average 13,191.90 kilometres each in one year, and the average fuel consumption is 9,351.30 litres of diesel per year per truck. Moreover, since private companies use different type of trucks with different emission standards, the emissions attributed to these companies are calculated on the subtotal of Lugano in order to have an average measure.

Vehicles	Kilometres	Litres	Standard	NOx (kg)	PM (kg)	HC (kg)	CO (kg)
5	65,959.5	46,756.5	EURO 5	327.30	4.60	0	56.10
2	26,383.8	18,702.6	EURO 4	243.10	1.80	0.75	18.70
3	39,575.7	28,053.9	EURO 3	504.90	8.40	22.40	67.30
Subtotal	131,919	93,513		1075.30	14.80	23.15	142.10
+35% private companies	46,171.65	32,729.55		376.35	5.18	8.10	49.70
Total	178,090.65	126,242.55		1451.65	19.98	31.25	191.80

TABLE 18: KILOMETERS TRAVELLED, LITRES CONSUMED AND EMISSIONS FROM MSW COLLECTION'S TRUCKS (SOURCES: DI GIANFRANCESCO, 2013B; VOLVO TRUCKS, 2013 AND DE BRUYN ET AL, 2010)

Considering the shadow prices, the monetised damage costs related to emissions from collection of MSW are: 23,696.70 CHF for NOx, 696.40 CHF for PM, 13.80 CHF for HC and 7.70 CHF for total carbon[44]. Therefore, the total environmental costs of collection are estimated at 24,414.60 CHF.

Environmental costs of disposal: Lugano in 2011 produced 18,652 tons of residual waste and 1,526 tons of bulky waste. Lugano is responsible for the production of 121 million of m^3 of fumes and 1.2 million of litres of waste waters. Therefore, with a total of 20,178 tons of waste burned in 2011, the incinerator's emissions created a total environmental cost of 98,839.30 CHF. The following tables show in detail the contribution and costs of each of the pollutant emitted into air and into water.

[43] For more information about sources and methods of calculating costs and benefits for these and the other cases please refer to section 2.2, Annex II and III.
[44] Exchange rate of 1.22 (average 2011).

AIR	mg/m3 emissions	Total emissions kg	Price in CHF/kg	Total Costs in CHF
Particulates (PM)	0.01	1.46	25.26	37.01
Carbon (C)	0.05	6.05	2.84	17.19
Carbon Monoxide (CO)	13.39	1,621.10	0.03	48.21
Nitrous Oxides (NOx, NO2)	48.60	5,883.90	11.85	69,723.60
Sulphur Dioxide (SO2)	6.06	733.67	10.34	7,586.68
Hydrogen Chloride (HCl)	0.25	30.27	4.82	145.83
Ammonia (NH3)	0.13	15.74	19.56	307.91
Hydrogen fluoride (HF)	0.09	10.90	48.13	524.39
Zinc (Zn) + Lead (Pb)	0.20	23.97	456.11	10,933.60
Mercury (Hg)	0.0011	0.13	12,297.05	1,637.66
Cadmium (Cd)	0.0012	0.16	141.98	22.35
Dioxins + Furans	0.22	26.63	286.19	7,622.55
Total Air				98,606.96

TABLE 19: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO AIR (LUGANO)

WATER	mg/l emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
DOC	2.20	2.80	0.00	0.00
Cadmium (Cd)	0.01	0.01	5.54	0.07
Chromium (Cr)	0.02	0.03	0.03	0.00
Mercury (Hg)	0.0001	0.0001	1,070.96	0.14
Nickel (Ni)	0.02	0.03	3.77	0.10
Lead (Pb)	0.03	0.04	9.42	0.36
Copper (Cu)	0.02	0.03	0.0047	0.00
Zinc (Zn)	0.10	0.13	1.80	0.23
Ammonia nitrogen (NH4-N)	5.80	7.37	31.08	229.14
Nitrous oxide (NO2-N)	0.15	0.19	11.85	2.29
Total Water				232.32

TABLE 20: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO WATER (LUGANO)

Illegal dumping

As stated by Di Gianfrancesco (2013b), illegal dumping is practically absent in Lugano. No waste illegally dumped into woods or public places has been found and no operations of cleaning up or enforcement have been performed. Only a few cases of bulky waste dumped next to underground containers or outside the ecocentre have been registered. This is mainly due to the fact that Lugano does not apply a PAYT scheme and a very efficient and widespread system of collecting MSW is available. The fact that the municipality is also very urbanised may be an additional reason for the absence of illegal dumping. Therefore, the costs of enforcement are zero and it is assumed that the quantities of waste disposed illegally are the 0.5% of the total MSW produced. The total quantities illegally dumped in Lugano are therefore estimated at 171.86 tons, at a total environmental cost of 841.83 CHF.

Waste tourism

Waste tourism concerns the municipality of Lugano only to a very limited extent. In areas close to PAYT municipalities, a slight increase in the waste collected has been perceived but no exact data is available (Di Gianfrancesco, 2013b). The municipalities that may potentially transfer their MSW to Lugano are Canobbio

and Vezia; both introduced a PAYT scheme respectively in 2006 and 2007. Moreover, although the municipalities of Caslano and Pura are ten kilometres from Lugano, it is assumed that part of their MSW is transferred; many work in Lugano so it is easy for them to transport and dispose waste within the municipality.

Considering the evolution in MSW quantities of these municipalities, it is estimated that Lugano has extra collection and disposal costs due to ingoing waste tourism of between 6,190.80 and 63,911.70 CHF. These costs are subtracted from the total costs of Lugano, since they are not related to its activities, but transferred from other municipalities. Moreover due to low extent of the problem, Lugano had no enforcement costs related to waste tourism.

Households' time and costs[45]

The following analysis of households' time and costs is based on data collected in the ecocentre of Noranco and in some of the ecopoints of Lugano. One hundred households were willing to answer to the questions about their habits regarding the separation and disposal of recyclable waste.

On average, households in Lugano are composed of 3 people; 92% of them stated that they always separate waste while 6% said often and only 2% sometimes. Households that own separated bins[46] are 85%. Paper, PET and glass are the materials most separated, stated by 89%, 87% and 88% of the households respectively. In order to dispose their recyclable waste, 58% of Lugano's households use only the ecocentre, 24% use only the ecopoint and 18% use both, depending on the type of waste they need to dispose (e.g., if it is bulky or not). On average, once a week they dispose waste to the ecopoint, and almost once every two weeks to the ecocentre[47].

As stated by Di Gianfrancesco (2013b), the average distance of a household to the nearest ecopoint is 250 meters. The distance and the extent to which containers for different recyclables are available vary among neighbourhoods. As already stated above there are four ecocentres, located in the neighbourhoods of Breganzona, Molino Nuovo, Pambio-Noranco and Pregassona. The average distance to the ecocentres was both measured through households' questionnaire and calculated; households reported themselves to be on average 4.55 kilometres from the ecocentre while the calculated distance is 5 kilometres (round trip). The same double measurement technique has been used to assess the time that household spend to travel to the ecocentre. From household questionnaire, the time includes also disposal time while the calculated time only includes travel time - 8.5 minutes for a round trip to the ecocentre was calculated. Households stated that to travel and dispose their waste they spend, on average, between 1.2 and 3.3 minutes a day[48]. The time needed only to separate waste was measured to be between 0.8 and 3 minutes a day. Therefore the total measured time to separate, travel and dispose recyclable waste in one day is between 2.14 and 6.3 minutes. To reduce their time spent separating, travelling and disposing waste, households are willing to pay on average between 0.25 CHF and 0.86 CHF for 10 minutes. Considering these results, the following table shows the monetisation of time allocated for waste separation, delivery and disposal in all its combinations.

WTP/Time	Min	Max
Min	14	44.36
Max	47.86	151.75

TABLE 21: COSTS FOR TIME SPENT IN SEPARATION, DELIVERY AND DISPOSAL (CHF IN ONE YEAR PER HOUSEHOLD)

To these amounts, the costs for delivery itself (including fuel and tyre wear, devaluation of the vehicle, etc.) need to be taken into account. Households stated to have yearly costs between 44.50 and 218.40 CHF for fuel and the depreciation of their vehicles. The total costs for waste separation, delivery and disposal

[45] Detailed information about the method used to monetize these costs can be found in Annex II. Details about calculations, descriptive statistics and graphs of all the variables measured within households 'surveys for all four cases are contained in the Annex III.
[46] Bags, boxes and any other type of container is included.
[47] Once every 12.58 days.
[48] Between 8.7 and 23.3 minutes every time.

sustained by the average household in Lugano vary from 58.50 to 370.15 CHF per year. Considering that in Lugano there are 24,160 households, the total social costs are between 1,413,650 and 8,942,921.50 CHF.

Waste-to-energy

As already stated within the environmental costs from the disposal section, the total amount of waste that Lugano sent to the incinerator of Giubiasco was 20,178 tons. With this amount, it was able to contribute to the production of 15,730,840 Kw/h of electricity. The average selling price for electricity applied to households is 0.20 CHF/Kwh and the average operating cost of a modern incinerator is 153.50 CHF a ton[49]. Therefore the gross profit is 3,146,168 CHF, to which the total estimated costs of production of 3,097,323 CHF must be deducted. Therefore the net profits for the production of electricity that can be attributed to the municipality of Lugano are 48,845 CHF.

Profits from recyclable waste

As for every municipality in Ticino, paper is the material that is produced, separated and recycled in largest quantity. Often in Ticino, paper quantities are higher than the recycling capacity and therefore paper materials must be disposed in the incinerator. Lugano collected 4,297 tons of paper for a profit of 93,400 CHF. The second most recycled material is glass, mainly from bottles; 2,154 tons of separated glass provided an income of 21,540 CHF in 2011. Last but not least, aluminium and other metals were sold for a total profit of 70,472. 69 tons of PET were collected and disposed in Lugano, but despite this, PET must be returned to producers, distributors or convenience stores and therefore no profits are made.

Material	Price (CHF/ton)	Quantity (ton)	Total Profit (CHF)
Paper	N.A.	4,297	93,400
Glass	10	2,154	21,540
Aluminium and Metals	N.A.	N.A	70,472
Others	N.A.	N.A.	83,000
Total			**268,412**

TABLE 22: PROFITS FROM RECYCLABLE MATERIALS IN LUGANO (DATA 2011) (SOURCE: DI GIANFRANCESCO, 2013B)

Other costs

In order to inform the population about waste collection, a calendar containing opening times of the ecocentres, days and times of kerbside collection, and where to dispose which type of waste is printed. The printing and delivery costs of this calendar are in total 60,000 CHF a year (Di Gianfrancesco, 2013). No other costs not included above were found to be relevant.

[49] See Annex II.

The following table summarises all costs and benefits, described in detail above, and shows the total costs and benefits as well as the net result.

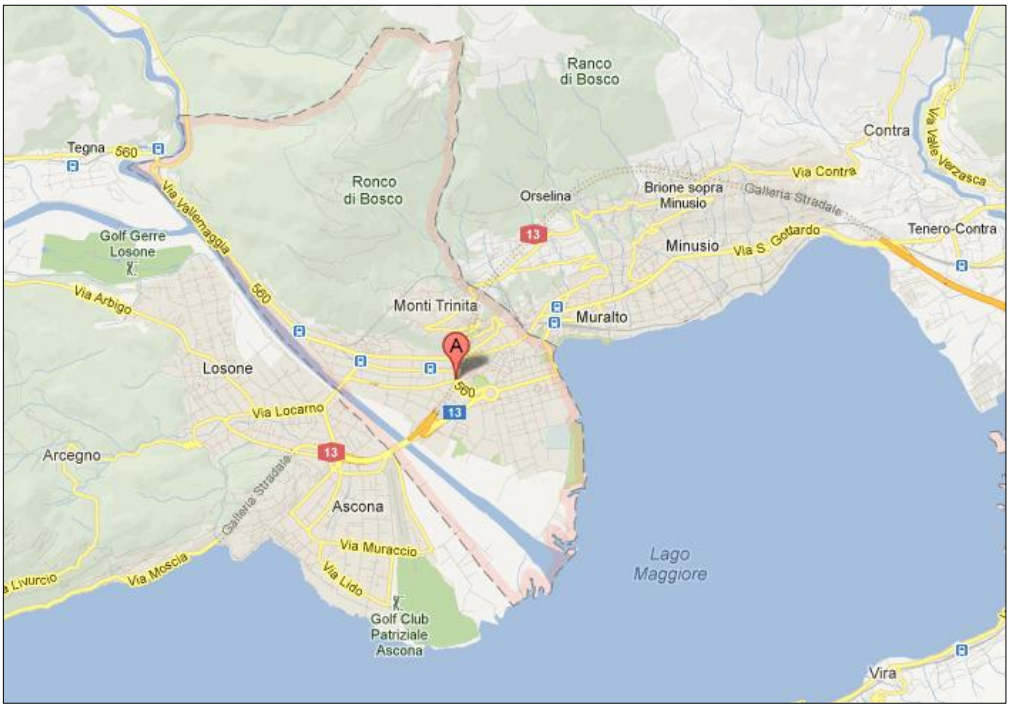
Costs	CHF/year	Benefits	CHF/year
Collection costs - residual	2,131,134	**Waste-to-energy (WTE)**	48,845
Collection costs - bulky	377,177	**Profits from recyclable materials** • **Paper** • **Glass** • **Metals & Aluminium** • **Others**	 • 93,400 • 21,540 • 70,472 • 83,000
Disposal costs - residual	3,526,154		
Disposal costs - bulky	288,321		
Collection and disposal - recyclables	1,178,205		
Environmental costs: • **From collection** • **From disposal**	 • 24,424.60 • 98,839.30		
Illegal dumping	841.80		
Deduction for ingoing waste tourism	(-)6,190.80 - (-)63,911.70		
Households' time and costs for recyclable delivery	1,413,650 - 8,942,921.50		
Other costs	60,000		
Total	9,092,556 - 16,564,106.50		317,257
Net result	8,775,299 - 16,246,849.50		

TABLE 23: OVERVIEW OF COSTS AND BENEFITS RELATED TO MSW MANAGEMENT IN LUGANO

CHAPTER 6 - BASE CASE: LOCARNO

6.1 INTRODUCTION

Locarno is located in the central-west area of Canton Ticino, on the northern tip of Lago Maggiore and on the right side of the river Maggia. Locarno is the capital of Locarno district and, with a population of 15,153, is the third largest city in Ticino after Lugano and Bellinzona.



The municipality of Locarno has a total surface of about 19 square kilometres and on its territory there are on average 786 people per square kilometre. Locarno is economically very active, with 1,136 businesses operating - about 13 people for each business. Most of the businesses (84.4%) are from the tertiary sector. The demographic structure is similar to the cantonal average: 46.7% of the population are male, 53.3% are women. The percentage of foreign people is higher than the cantonal average, at 34.5% (Ustat, 2013). The average education is considered to be on a low-middle level, as well as the average salary. The average age of Locarno's citizens is between 40 and 49. Households are composed on average of 2 people, and they are considered to have average environmental awareness. In the city council, there are about 15.4% from social party and 7.5% from green party (Zamboni, 2013). The political will has been recognised as the main obstacle to the introduction of a PAYT scheme in the municipality of Locarno (Zamboni, 2013).

Variable	Locarno
Typology	Urban
Surface	19,27 m2
Population	15,153
Population density	786.35 capita/km^2
Percentage (male - female)	46.7% - 53.3%
Percentage (Swiss - foreign)	65.5% - 34.5%
Unemployed (registered)	460 (3%)
Percentage pop.:	
- 0-19	- 17.6%
- 20-64	- 59.7%
- More than 65	- 22.8%
Households:	6,730
- 1 person	- 41%
- Couples without children	- 21.9%
- 1 parent families	- 7.2%
- Couples with children	- 26.3%
Others	- 3.5%
Type of building:	1,636
- Single household	- 55.3%
- Multiple households	- 44.7%
Houses Size:	8,647
- 1-2 rooms	- 30.5%
- 3-4 rooms	- 59.3%
- 5 or more rooms	- 10.1%
Businesses	1,136

TABLE 34: SUMMARY OF GEOGRAPHIC AND DEMOGRAPHIC VARIABLES FOR THE CITY OF LOCARNO (DATA 2010) (SOURCE: USTAT, 2013)

6.2 Infrastructure and collection system

In total, Locarno produces 9,467 tons of MSW, 33% of which are recyclable materials (Repubblica e Cantone Ticino, 2011).

Locarno has a good infrastructural level in terms of MSW collection and disposal. The collection system of the municipality of Locarno is based on three levels: a kerbside collection system, ecopoints and an ecocentre. In the municipality, there are 20 locations in which households can deposit their waste. The locations almost always include underground containers for residual waste as well as other containers for recyclable waste. The recyclables that can be disposed vary among ecopoints. Glass, paper and PET are the most commonly found - aluminium, metals, textiles and batteries follow, in order of total number. The ecocentre is open four days a week[50] for an average of 3.5 hours a day. Bulky waste, other metals, oils, electronics can be disposed only in the ecocentre. Specific days are fixed for the kerbside collection of residual, paper and organic waste (Zamboni, 2013).

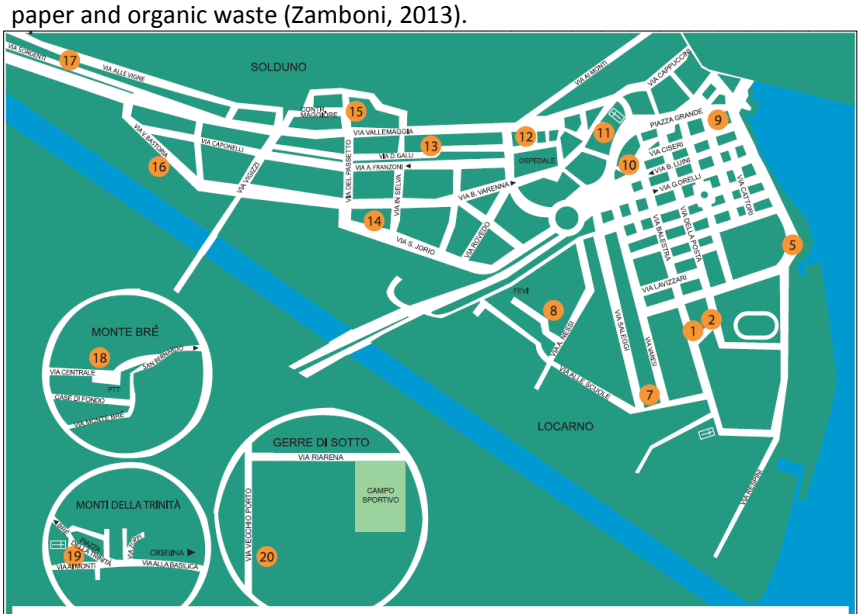


FIGURE 16: LOCATION OF THE DIFFERENT ECOPOINTS AND ECOCENTRE IN LOCARNO

Locarno has on average one ecopoint per square kilometre and each serves 757 households.

A calendar is distributed in order to inform the population about where and when the waste can be disposed. Usually, residual waste is collected kerbside 3 times a week (Monday, Wednesday and Friday), paper is collected once a week on Tuesdays, and organic waste on Thursdays.

As stated by Zamboni (2013), the city of Locarno is trying to substitute the entire kerbside collection system with centralised and automated systems to reduce costs. In order to do this, they will invest in more centralised locations with differentiated containers and automated trucks. The municipality of Locarno, in 2011, had an expenditure of 131,000 CHF including costs for staff in the centres, and the maintenance of the structures. These costs are included in collection and disposal of MSW.

In order to perform MSW collection service, three trucks (plus one kept as reserve) are used. These are cutting-edge trucks (26 tons), three axes with a capacity of 18 to 20 cubic meters of cargo. They are equipped with hydraulic cranes to lift the underground containers. The total costs of maintenance of these vehicles varied, from 88,000 CHF in 2010 to 60,566 CHF in 2011 and 123,915 CHF in 2012. These maintenance costs are not included in the collection costs (Zamboni, 2013).

Locarno directly manages its MSW collection and does not use other companies to provide the service as in Caslano or Lugano. It collaborates with Orselina for collection of its bulky waste and two underground containers. These quantities and costs are attributed to Orselina, although the service is provided by the city of Locarno (Zamboni, 2013).

In Locarno, households pay a lump sum tax, depending on the households' size, type of resident and if registered within the city. The businesses of Locarno pay a tax that is calculated on the quantities of waste. Every business must pay a minimum of 500kg of waste, even if the actual production is lower. The following table provides an overview of the taxes applied to both households and businesses in Locarno.

[50] Tuesday morning, Wednesday afternoon, Thursday afternoon and Saturday morning.

Subject	Type		Price (CHF)
Households	Registered	Single person	126
		Up to 2 people	156
		More than 2 people	201
	Not registered	Single person	252
		Up to 2 people	312
		More than 2 people	402
	Secondary residences	Up to 2 rooms	156
		More than 2 rooms	201
Businesses			0.43 CHF/kg with a minimum tax of 222 CHF

TABLE 25: TAXES ON MSW APPLIED IN LOCARNO (SOURCE: ZAMBONI, 2013)

In the quantities of MSW, waste collected from public garbage bins and some of the businesses are also considered. This again may be subject to a high level of seasonality, since Locarno is very popular among tourists especially in the summer months.

As it is for the whole of the municipality in canton Ticino, Locarno also disposes its residual and bulky waste through the ACR at the incinerator of Giubiasco. On the contrary, though, recyclable waste is disposed through different private companies. For example, paper and glass are disposed through Giuliani in Riazzino, and organic waste through Compodino SA in Gordola.

6.3 TOTAL COSTS AND BENEFITS

Collection and disposal costs

Again, data are taken from the cantonal census (Repubblica e Cantone Ticino, 2011) and an interview with the responsible person. As in the previous case study - and for all the municipalities - the main costs sustained by a municipality for MSW are those for collection and disposal. In 2011, Locarno had total collection and disposal costs of 2,843,000 CHF. These are divided as follows: residual waste cost Locarno a total of 1,701,000 CHF - 749,000 CHF for collection and 952,000 for disposal. In the same year, Locarno spent 4,000 and 112,000 CHF respectively on collection and disposal of bulky waste. Lastly, the total expense for recyclables' collection and disposal was 1,026,000 CHF.

Environmental costs

Environmental costs of collection: as already stated above, three trucks are used in order to perform the collection service. The total number of kilometres travelled is about 62,000 a year. The total consumption of fuel in one year is 48,084 litres. Since detailed data on the exact number of kilometres and litres consumed by each truck was not available, the total kilometres and litres are divided by the number of trucks in order to obtain an average. The emissions are then calculated on this average. In order to calculate the emissions from the collection system, the kilometres, fuel consumption, year of production and standard emissions of the trucks are the data considered. The total damage costs of the different pollutants emitted by MSW collection trucks in the municipality of Locarno are 18,593.40 CHF: namely 16,879 CHF for nitrogen oxides, 1,677.50 CHF for particulates, 31.50 CHF for hydrocarbs and 5.40 CHF for total carbon.

Vehicles[51]	Kilometres	Litres	Standard	NOx (kg)	PM (kg)	HC (kg)	CO (kg)
Volvo FS10 (1991)	15537.5	10771	-	624.70	43	64.60	86.20
Volvo FS10 (2011)	15537.5	10771	EURO 5	75.40	1	0	12.90
Mercedes Econic (2002)	15537.5	10771	EURO 3	193.90	3.20	8.60	24.70
IVECO Stralis (2006)	15537.5	10771	EURO 4	140	1	0.40	10.70
Total	62,150	43,084		1,034	48.20	73.60	134.50

TABLE 26: KILOMETERS TRAVELLED, LITRES CONSUMED AND EMISSIONS FROM MSW COLLECTION'S TRUCKS (SOURCES: ZAMBONI, 2013; VOLVO TRUCKS, 2013 AND DE BRUYN ET AL, 2010)

[51] Data 2012.

Environmental costs of disposal: Locarno produced in total 6,347 tons of residual and bulky waste in 2011. With such quantities of waste burned, Locarno contributed to 38,082,000 m^3 of fumes and 399,861 litres of waste waters. Taking into account the quantities of pollutants contained in air and water, Locarno has an estimated environmental cost of 31,089.95 CHF. The following two tables show the pollutants and the relative damage costs.

AIR	mg/m3 emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
Particulates (PM)	0.01	0.46	25.26	11.64
Carbon (C)	0.05	1.90	2.84	5.41
Carbon Monoxide (CO)	13.39	509.92	0.03	15.16
Nitrous Oxides (NOx, NO2)	48.60	1850.79	11.85	21931.59
Sulphur Dioxide (SO2)	6.06	230.78	10.34	2386.40
Hydrogen Chloride (HCl)	0.25	9.52	4.82	45.87
Ammonia (NH3)	0.13	4.95	19.56	96.85
Hydrogen fluoride (HF)	0.09	3.43	48.13	164.95
Zinc (Zn) + Lead (Pb)	0.20	7.54	456.11	3439.17
Mercury (Hg)	0.0011	0.04	12297.05	515.13
Cadmium (Cd)	0.0013	0.05	141.98	7.03
Dioxins + Furans	0.22	8.38	286.19	2397.68
Total Air				31016.87

TABLE 27: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO AIR (LOCARNO)

WATER	mg/l emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
DOC	2.20	0.88	0.00	0.00
Cadmium (Cd)	0.01	0.004	5.54	0.02
Chromium (Cr)	0.02	0.01	0.03	0.00
Mercury (Hg)	0.0001	0.008	1070.96	0.04
Nickel (Ni)	0.02	0.01	3.77	0.03
Lead (Pb)	0.03	0.01	9.42	0.11
Copper (Cu)	0.02	0.01	0.00	0.00
Zinc (Zn)	0.10	0.04	1.80	0.07
Ammonia nitrogen (NH4-N)	5.80	2.32	31.08	72.08
Nitrous oxide (NO2-N)	0.15	0.06	11.85	0.72
Total Water				73.08

TABLE 28: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO WATER (LOCARNO)

Illegal dumping

Two main sites of illegal dumping were recognised by Zamboni (2013) during the interview. The first relates to dumping of organic waste along the street from Locarno city to the upper side of the Monte Bre. This site is not considered harmful for the environment, since only organic waste is dumped here. Another site was in Riazzino, where pneumatics were illegally dumped. This illegal dump was burned in 2006, leading to high environmental and economic damage. The city of Locarno received 100,000 CHF as compensation from the responsible party. Excluding these exceptional cases, there is no systematic tendency of dumping waste illegally in Locarno, so the municipality did not adopt any measure to reduce illegal dumping. The majority, if not all of the MSW that is illegally left beside the road, near the ecocentre or next to ecopoints comes from

other municipalities and is not internally produced. This is accounted for as waste tourism, and therefore the assumption is that illegal dumping in Locarno accounts for 0.5% of its MSW quantities. In absolute terms, the total quantities of MSW dumped is 47.33 tons at a total environmental cost of 231.86 CHF.

Waste tourism

Locarno is a singular case in Ticino concerning the composition of neighbouring municipalities. It is comparable to the case of Helmond (The Netherlands) as presented by Dijkgraaf & Gradus (2003). In fact, Locarno is surrounded by nine municipalities with a PBV scheme: Minusio (1999), Brione sopra Minusio (2002), Muralto (2002), Tenero-Contra (2002), Orselina (2003), Cugnasco (2007), Brissago (2008), Losone (2009) and Lavertezzo (2009). Other neighbouring municipalities, such as Ascona, Tegna, Gambarogno and Avegno-Gordevio, have not yet introduced a PAYT scheme. Although the effect of waste tourism may be spread around all the municipalities without a PAYT scheme, especially in Ascona, and not only in Locarno, it is more plausible that Locarno is the municipality to receive the biggest amount of MSW from PAYT municipalities since all the others are small and often rural (e.g., Tegna, Gambarogno, Avegno-Gordevio). In fact many of their households travel to Locarno to work or to shop, thus increasing the chance for waste tourism (Zamboni, 2013). Moreover it makes little sense, both geographically and economically, for a household to drive into a rural and more distant municipality to dispose its waste for free, since it will constitute an extra cost to travel. As stated by Zamboni (2013) and by the employees of the ecocentre, usually on Mondays, large quantities of waste from other municipalities are found near the ecocentre or other ecopoints. This waste usually comes from other municipalities that have PAYT schemes (more often from Brissago and Minusio).

The evolution of MSW quantities for all the PAYT municipalities that surround Locarno has been analysed. The reductions from the previous years are calculated and an estimation of waste tourism is made for the highest and lowest reduction[52]. Some data were missing for the period between 1998 and 2000 for the municipality of Minusio. This could not be excluded due to its importance in terms of size and waste quantities, therefore Losone[53] is used as a proxy in order to estimate the total quantities of MSW exported. The results suggest that Locarno had to sustain extra costs, due to MSW imported from neighbouring municipalities, of between 12,513.05 CHF and 139,651.50 CHF. Due to the high frequency of waste tourism, Locarno had to introduce enforcement and control systems around the eight ecocentres. The installation of cameras cost 34,000 CHF divided into civil engineering works for 8,000 CHF and electronic Installations (cameras, rack, etc.) for 26,000 CHF (Zamboni, 2013).

Moreover, up to 100 fines were given to people that illegally dumped their garbage bags in Locarno. It is important to notice that the number of fines given in Locarno is higher than those given in Bellinzona. It is clear that the schemes adopted by surrounding municipalities are very important in the determination of the level of waste tourism in a municipality. Despite the control system and fines, Locarno did not engage in awareness-raising actions against illegal dumping or waste tourism, and did not enforce the current laws.

Households' time and costs

In Locarno, 69 households answered the questionnaire while they were disposing waste either to the ecocentre, or to the ecopoint directly outside of the ecocentre. Of these 69 questionnaires, two were not valid or not complete. Therefore the following data are based on 67 observations.

The average household in Locarno is composed of 2.7 people, 91% of the households always separate their waste, 6% often and 3% only sometimes. Most of the households (87%) have separate bins at home; paper, glass and PET are the most separated materials, followed by aluminium. Households favour underground containers (or ecopoints) for disposal of their waste. In fact, 49% of Locarno's households use only underground containers to dispose their recyclable waste, 29% use the kerbside system and the remaining 22% go to the ecocentre.

[52] See Annex II for further information about the monetisation method.
[53] Losone is used since it has similar quantities of MSW, similar costs per ton and similar size.

The average distance for households in Locarno to the ecocentre is 7.4 kilometres - 14 minutes for a round trip. 1 kilometre and 3.25 minutes are needed on average to reach the nearest ecopoint (round trip)[54]. These statistics also reflect what has been measured through households' questionnaire. In fact, the individuals stated that they were, on average, a maximum of 880 meters from the place where they dispose recyclable waste. Moreover, the stated time to deliver and dispose waste is between 4.5 and almost 12 minutes in a week (round trip). In Locarno, households stated that they spend on average between 1 and 3.4 minutes a day simply to separate different recyclable materials. Therefore, the total daily time spent for separating, delivering and disposing recyclable waste is a minimum of 1.6 and maximum of 5.1 minutes a day for the average household. The willingness to pay to save 10 minutes of the time spent for waste-related activities of the average Locarno's household was between 0.2 and 0.9 CHF.

WTP/Time	Min	Max
Min	12.58	37.70
Max	51.60	154.10

TABLE 29: COSTS FOR TIME SPENT IN SEPARATION, DELIVERY AND DISPOSAL (CHF IN ONE YEAR PER HOUSEHOLD)

Moreover, the yearly costs for fuel and tyre consumption, and the depreciation of the vehicle are on average between 19.10 CHF and 154 CHF per household. Therefore, the total cost per household is between 31.70 CHF and 308.10 CHF. If multiplied by the number of households (6,730), the total social costs are between 213,587 CHF and 2,073,982.8 CHF in one year.

Waste-to-energy

In 2011, Locarno produced 6,347 tons of non-recyclable waste - that is to say, 5,790 tons of residual waste and 557 tons of bulky waste. Therefore, the total amount of electricity produced by Locarno was 4,950,660 kwh. With a gross profit of 990,132 CHF and total operating costs of 974,264.5, Locarno created a net profit for society of 15,867.5 CHF.

Profits from recyclable waste

Before 2011, paper did not provide any profits; in fact, Locarno had to pay to recycle it. This was mainly due to the fact that, in general in Ticino, there is an overproduction and recycling of paper material; as a result, this is often burned in the incinerator since there is not enough capacity to recycle all the paper separated (Zamboni, 2013). From 2011, the profits for paper materials sold were 20 CHF per ton and - considering that 1077 tons of paper were recycled - the total profits were 21,540 CHF. Metals and aluminium are the most profitable materials, being sold for 170 CHF a ton. Since Locarno collected 10 tons of metals and aluminium in 2011, the profits were 1,700 CHF.

As is the case for all the municipalities in Ticino, the profits from recyclable glass come from Vetrosuisse, which refunds the municipalities with money coming from the anticipated taxes that producers and importers must pay on glass bottles (between 0.03 to 0.07 CHF a bottle). The total profits for glass material were 54,437 CHF in 2011 - an average of 81 CHF a ton for 671 tons of glass collected. Last but not least, from the 729.4 tons of other recyclables sold, on average for 30 CHF a ton, Locarno accounted a total profit of 21,886 CHF. As already stated above PET does not produce any profits, as it must be returned to producers and convenience shops.

Material	Price (CHF/ton)	Quantity (ton)	Total Profit (CHF)
Paper	20	1,077	21,540
Glass	81	671	54,437
Aluminium and Metals	170	10	1,700
Others	(depending on item)	729.4	21,886
Total			99,563

TABLE 30: PROFITS FROM RECYCLABLE WASTE IN LOCARNO (DATA 2011) (SOURCE: ZAMBONI, 2013)

[54] Excluded the regions of Monte Bre, Monti della Trinita e Gerre di sotto since they have their own ecopoints at less than 1km.

Other costs

As many municipalities do, Locarno also prints a calendar in order to inform the households on where, how and when it is possible to dispose their garbage. The costs for designing and printing these calendars are about 10,000 CHF per year (Zamboni, 2013). There are no other costs for awareness-raising, since the only awareness campaign on littering (IGSU) is sponsored by external producers (Zamboni, 2013).

In the following table all costs and benefits are summarised, totalled, and the net result is presented.

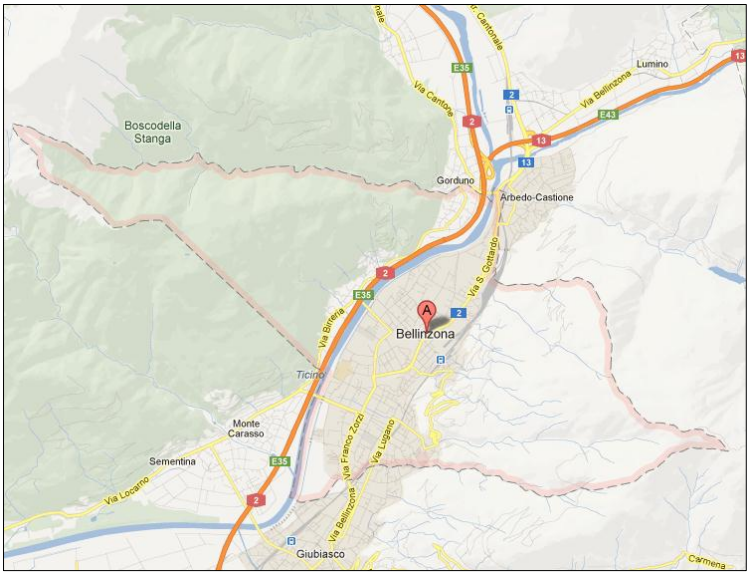
Costs	CHF/year	**Benefits**	CHF/year
Collection costs - residual	749,000	**Waste-to-energy (WTE)**	15,867.50
Collection costs - bulky	4,000	**Profits from recyclable materials** • **Paper** • **Glass** • **Metals & Aluminium** • **Others**	 • 21,540 • 54,437 • 1,700 • 21,886
Disposal costs - residual	952,000		
Disposal costs - bulky	112,000		
Collection and disposal - recyclables	1,026,000		
Environmental costs: • **From collection** • **From disposal**	 • 18,593.40 • 31,089.95		
Illegal dumping	• 231.9 • 34,000		
Deduction for ingoing waste tourism	(-)12,513.050 - (-) 139,651.50		
Households' time and costs for recyclable delivery	213,587 - 2,073,982.80		
Other costs	10,000		
Total	3,137,989.20 - 4,871,246.55		115,430.50
Net result	3,022,558.70 - 4,755,816.05		

TABLE 31: OVERVIEW OF COSTS AND BENEFITS RELATED TO MSW MANAGEMENT IN LOCARNO

CHAPTER 7 - ALTERNATIVE 1: BELLINZONA (PAY-BY-VOLUME)

7.1 INTRODUCTION

Bellinzona is the capital of canton Ticino; it is the administrative and political centre of the whole region. The municipality of Bellinzona is situated at an altitude of 239 meters above sea level and stretches along the valley of the river Ticino. It is surrounded by the Lepontine Alps (east and west) and by the Lugano Prealps (south). Bellinzona - with a population of 17,373 - is the second largest city in Ticino, after Lugano. It extends over 19.15 square kilometres and has a population density of 907.21 inhabitants per square kilometre. The percentage of women is approximately 58%, and the number of foreign people living in Bellinzona is 5,086 (29.3% of the total population). The average age is around 45. The people registered to the unemployment offices are 2.5% of the total population and the average wage is medium-low when compared to the cantonal average (see Annex IV).



The level of environmental awareness in Bellinzona is considered to be medium-high. As stated by Baroni (2013), there is a high level of solidarity in the municipality. In fact, old people who may not have the chance of disposing their residual, recyclable or bulky waste are often helped by their neighbours. The level of environmental awareness within the city council is also medium-high. Individuals from the green party, such as Luca Buzzi and Sergio Savoia, are very active in enhancing the level of sustainability of the city and in awareness-raising among the population. The percentage of councillors from the social part is 17%, while 13% are from green or other party (Baroni, 2013). Bellinzona is a very economically active city and 1,248 businesses, mainly from the tertiary sector (88.9%), are present on its territory (Ustat, 2011).

Variable	Bellinzona
Typology	Urban
Surface	19.15 km^2
Population	17,373
Population density	907.21 capita/km^2
Percentage (male - female)	47.1% - 57.9%
Percentage (Swiss - foreign)	70.7% - 29.3%
Unemployed (registered)	440 (2.5%)
Percentage pop.: - 0-19 - 20-64 - More than 65	 - 18.2% - 61.4% - 20.4%
Households: - 1 person - Couples without children - 1 parent families Couples with children Others	7,294 - 36.5% - 22.7% - 6.8% - 30.3% - 3.6%
Type of building: - Single household - Multiple households	2,551 - 58.4% - 41.6%
Houses Size: - 1-2 rooms - 3-4 rooms - 5 or more rooms	8,455 - 20.8% - 64.4% - 14.8%
Businesses	1,248

TABLE 32: SUMMARY OF GEOGRAPHIC AND DEMOGRAPHIC VARIABLES FOR THE CITY OF BELLINZONA (DATA 2010) (SOURCE: USTAT, 2013)

7.2 INFRASTRUCTURE AND COLLECTION SYSTEM

Bellinzona introduced a PAYT scheme in 2007 based on coloured and marked bags (i.e., a PBV system). These bags can be purchased in different sizes and at different prices in 21 different locations, including convenience stores, pharmacies, gas stations and others. For businesses and in special cases, bins with special tags can be used to dispose the waste. The businesses have to pay each time the bins is emptied (art. 9 cpv. 2, Bellinzona, 2013). Special taxes on bulky waste are also levied (after

50kg, 4 CHF every additional 50kg; car batteries 10 CHF a piece; pneumatics from 3 to 8 CHF a piece).

	Type	Price (CHF)
Lump sum (in 2013)	Household	50 (exc. VAT)
	Business	250 (exc. VAT)
Pay-by-volume (in 2013)	10 bags 17 litres	9
	10 bags 35 litres	16
	10 bags 60 litres	28
	5 bags 110 litres	26
	Bins (for each emptying)	38
	Bins for organic	40 (year)
		1.20 (each emptying)

TABLE 33: TAXES ON MSW APPLIED IN BELLINZONA (SOURCE: BELLINZONA, 2013)

All the municipalities that surround Bellinzona apply a PBV scheme. Giubiasco was one of the first to introduce a PAYT scheme in Ticino in 1997; all other neighbouring municipalities (Arbedo-Castione, Gorduno and Monte-Carasso) introduced the scheme simultaneously with Bellinzona, in 2007.

Bellinzona produced, in 2011, a total of 8,859 tons of MSW. In this quantity, the waste collected within small businesses and in public garbage bins is also included. Public bins are emptied twice a day. The percentage of recyclable waste out of the total amount of MSW produced is 60% (Repubblica e Cantone Ticino, 2011). Bellinzona does not collaborate in any way with other municipalities for the collection or disposal of MSW, and the system is managed directly (i.e., it is not outsourced to private companies) (Baroni, 2013).

The MSW collection of Bellinzona is based on a three-level system. The residual waste is collected kerbside two days per week, on Tuesdays and Fridays. Paper and organic waste are also collected kerbside, but only two or three times a month. The second level is based on 5 ecopoints[55], in which only recyclable waste such as PET, glass, aluminium and batteries can be disposed. These and all the other recyclable and non-recyclable waste (including bulky, but excluding residual) can be disposed in the ecocentre Ex Birreria[56]. The ecocentre in Bellinzona is open 5 days a week[57] from 13:30 until 16:45 (except on Wednesday, when it is open from 08:00 until 11:30). In order to have access, there is no magnetic or specific card - as is the case in Lugano and Caslano - but an identity check is performed by a security guard (Baroni, 2013).

In Bellinzona, one collection location covers on average an area of 3.19 square kilometres and serves 2,895 households (including the ecocentre). To this, it must be added that an extra service for residuals, paper and organic is administered, kerbside. Therefore fewer collection centres are required.

Six vehicles - three big trucks, one medium-sized and two small (for collection of public garbage bins) - are used for the collection service within the city of Bellinzona. The costs of maintenance of these vehicles were, on average a year for the past five years, 122,400 CHF. The investment costs in new vehicles were on average 41,400 a year (past five years). These costs are not included within the total collection costs. While the maintenance costs are fairly high, the investment costs are low. The high maintenance costs are mainly due to the fact that the vehicles cover many kilometres in one year, and one of the trucks is 24 years old with no emission standard. This truck will be replaced at the end of this year, thus increasing the investment costs and probably lowering the maintenance costs (Baroni, 2013).

As is the case for all municipalities in Ticino, residual and bulky waste are disposed in the incinerator of Giubiasco, while recyclable waste is deposited to different private companies.

The five ecopoints and the ecocentres have been built and adapted specifically after the introduction of the PBV scheme. Nowadays, adjustments are made in order to achieve a more efficient and functional system that respects the will of the citizens (e.g., providing more containers for batteries). Also in Bellinzona, a

[55] Number 2, 5, 8, 10 and 11 in figure 17.
[56] Number 5 in figure 17.
[57] All days of the week except for Sunday and Monday.

calendar with the information on where and when to trash which type of waste is given for free to the entire population.

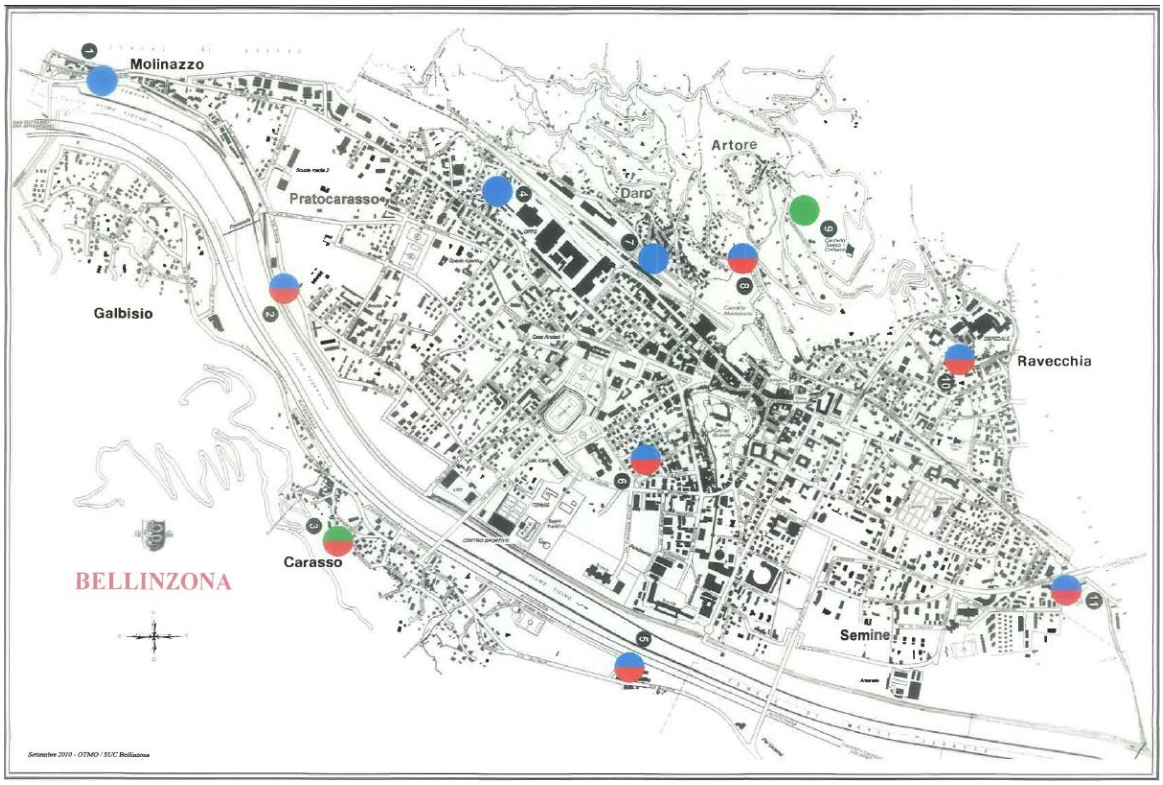


FIGURE 17: ECOCENTRE AND ECOPOINTS IN BELLINZONA (SOURCE: BARONI, 2013)

7.3 TOTAL COSTS AND BENEFITS

Collection and disposal costs

In 2011, the residual waste cost to Bellinzona was 1,199,194 CHF in total (602,355 CHF for collection and 596,839 CHF for disposal). Costs related to bulky waste are much lower: 104,000 CHF for collection and 156,605 CHF for disposal. It is possible to notice that while, for residual waste, the disposal costs are lower than the collection costs, for bulky waste the opposite is true and disposal costs are on average 50% higher than collection costs. Last but not least, total costs for recyclable materials collected and disposed in Bellinzona are 1,123,000 CHF. The high costs for recyclable waste are mainly due to the high quantities separated and disposed by the households.

Environmental costs

Environmental costs of collection: Detailed data regarding the exact fuel consumption of each truck was not available. Only the exact amount of kilometres travelled by each truck has been measured. Therefore, data from the other municipalities is used as proxy to calculate the average truck fuel consumption. The result obtained is a ratio of 70l/100km[58]. For the two smaller trucks (Renault Maxity and Mercedes Lastrato), an average fuel consumption of 13.5l/100km is used in order to calculate fuel consumption and emissions (Motostat, 2013).

[58] The stated kilometres and litres of the previous municipalities have been divided in order to obtain the average fuel consumption.

Vehicles[59]	Kilometres	Litres	Standard	NOx (kg)	PM (kg)	HC (kg)	CO (kg)
Mercedes 2528 (1989)	3,421	2,443.5	Euro 0	103.80	3.90	4	11
Man 18.310 - 10,518cc (2006)	7,981	5,701	Euro 3	102.60	1.70	4.60	13.70
Mercedes 2531 (1994)	8,110	5,792.85	Euro 1	173.80	2.30	4.90	29
Mercedes DRM - 4,249cc (2003)	12,906	9,218.5	Euro 3	165.90	2.80	7.40	22.10
Renault Maxity (2012)	13,371	1,805.1	Euro 5	12.60	0.20	0	2.20
Mercedes Lastro - 2,150cc (2000)	20,461	2,762.2	Euro 3	49.70	0.80	1.10	6.60
Total	66,250	27,723.15		608.40	11.70	22	84.60

TABLE 34: KILOMETERS TRAVELLED, LITRES CONSUMED AND EMISSIONS FROM MSW COLLECTION'S TRUCKS (SOURCES: BARONI, 2013; VOLVO TRUCKS, 2013 AND DE BRUYN ET AL, 2010)

By applying shadow prices to the emissions from the different vehicles, the total environmental costs related to MSW collection are estimated to be 8,200.50 CHF (composed of 7,867.80 CHF for NOx, 322.50 CHF for PM, 7.50 CHF for HC and 2.70 CHF for CO).

Environmental costs of disposal: In 2011, Bellinzona sent 3,250 tons of residual waste and 300 tons of bulky waste to the incinerator. With a total of 3,550 tons of waste burned, the environmental costs that can be attributed to Bellinzona are calculated as follows: 3,550 tons of waste burned produces 21,300,000 cubic meters of fumes and 223,650 litres of waste waters. If the relative shadow prices are applied (see tables 35 and 36) the total environmental costs of disposal are 17,389.20 CHF (17,348.30 CHF for emissions into air and 40.80 CHF into water).

AIR	mg/m3 emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
Particulates (PM)	0.01	0.26	25.26	6.51
Carbon (C)	0.05	1.07	2.84	3.02
Carbon Monoxide (CO)	13.39	285.21	0.03	8.48
Nitrous Oxides (NOx, NO2)	48.60	1035.18	11.85	12266.76
Sulphur Dioxide (SO2)	6.06	129.08	10.34	1334.76
Hydrogen Chloride (HCl)	0.25	5.33	4.82	25.66
Ammonia (NH3)	0.13	2.77	19.56	54.17
Hydrogen fluoride (HF)	0.09	1.92	48.13	92.26
Zinc (Zn) + Lead (Pb)	0.20	4.22	456.11	1923.59
Mercury (Hg)	0.0011	0.02	12297.05	288.12
Cadmium (Cd)	0.0013	0.03	141.98	3.93
Dioxins + Furans	0.22	4.69	286.19	1341.07
Total Air				17348.34

TABLE 35: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO AIR (BELLINZONA)

[59] Data 2012.

WATER	mg/l emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
DOC	2.20	0.49	0.00	0.00
Cadmium (Cd)	0.01	0.00	5.54	0.01
Chromium (Cr)	0.02	0.00	0.03	0.00
Mercury (Hg)	0.0001	0.00002	1070.96	0.02
Nickel (Ni)	0.02	0.00	3.77	0.02
Lead (Pb)	0.03	0.01	9.42	0.06
Copper (Cu)	0.02	0.00	0.00	0.00
Zinc (Zn)	0.10	0.02	1.80	0.04
Ammonia nitrogen (NH4-N)	5.80	1.30	31.08	40.31
Nitrous oxide (NO2-N)	0.15	0.03	11.85	0.40
Total Water				40.87

TABLE 36: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO WATER (BELLINZONA)

Illegal dumping

Illegal dumping is found to be important in Bellinzona and has increased since the introduction of the PBV scheme in 2007. MSW is illegally dumped in the five ecopoints, especially in the "Semine" neighbourhood, in which there is a high concentration of low income households, and in the area of Geretta Stadium. People also used to trash waste in special containers owned by restaurants and other big businesses. Both the households and Baroni (2013) stated that public garbage bins along the streets are always filled with domestic waste and that illegal dumping along the river Ticino has increased. The types of MSW that are more often illegally dumped are residuals in non-official bags, and bulky waste. The biggest problems are found where high-rise buildings and low income households are concentrated (Baroni, 2013). Fines of up to 200 CHF are given to households that dump non-official bags within the municipality (Baroni, 2013). This enforcement law is important in order to limit the extent of illegal dumping and incentivise the use of the official bags. During the past three years, the municipality of Bellinzona gave on average 40 fines a year for this reason. Moreover, Bellinzona had expenses for surveillance of the ecocentre and the five collection centres (cameras and security agents) of 34,930.70 CHF in 2011 (Baroni, 2013).

Taking into account what was stated above, it is assumed that in Bellinzona at least 2% of MSW is diverted to illegal dumping. Therefore, considering that the total production was 8,859 tons of MSW, the estimated amount of waste illegally dumped is 177.18 tons. This reflects into environmental costs of 867.90 CHF.

Waste tourism

The fact that Bellinzona is surrounded by municipalities with PBV schemes, and that it is the biggest city in the district, makes it very difficult for households to travel further away to trash their waste in other municipalities. This is especially true when we consider that the nearest municipality without a PAYT scheme is Locarno - 25 kilometres away. Dijkgraaf & Gradus (2003) assumed that the impact of municipalities more than 50 kilometres away is zero, and that the larger the distance, the smaller the impact of waste tourism. Therefore, it is possible to assume that the costs for a household to travel and dispose its residual waste in Locarno are higher than the extra costs paid for the bags. Moreover, it must also be considered that Bellinzona introduced the PBV scheme after or together with neighbouring municipalities, thus reducing the chances of having transferred MSW to other municipalities in the past. The prices applied are exactly the same (e.g., in Giubiasco, Sant. Antonino), or slightly higher (e.g., in Biasca, Camorino, Monte Carasso). Because of the fact

that differences in prices are very small[60] and different colours for the bags are used, it is assumed that outgoing waste tourism in Bellinzona is not relevant and equal to zero.

Though outgoing waste tourism is found to be irrelevant, it is not possible to say the same for ingoing waste tourism. As stated by Baroni (2013), households of other municipalities that do not have an ecocentre (e.g., Giubiasco) try to dispose their waste in the ecocentre in Bellinzona. In this case, some of the costs for collection and disposal as well as some benefits (if recyclable waste is brought) are transferred to Bellinzona. For this reason, a security agent is placed at the entrance of the ecocentre to check that the users are actually from Bellinzona. Therefore, part of the surveillance costs stated above is actually related to waste tourism.

Households' time and costs

Over three days, the opinions of 83 households were collected at the ecocentre of Bellinzona. The average household in Bellinzona has 2.8 people. 95% always separate their waste, while the remaining 5% do so often. 82% of the households in Bellinzona use separated bins for different recyclable waste. Surprisingly, 87% of households stated that the type of waste that is separated most often is plastic; second is paper, with 79%; and in third place is glass with 54%. 83% of households use only the ecocentre to dispose their separated waste, 11% use both the ecocentre and the ecopoints, 4% use the kerbside collection system for paper and organic waste and the ecocentre for other waste, and 2% use all three services. 70% of the households travel to the ecocentre to dispose their separated waste at least once every two weeks, of which 43% travels once a week. Therefore it is estimated that a household, on average, travels to the ecocentre to dispose its waste once every 13 days.

85% of the households recognised that the PBV scheme adopted by the municipality of Bellinzona is a good incentive for increasing separation, source reduction and lowering residual waste.

The average distance to the ecocentre for a household is calculated to be 7.90 kilometres - 16 minutes for a round trip. Results obtained from the household surveys are slightly lower; the average distance to the ecocentre was between 2.7 and 4.7 kilometres for a round trip and the time needed to travel and dispose waste is on average between 8 and 23.3 minutes each week. The high average results of the calculated measures are mainly due to the fact that the ecocentre is situated on one side of the city; households that live on the other side of the mountain must travel up to 15.2 kilometres (both ways) to reach the ecocentre, thus increasing significantly the average. It must also be considered that only a small percentage of the population lives in these areas - the majority of households live in the centre, less than 3.5 kilometres from the ecocentre.

The time spent to separate waste is estimated to be between 1.4 and 3.8 minutes. Therefore the total time dedicated to separation, travel and disposal is estimated between 2.2 and 6.13 minutes a day. Households in Bellinzona are willing to pay between 0.04 and 0.40 CHF to reduce the time spent for waste-related activities by 10 minutes.

WTP/Time	Min	Max
Min	2.97	8.48
Max	30.51	86.10

TABLE 37: COSTS FOR TIME SPENT IN SEPARATION, DELIVERY AND DISPOSAL (CHF IN ONE YEAR PER HOUSEHOLD)

Moreover, the costs for the delivery of waste itself must be taken into account - stated to be between 10.70 CHF and 205.20 CHF in one year.

Taking into account the time and costs for each household (7294 in total), the total social costs for waste-related activities are between 99,793 CHF and 2,124,962.50 CHF.

For what concerns the situation before and after the PBV scheme, the following can be said:

- The household perceived no change in the time spent on waste-related activities (51%), or even an increase (43%), primarily due to the fact that the kerbside collection has been partially removed and the increased separation. Only 6% of the households perceived a decrease in time spent to separate and transport recyclable waste after the introduction of the PBV scheme.

[60] 0.9 CHF in the case of Camorino.

- Only one household in 75 recognised an increase in the time needed to purchase the bags and other equipment, related to the introduction of the PBV scheme.
- The majority of Bellinzona's households (70%) considered the costs related to the PBV scheme to be normal and justified. For 15%, the costs were too high and for 8%, they were more than expected. These answers are usually related to the fact that, within the PBV scheme, the causal tax is combined with a lump sum tax.
- Almost one-third of the households (31%) stated that, since the introduction of PBV scheme, they produce the same amount of waste but pay less, as they separate more. On the contrary 25% think that they produce the same amount of waste but pay more. 24% are convinced that their expenses for waste-related activities did not change; nor did their quantities. 16% feel that they produce less waste but pay more (3%), the same (9%) or less (4%). Only 4% of the households believe that their quantities have increased, and that they either pay the same (1%) or more (3%). In this case producers are often blamed for using too much packaging.
- Lastly, the situation in general was investigated. Households believe that after the PBV scheme, the situation got better (57%). Streets are cleaner, more households separate more, and costs related to waste decreased. 23% stated that for them the situation did not change; also some things got worse (e.g., illegal dumping), and some got better (e.g., more separation). For 7% of the households, the situation actually became worse, because public garbage bins are always full, and trash bags are left along the road, next to the ecopoints or in the wood.

Distributive issues

There is no evidence of problems related to families with babies, the elderly or low-income in paying for the bags. During the interview, Baroni (2013) stated that no households complained about not being able to pay to dispose their waste, not even in cases of having many diapers. For this reason, the municipality does not adopt ad-hoc solutions or other types of incentives for families.

Waste-to-energy

With 3,550 tons of waste sent to the incinerator, Bellinzona was able to produce 2,769,000 Kw/h of electricity in 2011. Considering the selling price (0.20 CHF/Kwh) and the operating costs (153.50 CHF) the net profits from incineration of waste that can be attributed to Bellinzona are 8,875 CHF.

Profits from recyclables

Detailed data about the selling price and profits from recyclable waste was not available. Despite this, some data about quantities produced and sold were available from the census on waste, and the total profits of all recyclable waste were given during the interview with the municipality of Bellinzona (Baroni, 2013).

Material	Price (CHF/ton)	Quantity (ton)	Total Profit (CHF)
Paper	N.A.	1656	N.A.
Glass	N.A.	560	N.A.
Aluminium and Metals	N.A.	44	N.A.
Others	N.A.	N.A.	N.A.
Total			161,990.4

TABLE 48: PROFITS FROM RECYCLABLE MATERIALS IN BELLINZONA (DATA 2011) (SOURCE: BARONI, 2013)

Enhanced equity

From the households' questionnaires, the fact that the PBV enhanced the equity among households is found to be important. In fact, 51% of households recognised enhanced equity as an important factor, 15% more than important and 19% very important. Only 9% of the households believed that the fact that a PAYT scheme enhances equity is less than important[61].

[61] 6% did not know or did not answer the question.

Other costs

Bellinzona prints a leaflet with information for households on the collection and disposal system. This leaflet costs the municipality a total of 4032.32 CHF for design, print and delivery (Baroni, 2013).

Moreover, discounting must be calculated, whereby the investments that are strictly related to the introduction of the PBV scheme are considered. The ecocentre was built in 2002, before the introduction of the PBV scheme. After the new scheme was introduced, the amount of waste collected and number of users increased. Therefore a credit of 970,000 CHF has been requested to adapt the ecocentre according to the new needs (Bellinzona, 2011). Moreover, as already stated above, in correspondence with the introduction of the new scheme, three new ecopoints were built and old ones were adapted. This required an extra investment of 250,000 CHF. Lastly, in order to inform the citizens, fliers were distributed for 18,000 CHF (Bellinzona, 2006). Therefore the total investment that can be attributed to the introduction of the PBV scheme is 1,238,000 CHF. The 4% discount rate described in section 3.3 is applied in order to take into account the opportunity cost of investing in other projects or programs. The total amount to discount is therefore 49,520 CHF.

The following table summarizes all costs and benefits described previously, and presents the net result.

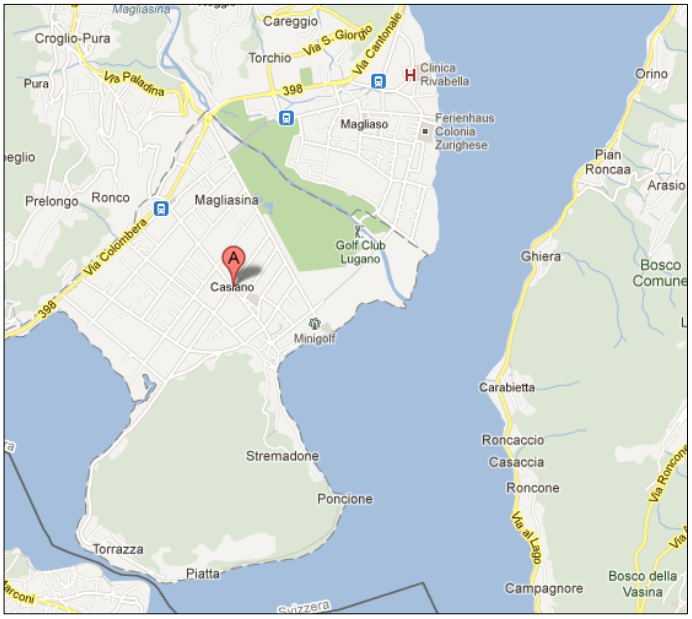
Costs	CHF/year	**Benefits**	CHF/year
Collection costs - residual	602,355	**Waste-to-energy (WTE)**	8,875
Collection costs - bulky	104,000	**Profits from recyclable materials**	161,990.40
Disposal costs – residual	596,839	**Enhanced equity in paying for the service (PM+)**	For 85% important or more
Disposal costs - bulky	156,605		
Collection and disposal - recyclables	1,123,000		
Environmental costs: • **From collection** • **From disposal**	• 8,200.50 • 17,389.20		
Illegal dumping and waste tourism	• 34,930.70 • 867.90		
Households' time and costs for recyclable delivery	99,793 - 2,124,962.50		
Distributive issues: families with babies, low-income and elderly (PM-)	No cases		
Discounting	49,520		
Other costs	4,032.3		
Total	2,797,532.60 - 4,822,702.10		170,865.40
Net result	2,626,667.20 - 4,651,836.70		

TABLE 39: OVERVIEW OF COSTS AND BENEFITS RELATED TO MSW MANAGEMENT IN BELLINZONA

CHAPTER 8 - ALTERNATIVE 2: CASLANO (PAY-BY-WEIGHT)

8.1 INTRODUCTION

Caslano is located in the southern area of canton Ticino on the banks of "lago Ceresio". It is part of Lugano district and, with a population of around 4,000, it is the 20th biggest municipality in Ticino.



Caslano is the smallest municipality considered in the research; its surface area is 2.84 square kilometres and it has a density of 1,404 people per square kilometres. Again, the demographic composition is very similar to the average. Male inhabitants constitute 47%, while women form 53% of the population. There are 1,103 foreign people, which represents 27.7% of the total population. The average age in the municipality is about 46. Data about the average income or average household size were not available.

The level of environmental awareness in Caslano is considered to be on a medium level and in the city council, 24% of the councillors are from social or green parties (Rossinelli and Sormani, 2013).

Economically speaking, Caslano cannot be compared to the other municipalities analysed and only 158 businesses, mainly small businesses from the tertiary sector (77.2%), operate in the area.

Variable	Caslano
Typology	Urban
Surface	2.84 km^2
Population	3,988
Population density	1,404.23 capita/km^2
Percentage (male - female)	47% - 53%
Percentage (Swiss - foreign)	72.3% - 27.7%
Unemployed (registered)	120 (3%)
Percentage pop.:	
- 0-19	- 21.9%
- 20-64	- 57.8%
- More than 65	- 20.3%
Households:	1,497
- 1 person	- 31.9%
- Couples without children	- 23.8%
- 1 parent families	- 8.1%
- Couples with children	- 33.5%
Others	- 2.5%
Type of building:	742
- Single household	- 66.3%
- Multiple households	- 33.7%
Houses Size:	2,170
- 1-2 rooms	- 26.6%
- 3-4 rooms	- 56.5%
- 5 or more rooms	- 16.9%
Businesses	158

TABLE 40: SUMMARY OF GEOGRAPHIC AND DEMOGRAPHIC VARIABLES FOR THE CITY OF CASLANO (DATA 2010) (SOURCE: USTAT, 2013)

8.2 INFRASTRUCTURE AND COLLECTION SYSTEM

Caslano is one of the only three municipalities in Ticino that introduced a PBW scheme (as well as Vernate and Camorino). The process of introducing such a scheme did not come without problems. In 2000, Caslano started considering the introduction of a PAYT scheme after several laws at a cantonal and federal level were introduced. In 2002, Caslano opted for a PBW scheme and not a PBV because of the control on the quantities in terms of weight that this scheme provides (Rossinelli & Sormani, 2013). In the same year, several studies that aimed to determine the costs for switching from the old scheme (lump sum) to a PBW scheme were carried out. The political will was also assessed. In 2003, the city council accepted the scheme. The municipality asked for a credit of 1,650,000 CHF in order to sustain the initial investment costs (building of ten ecopoints and one ecocentre). In autumn 2006, the first ecopoint was built in "Via Martelli" as a pilot test. The first magnetic cards were distributed and feedback collected. In 2007, the construction of the other nine ecopoints and the ecocentre began. In 2008, the scheme was officially functional. In the following years the costs of maintenance rose above the estimated budget - mainly because of technical problems related to the scaling system within the underground containers, and because a PBW scheme had never been introduced before and needed to be tested. In 2011, the costs were 2,459,345.85 CHF - 809,345.85 CHF more than estimated (Per Caslano, 2011; Rossinelli & Sormani, 2013). In the same year, a referendum was demanded by a group of politicians ("gruppo Lega UDC per Caslano") and signatures were collected in order to block the request of the municipality for extra money to invest in the PBW scheme. The referendum failed after the vote in November 2011.

Caslano nowadays combines a lump sum tax that changes according to the number of people in the household, and a casual tax depending on the number of kilos and material disposed. The quotes that need to be paid are summarised in the following table:

	Type	Price
Lump sum (in 2008)	Household of 1 person	51.65
	Household of 2 people	77.50
	Household of 4 people	103.30
Pay-by-weight (in 2011)	Residual	0.40 CHF/kg
	Organic	0.25 CHF/kg
	Wood	0.25 CHF/kg
	Bulky	0.45 CHF/kg
	Paper	Free
	Aluminium and other metals	Free
	PET	Free
	Glass	Free
	Others (textile, electronics, oils, etc.)	Free

TABLE 41: TAXES ON MSW APPLIED IN LOCARNO (SOURCE: ROSSINELLI & SORMANI, 2013)

Caslano does not provide the collection service to businesses, but they must organise themselves through private and certified companies in order to dispose their waste. As already stated above, the collection system in Caslano is based on ten ecopoints with the possibility of separated waste, and one ecocentre. In each of the ecopoints, it is possible to deposit residuals, PET and glass. In the ecocentre one can dispose recyclables, organics, wood, bulky waste and all other non-recyclable waste, but not residuals. The ecocentre is open 5 days a week[62] for two hours during winter time and for three hours during summer time. The access to the ecocentre and the underground containers in the ten ecopoints only works with the specific prepaid magnetic card, which can be obtained from the "Ufficio tecnico" and can be recharged with a specific machine near the post office (Rossinelli and Sormani, 2013).

[62] Monday afternoon, Tuesday morning, Wednesday evening, Friday afternoon and Saturday afternoon.

FIGURE 18: LOCATION OF THE DIFFERENT ECOPOINTS AND ECOCENTRE IN CASLANO

Compared to other municipalities, Caslano has a very high ratio of ecopoints per capita or per square kilometre: on average, one collection location for 365 households and one collection location per 258 m^2 (including the ecocentre). Despite this, it must also be taken into account that Caslano does not provide a kerbside collection system and therefore the high number of ecopoints is justified.

Mainly due to the small size of the municipality, the collection service is not performed by the municipality itself, but by a private company in both the ecocentre and the ecopoints (Agustoni Giovanni Ecologia[63]). These private companies are selected with public contracts, based on the best offer. The truck used is a three-year-old Volvo FM12 with three axes and a capacity of 18-20 cubic meters. It travels on average 3,000 kilometres a year and it respects the EURO 5 emissions standard[64]. Maintenance costs are not known and not included within costs of the municipalities. Caslano does not collaborate with other municipalities for the collection of MSW.

MSW is collected twice a week, on Mondays and Fridays. With the old system (non-PAYT) MSW was collected four times a week. Caslano produced 1,269 tons of MSW and its percentage of recycling materials collected is 55%.

Despite that there are no parallel programs for raising awareness about recycling, Caslano makes an extra effort in separating and recycling polystyrene and different types of plastics (Rossinelli and Sormani, 2013).

8.3 Total costs and benefits

Collection and disposal costs

Between 2007 and 2008, the years of introduction of the PBW scheme, the municipality of Caslano experienced a decrease in costs for MSW. The smaller reduction in costs was on recyclable waste (40.9% in respect to the previous year), while the highest reduction was 56.6% on residual waste.

In 2011, Caslano spent 45,677 CHF for the collection and 100,840 CHF for the disposal of residual waste. Therefore, the total costs of residual waste in Caslano were 146,517 CHF. Due to low quantities of bulky waste, these costs are the lowest if the absolute number is considered. In fact, Caslano in 2011 spent 6,048 and 10,336 CHF on the collection and disposal of bulky waste respectively. Last but not least, the total costs for collection and disposal of recyclable waste in 2011 accounted for a total of 61,194 CHF.

Environmental costs

Environmental costs of collection: As was the case of Bellinzona, data regarding the exact fuel consumption of the collection vehicle used was not available. Therefore here again, the average truck consumption of 70l/100km is used in order to calculate the amount of fuel used, and therefore the emissions.

[63] http://www.giovanniagustoniecologia.ch/ambiente/index.html.

[64] These data have been collected partially through the municipality and partially through the private company that provides the collection service for the municipality of Caslano (website: Agustoni Giovanni ecologia).

Vehicles[65]	Kilometres	Litres	Standard	NOx (kg)	PM (kg)	HC (kg)	CO (kg)
Volvo FM12	3,000	2,142	EURO 5	14.90	0.20	0	2.50

TABLE 42: KILOMETERS TRAVELLED, LITRES CONSUMED AND EMISSIONS FROM MSW COLLECTION'S TRUCKS (SOURCES: ROSSINELLI E SORMANI, 2013; VOLVO TRUCKS, 2013; DE BRUYN ET AL, 2010)

Caslano contributed to air pollution due to its MSW collection duty, and therefore had total costs of 159.06 CHF. These are respectively 158 CHF for NOx, 1 CHF for PMs, no costs for HC (since the emissions with EURO 5 trucks are zero), and 0.06 CHF for CO emissions.

Environmental costs of disposal: The total amount of non-recyclable waste produced in the municipality of Caslano and sent to the incinerator at Giubiasco was 577.5 tons in 2011. This was composed of 44 tons of bulky and 533.50 tons of residual waste. With such an amount of waste burned, Caslano is responsible for the production of 3,465,000 cubic meters of fumes and 36382.50 litres of treatment waters. The total environmental cost of disposal in 2011 was therefore 2,828.80 CHF (2822.16 CHF of damage into air and 6.65 CHF of damage into water). The following two tables describe in detail the quantity of each pollutant and the relative damage costs.

AIR	mg/m3 emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
Particulates (PM)	0.0121	0.0419	25.26	1.06
Carbon (C)	0.05	0.1733	2.84	0.49
Carbon Monoxide (CO)	13.39	46.3964	0.03	1.38
Nitrous Oxides (NOx, NO2)	48.6	168.3990	11.85	1,995.51
Sulphur Dioxide (SO2)	6.06	20.9979	10.34	217.13
Hydrogen Chloride (HCl)	0.25	0.8663	4.82	4.17
Ammonia (NH3)	0.13	0.4505	19.56	8.81
Hydrogen fluoride (HF)	0.09	0.3119	48.13	15.01
Zinc (Zn) + Lead (Pb)	0.198	0.6861	456.11	312.92
Mercury (Hg)	0.0011	0.0038	12,297.05	46.87
Cadmium (Cd)	0.0013	0.0045	141.98	0.64
Dioxins + Furans	0.22	0.7623	286.19	218.16
Total Air				2,822.16

TABLE 43: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO AIR (CASLANO)

WATER	mg/l emissions	Total emissions kg	Price in CHF/kg	Costs in CHF
DOC	2.20	0.080042	0.00	0.00
Cadmium (Cd)	0.01	0.000364	5.54	0.002017
Chromium (Cr)	0.02	0.000728	0.03	0.000023
Mercury (Hg)	0.0001	0.000004	1,070.96	0.003896
Nickel (Ni)	0.02	0.000728	3.77	0.002741
Lead (Pb)	0.03	0.001091	9.42	0.010286
Copper (Cu)	0.02	0.000728	0.00	0.000003
Zinc (Zn)	0.10	0.003638	1.80	0.006548
Ammonia nitrogen (NH4-N)	5.80	0.211019	31.08	6.558033
Nitrous oxide (NO2-N)	0.15	0.005530	11.85	0.065532
Total costs Water				6.65

TABLE 44: EMISSIONS AND DAMAGE COSTS FOR POLLUTANTS INTO WATER (CASLANO)

[65] Data 2012.

Illegal dumping

Caslano has problems of illegal dumping on a daily basis. Garbage is abandoned outside the underground containers every day, and sometimes found in woods or on unused land. Bulky waste, construction materials and organic waste are more often dumped in woods and free lands. This type of behaviour was present before the introduction of the new PBW scheme, and it did not become more frequent afterwards. Since the introduction of the new scheme, an ecocentre has been built where bulky and other non-recyclables can be disposed; thus the frequency of illegal dumping of these materials has diminished (Rossinelli and Sormani, 2013). Clean-up and surveillance costs are also not directly related to the introduction of the PBW scheme but are caused by the high number of tourists using the beaches in Caslano creating big quantities of waste in the parks, parking lots and other public areas. On the contrary though, the situation of abandoned garbage bags next to the ecopoint has worsened since the introduction of the PBW scheme. Households pretend to pass the magnetic card and then, with the excuse of malfunctions, just leave their bags outside the underground containers. Others are more ingenious and they tie a rope around the bag in order the keep it above the scale, so the weight and therefore the costs for disposal are zero (Rossinelli and Sormani, 2013). Caslano noticed an increase in these episodes after the introduction of the PBW scheme, mainly due to the fact that the new scheme increased the costs of disposal for households that are now more prone to illegal dumping acts. In order to reduce this, the municipality is evaluating the possibility of installing a system of video surveillance in the ecocentre and ten ecopoints. This project is not yet implemented but a plan has already been drawn up (Caslano, 2011). It is possible to assume that costs related to video surveillance will be around 42,500 CHF, estimated on the basis of costs stated by the municipality of Locarno for the installation of cameras (see section 6.3)[66]. This is the only extra economic cost since waste is illegally dumped in the ecopoint and therefore there are no extra collection or clean-up costs. Moreover, the bags that are abandoned in the ecopoints are often (but not always) checked and if references are found (e.g., headed mails), a fines procedure is started. Since the municipality has total control on each of the household thanks to the magnetic card that registers data about waste disposal, it is possible for them to know which households dropped their waste quantities rapidly, or to zero, and therefore are responsible for illegal dumping or waste tourism. Unfortunately this data was not available for the research due to privacy protection laws.

Considering the above, it is assumed that illegal dumping in Caslano has an impact equal to 1.5% of its total quantity of MSW. Therefore 190.35 tons of waste are illegally dumped at a total cost of 932.40 CHF.

Waste tourism

Caslano borders three municipalities: Magliaso, Ponte-Tresa and Croglio-Pura. Of these, only the last one has introduced a PAYT scheme (PBV) in 2009. This is also a rural municipality situated on the mountain above Caslano. As stated by Rossinelli & Sormani (2013), Magliaso and Ponte Tresa, during the years immediately following the introduction of the PBW scheme in Caslano, complained and sent official communications because of the significant quantities of MSW that were diverted to their municipalities from Caslano. Moreover Agno and Bioggio also very close[67] to Caslano and, without a PAYT scheme, they are also liable to inbound waste tourism. Last but not least, it must be also considered the fact that since many of Caslano's households work in Lugano, it is easy for them to bring their garbage and dispose it in Lugano for free (Rossinelli and Sormani, 2013).

Caslano is also considered one of the municipalities that applies the highest taxes on MSW, especially for residuals, bulky and organic. This has been expressed through protests and referendums from households and politicians in Calsano (e.g., Per Caslano, 2011).

Another possible indication of the presence of waste tourism in Caslano is given by the analysis of time series for different types of MSW. Figure 19 shows the evolution of the quantities per capita of residual, recyclable, organic and bulky waste. It is clear that, from when the PBW scheme was introduced in 2008, all

[66] Considering that the total expenses of Locarno for the installation for eight cameras within the ecopoints were 34,000 CHF, the relative expense (with same installations) for Caslano are 42,500 CHF for ten cameras.
[67] Less than 10 kilometres.

quantities of waste have significantly decreased, recyclables included. This is contrasting to what was expected and measured in Belllinzona. Moreover, if compared to Bellinzona (which decreased its quantities of residual waste over several years), Caslano had a steep drop of 50% in only one year and then stabilised at around 550,000 tons. This might be a signal of the fact that the PBW scheme did not actually increase separation, but pushed households to bring all sort of waste to neighbouring municipalities.

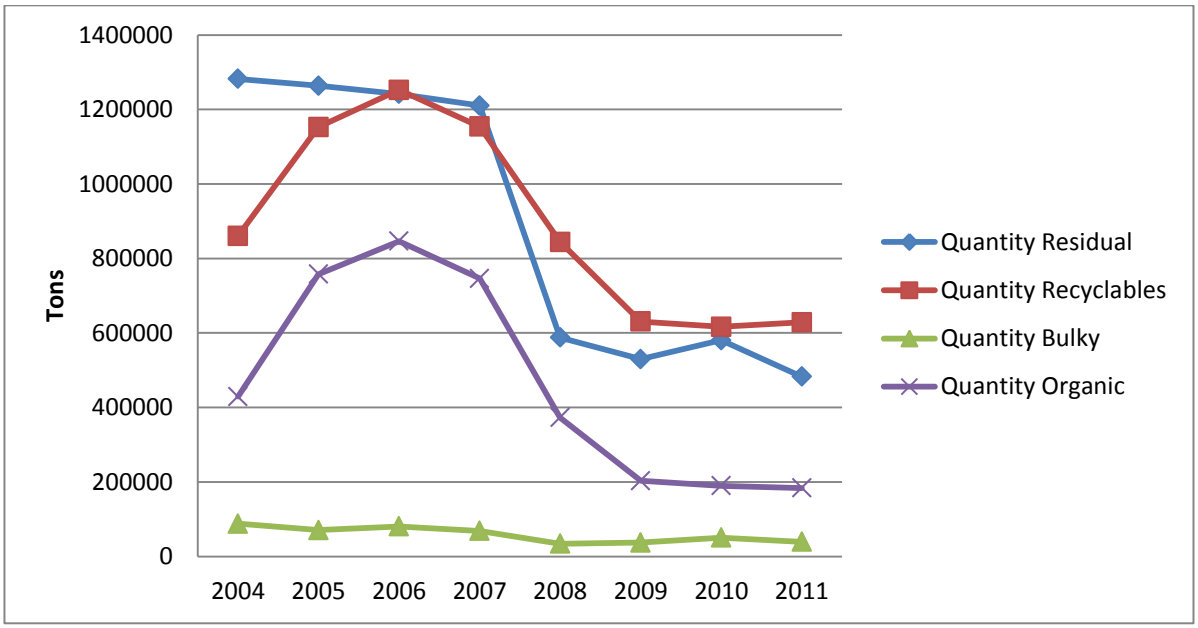


FIGURE 19: TIME SERIES OF QUANTITIES OF DIFFERENT TYPES OF MSW IN CASLANO

Therefore, because of the high difference in the neighbouring municipalities' schemes and prices, because of the disagreement among the population, and because of the parallel evolution in residual and recyclable waste, it is possible to assume that waste tourism in Caslano accounts for at least the 17% of the MSW reduction.

Taking into account that the highest reduction in MSW experienced in Caslano was in the same year of the introduction of the PBW scheme (2008, 970 tons), and the lowest reduction was 70 tons in 2011, the lowest and highest quantities of MSW diverted to waste tourism were 11.9 and 164.9 tons respectively. Therefore total costs[68] of between 2,626.20 CHF and 36,392.20 CHF are estimated.

Households' time and costs

As is the case for the previous municipalities, here data are taken from 51 households interviewed through a questionnaire in the ecocentre of Caslano.

On average, 2.4 people live in a household, 94% stated that they always separate their waste and 88% own separated bins within their houses. Not surprisingly, the material most separated is paper, followed by PET, glass and aluminium. In order to dispose their separated materials, 56% use only the ecocentre while 42% use both the ecocentre and the ecopoint for recyclable materials separated. 66% of the households travel at least once a week to dispose the waste that they separated. The average disposal frequency is around 2.7 times a month.

Each of the ten ecopoints is placed in order to have a maximum distance from the households of 200 meters (Rossinelli & Sormani, 2013). The average household's distance to and from the ecocentre is 2.5 kilometres, or 5.5 minutes. The stated distance and times are very similar. In fact, households need to travel on average between 1.3 kilometres and 2.2 kilometres in order to reach the place of disposal and to return home. The stated time needed to travel and dispose their waste is between 6 minutes and 16.5 minutes in one week (0.84 to 1.6 minutes a day). Households need on average between 0.8 and 3 minutes a day to separate

[68] Average cost per ton of 195.5 CHF.

their waste. Therefore the time needed to separate, travel and dispose waste at the ecocentre is between 1.64 and 4.6 minutes a day. Finally Caslano's households are willing to pay between 0.3 and 0.8 CHF in order to save ten minutes of the time currently allocated for waste-related activities.

WTP/Time	Min	Max
Min	17.20	57.20
Max	39	130.10

TABLE 45: COSTS FOR TIME SPENT IN SEPARATION, DELIVERY AND DISPOSAL (CHF IN ONE YEAR PER HOUSEHOLD)

Moreover the cost of delivery itself is measured to be between 34.50 CHF and 230.50 CHF in one year. Therefore the total annual costs relating to waste separation, delivery and disposal of the average household in Caslano is a minimum of 51.70 CHF and maximum of 360.60 CHF per household. Considering the 1,497 households in Caslano, the total costs are between 77,481.90 CHF and 540,078.90 CHF a year.

Households expressed also opinions about the situation before and after the PBW scheme:

- The majority of households consider the introduction of a PAYT scheme as a good incentive to separate and recycle more, the remainder are against the PBW scheme more than against a general PAYT scheme (i.e., they would be in favour of a PBV scheme).
- The introduction of PBW scheme has led to better conditions for 51% of the households, while for 25% it did not change, and for 16% the situation got worse. The fact that a good percentage perceived a worse situation after the introduction of the PBW scheme is due to the fact that the municipality experienced many technical problems with the functioning of the scale within the underground containers; often, trash was dumped outside the underground containers thus creating smell and a bad image for the households near the ecopoints.
- 39% of the households stated that, after the introduction of the PBW scheme, they produce the same quantities of MSW but they pay more, 21% produce less and pay less and 12% produce and spend the same amount as before. Other combinations are less common: 10% have the same waste and pay less, 10% produce less waste and pay more and 6% produce less waste and spend the same.
- 40% of the households believe that the time needed to transport the waste was lower before the introduction of PBW scheme, while 48% believe that it did not change. Only 12% think that the time needed to travel to the disposal place was higher before the scheme.
- Most of the households (86%) did not perceive an increase in time needed to dispose their waste (excluding travel, e.g., to charge the magnetic card).

Distributive issues

Caslano experienced problems related to families with babies or elderly people to a very limited extent. Only ten households, five with babies and five elderly people, complained of the problem of paying a lot for disposing large amounts of diapers (Rossinelli and Sormani, 2013). Moreover, when asking the households if they experienced problems in paying the tax, only 4% (two households of 51) answered positively. This confirms that social issues related to the PBW scheme are not widely spread across the households. The municipality took into account this issue but has not yet provided ad-hoc solutions and thus has no costs related to distributive or social issues.

Waste-to-energy

Considering that, as already stated above, the total amount of waste burned in the incinerator of Giubiasco was 577.5 tons and that one ton of waste produces 780kwh of electricity, the total amount of energy produced that can be attributed to Caslano is 450,450Kwh. This result is a total gross profit of 90,090 CHF. Considering the costs of 153.50 CHF a ton, the net profit of the electricity production attributed to Caslano is 1,443.75 CHF.

Profits from recyclable

As was for all the other municipalities, Caslano also perceived profits from selling recyclable materials, except for PET. Quantities, price applied and the total profits are summarised in the following table.

Material	Price (CHF/ton)	Quantity (ton)	Total Profit (CHF)
Paper	30	256	7,680
Glass	60	167	10,020
Aluminium and Metals	100	30	3,000
Others (Electronics)	(depending on item + 1,800 CHF/ton)	N.A.	1,479.72
Total			22,179.72

TABLE 46: PROFITS FROM RECYCLABLE WASTE IN CASLANO (SOURCE: ROSSINELLI & SORMANI, 2013)

Enhanced equity

Most households recognised the importance of having more equity in paying for service of collection and disposal when a PAYT scheme is introduced. In fact, 86% found this factor to be at least important, 17% believed that increased equity in paying for the service is very important. Only 10% recognised this to be less important, and none of them saw it as not at all important[69].

Other costs

In order to inform the population about when, where and at what price the different types of waste can be disposed, the municipality prints a calendar that is distributed to all households every year. The costs for designing and printing these calendars are around 10,000 CHF a year (Rossinelli and Sormani, 2013).

Moreover, a discount rate of 5% is applied on the total investment of 2,459,345.85 CHF (Caslano, 2011) in order to take into account the opportunity cost of investing in other projects or solutions. Therefore a total of 122,967.30 CHF is taken into account as discounting.

[69] 4% did not know or did not answer the question.

The following table summarises all costs and benefits described above, then presents the totals and the net result.

Costs	CHF /year	**Benefits**	CHF/year
Collection costs - residual	45,677	**Waste-to-energy (WTE)**	1,443.75
Collection costs - bulky	6,048	**Profits from recyclable materials** • **Paper** • **Glass** • **Metals & Aluminium** • **Others**	 • 7,680 • 10,020 • 3,000 • 1,479.72
Disposal costs - residual	100,840	**Enhanced equity in paying for the service (PM+)**	For 86% of the population at least important factor
Disposal costs - bulky	10,336		
Collection and disposal - recyclables	61,194		
Environmental costs: • **From collection** • **From disposal**	 • 159 • 2,828.80		
Illegal dumping and waste tourism	• 42,500 • 2,626.20 -36,392.20 • 932.40		
Households' time and costs for recyclable delivery	77,481.9 - 540,078.9		
Distributive issues: families with babies, low-income and elderly (PM-)	10 households (5 old and 5 large families with babies)		
Discounting	122,967.30		
Other costs	10,000		
Total	483,590.60 - 979,953.60		23,623.47
Net result	459,967.13 - 956,330.13		

TABLE 47: OVERVIEW OF COSTS AND BENEFITS RELATED TO MSW MANAGEMENT IN CASLANO

CHAPTER 9 - COMPARISON OF FINANCIAL INCENTIVE SCHEMES

After having assessed the total costs and benefits of each single municipality, it is now possible to compare them and determine which has the highest social efficiency. In order to do this, three steps have been taken. First, total costs and benefit have been standardised; since the municipalities have different population sizes, comparing total costs and benefits was not possible and a common denominator must be used. Therefore total costs and benefits have been translated into per capita costs and benefits, dividing them by the population of the municipality in 2011. Next, per capita costs and benefits have been multiplied by the population of Lugano (BAU scenario) to obtain a standardised and comparable measure of the total efficiency of the cases. The population of Lugano (55,151) is used since this case is chosen to isolate the net effects of the other three cases[71]. Moreover, by using Lugano (the city with the highest population in Ticino) we can obtain results that show the maximum potential effects in terms of social costs and benefits. Then, in order to identify the net effects, the costs and benefits of the BAU scenario (Lugano) are detracted by the costs and benefits in each single municipality. In this way it is possible to have measures of net costs and benefits that express only the efficiency effect given by doing something different rather than doing nothing. Lastly, the net costs and benefits of alternatives 1 and 2 are compared to those of the base case in order to identify the extra effects caused by the implementation of a PAYT scheme.

Costs (CHF/year)	Locarno (Base case)	Bellinzona (PBV)	Caslano (PBW)
Collection costs - residual	568,212.50	-237,581.75	-1,515,209.25
Collection costs - bulky	-362,761.30	-50,244.50	-295,623.60
Disposal costs - residual	-95,209	-1,649,941.75	-2,166,391.90
Disposal costs - bulky	115,319.60	203,979.60	-148,946.70
Collection and disposal - recyclables	2,519,431.15	2,352,037.40	-353,043.60
Environmental costs	55,791.6	-42,820.60	-82,975.35
Illegal dumping	122,527.70	111,694	584,816
Waste tourism[70]			
Min	-38'905.40	6,190.80	41,603.40
Max	-439'383.07	63,911.70	554,636.95
Households time and costs for recyclable delivery			
Min	-643,896.60	-1,099,942.60	-368,856.80
Max	-1,468,424.60	-2,262,927.95	-1,660,307.50
Discounting	0	155,670.20	1,658,134.40
Other costs	-23,960.7	-47,324.10	74,843.50
Distributive issues (PM-)	No cases	No Cases	10 households
Total			
Min	2,216,549.60	-298,283.25	-2,571,650
Max	991,543.90	-1,403,547.70	-3,350,067.10

TABLE 48: NET EFFECTS ON COSTS

Table 48 presents the net costs and benefits for the base case and the two alternatives.

As expected, both PAYT municipalities showed significantly lower costs for residual waste collection and disposal as a consequence of lower quantities. If compared to the base case, Bellinzona has extra savings of 1.4 million and Caslano of 3.2 million. This can be considered a valid result, taking into account that Rudin (2010) estimated savings for Lugano of around 2 million only related to reduced waste disposal, if a PAYT scheme is adopted. It is interesting to note that the base case has higher costs of collection if compared to the BAU. The kerbside collection service for RSU provided by Locarno could be the reason, and it may also explain the difference of only 237,581 CHF with the municipality of Bellinzona. Among the two PAYT schemes, the PBW seems to perform better in both collection and disposal.

Results about bulky waste are somehow ambiguous. Locarno has the lowest costs for collection and it performs better than the PBV system in disposal costs. The most efficient case for disposal costs of bulky waste is again Caslano.

[70] Bellinzona shows positive values for waste tourism even though its costs are zero (see section 7.3). This does not represent a cost for Bellinzona, but only its relationship with the BAU scenario (i.e., there are no deductions for ingoing waste tourism); in fact, the values correspond to the exact negative value counted for the BAU scenario. This has no negative influence on the results since, in the calculation of Bellinzona's total social costs, zero costs are counted (see Annex III).

[71] See Annex III for more information about the calculation of per capita and standardised total costs and benefits.

These results may suggest that the effect of a PAYT on collection and disposal costs of bulky waste is less important than the effect of technical, infrastructural and organisational conditions within the municipalities. Therefore it is assumed that a PAYT scheme has a limited influence on the efficiency related to bulky waste costs of a municipality.

Bellinzona, on the contrary, experienced high costs for recycling waste - only 167,393.7 CHF less than the base case and more than 2.5 million more than the PBW scheme. These higher costs are a logical consequence of the increased separation in waste and therefore increased quantities. As stated by Callan & Thomas (2001, p. 557), a *"…10% increase in recycled waste (or approximately 412 tons), should increase a town's annual recycling costs by 2.72%"*. It is interesting to note also that the effect of increased recycling costs in Bellinzona is higher than decreased in residual and bulky waste costs. This depends on the tax applied on residual waste. In fact, if the disposal tax did not decrease in 2010, the effect of cost reduction on residual waste would have been much higher[72]. The fact that Caslano and Bellinzona have the opposite results for recyclable waste can be explained by different quantities and by different collection systems: Bellinzona collects kerbside paper and organic waste between five and seven times a month, while Caslano relies on drop-off to the ecocentre. This naturally reflects in higher collection costs for recyclable waste in Bellinzona.

Bellinzona has the lowest costs for households' separation and disposal of recyclable waste. It saves up to 800,000 CHF a year, compared to the base case. If both maximum and minimum measures are considered, Caslano is in a similar situation as Locarno. These results are partially in contrast to the initial assumption made in section 3.6. Nevertheless, the fact that in Bellinzona and Locarno part of the recyclable waste is collected kerbside may explain the lower household costs. This seems plausible, since households do not have to travel to an ecocentre to dispose their recyclable waste. Therefore the fact that households in a PAYT municipality separate more does not necessarily mean that they will have higher costs[73]. In general, all three cases performed much better than the BAU on the variables households' time and costs. This is mainly due to the fact that Lugano had a much higher WTP for reducing the time spent on waste-related activities than the other cases, especially Bellinzona. This may be explained by different levels of environmental awareness.

In Caslano, the effect of waste tourism and illegal dumping was higher and this caused a steeper drop in the amounts of MSW. As a consequence Caslano has environmental and enforcement costs related to illegal dumping of around 460,000 CHF higher than the base case and the PBV. This is mainly due to high investments in surveillance to clamp down on illegal dumping within ecopoints. Bellinzona performs slightly better than the base case, with 11,000 CHF fewer costs. This result is explained by the fact that Locarno has higher enforcement costs for waste illegally dumped by other municipalities. Due to the exporting of important quantities of MSW, Caslano has higher costs of almost 1 million CHF. It is clear that the introduction of a PAYT scheme has the consequence of increasing waste tourism, more so than illegal dumping, but the negative effects may damage neighbouring municipalities rather than the municipality that introduced the PAYT scheme.

If compared to Locarno, PAYT municipalities have a significantly lower impact on the environment - between 98,600 CHF for the PBV and 138,766 CHF for the PBW. This is due to lower quantities of waste being sent to the incinerator. The fact that Bellinzona still operates with a very old truck may also have influenced the results negatively.

For the municipality of Caslano, the risk of investing money in a new technology is reflected as an extra cost of 1.6 million more than the base case Locarno, or 1.5 million more than the other alternative. A lower efficiency of Caslano is also found concerning other costs, such as costs for informing households.

The last variable is a PM-item and as such is assessed in a qualitative way. Locarno does not apply a causal tax and therefore has no distributive issues. Bellinzona performs as well as the minimum incentive,

[72] Around 1 million more difference in residual waste disposal costs and 64,000 CHF in bulky waste (see Annex III).

[73] Although households recognised the PAYT as a good incentive to separate more, many households in PAYT municipalities stated that they did not change their habits significantly, but that they already separated waste before the PAYT scheme. If this is true the effect of extra costs for households is very limited.

since it did not experience any type of social or distributive issues. Caslano on the contrary had complaints from the 0.7% of the households related to distributive issues. No solutions are as yet applied.

BENEFITS (CHF/year)	Locarno (Base case)	Bellinzona (PBV)	Caslano (PBW)
Waste-to-energy (WTE)	8,340.40	-20,945.70	-29,377
Profits from recyclables	90,406.50	240,818.10	30,667.15
Equity (PM+)	No equity	Preferred by the 85% (6200) households	Preferred by the 86% (1287) households
Total	98,746.90	219,872.40	1,290.20

TABLE 49: NET EFFECTS ON BENEFITS

Despite the fact that Caslano performed very well in cost reduction, the same cannot be said for benefits. In fact, Caslano is only 1,290 CHF more efficient than the BAU scenario and has 100,000 CHF fewer benefits than the base case. This is mainly due to the fact that the relatively low quantities of recyclable waste collected, which had previously explained the very low costs of collection and disposal of recyclable waste, gave also little profit margin. The municipality with the highest social efficiency within the benefits section is Bellinzona with 121,125.50 CHF more benefits than the base case. This is mainly thanks to the high profits perceived from the separation and recycling of materials. If compared to the costs, the total effect of the introduction of PAYT schemes measured on benefits is not very high. This is as expected; since PAYT municipalities have lower quantities disposed in the incinerator, they also have a lower contribution towards the energy produced. Moreover, the base case performed fairly well within the benefits section especially thanks to the combination of high production of electricity and good profits from recyclable waste.

An extra benefit comes from increased equity in paying for the service, which is revealed to be an important benefit for households in both PAYT municipalities. Bellinzona seems to place slightly more importance on this factor, since more households are included within the categories very important (+2%) and more than important (+5%)[74].

Net Result (CHF/year)	Locarno (Base case)	Bellinzona (PBV)	Caslano (PBW)
Min	2,117,802.7	-518,155.60	-2,572,940.20
Max	892,797.05	-1,623,420	-3,351,357.30

TABLE 50: NET EFFECTS ON RESULTS

In conclusion, taking into account both total costs and benefits, the municipality that showed the highest social efficiency in managing its MSW system is Caslano with the PBW scheme. This scheme has a potential saving of between 2.5 and 3.3 million compared to the BAU, and between 4 and 4.6 million compared to the base case. This result is partially because of more separation and source reduction caused by the introduction of the PAYT scheme, and partially because of the increase in illegal dumping and waste tourism. Also due to the good combination of the PAYT scheme and the collection system (no kerbside system; only a centralised drop-off), the municipality of Caslano saw a decrease in quantities of MSW and in costs of WMS. The decrease in costs of collection and disposal was actually greater than the extra costs provoked by illegal dumping and waste tourism, as well as the high risk investment that the municipality took to install and test a brand new system of weighing waste. Despite this, we must also consider that the costs related to illegal dumping and waste tourism are probably an underestimation of the real costs transferred to other municipalities. The fact that the PBW scheme is the most socially efficient is no surprise, since many studies have obtained the same result in respect to MSW reduction, when comparing different schemes (e.g., Dijgraaf and Gradus, 2003; Hogg et al, 2006b). Bellinzona is the second-best performing municipality in terms of social efficiency with savings of up to 2.5 million. This is thanks to the high profits from recyclable waste and low costs for collection and disposal of residual waste.

It is interesting to notice that the base case performs worse than the “do-nothing” case. However, this can be explained by the fact that the initial assumption of a lump sum as a minimum incentive is not confirmed. In fact, the effects on residual and recyclable waste are much smaller than in a PAYT municipality (MSW costs remain very high). Moreover, the extra effort made by Locarno in collecting kerbside reflects into very high costs for recyclables, without any benefit of large profits due to increased quantities.

[74] See Annex III.

CHAPTER 10 - CONCLUSIONS AND REFLECTIONS

10.1 GENERAL CONCLUSIONS

The effects that have been recognised within the different sources analysed are found to be largely truthful within the research. The biggest advantages of a PAYT scheme are not the direct benefits, but more the general reductions in costs. In fact, PAYT schemes have great potential for reducing MSW management costs within a municipality. The largest impact is found to be on quantities and costs of residual waste, which is either diverted to recycling and composting or reduced at source.

Waste tourism is found to be far more important than illegal dumping as an explanation for the reduction of MSW. This result goes against what is usually found in the literature (i.e., no influence of waste tourism)[75]. This may be due to the fact that, in Ticino, there is less homogeneity in the schemes adopted by municipalities than in previous studies. Moreover, the composition of neighbouring municipalities has a fundamental role in determining the level of waste tourism and therefore the social efficiency of a PAYT scheme.

The increase in quantities and costs for recyclable waste may be important, therefore it is important to consider the system of recyclable waste collection and disposal, and to evaluate the potential increase in costs (e.g., by eliminating kerbside collection and improving ecopoints and ecocentres).

Results about costs of bulky waste are ambiguous. They seem to depend more on technical and infrastructural conditions of the municipality itself than on the scheme adopted.

A PAYT scheme may increase time spent on separation of waste, but it is not necessarily true that households' costs for waste-related activities increase after the introduction of a PAYT scheme.

The extent to which low-income families or those with babies and the elderly experienced distributive issues is very low. On the contrary, the fact that a PAYT municipality applies taxes on waste in a fair and equitable way is well perceived by the population.

10.2 LIMITATIONS WITHIN THE APPROACH AND THE RESULTS

Giving monetary values for environmental and social goods and services is a practice that is often criticised. Not only is the general application of monetary value to non-monetary goods criticised, but also the different methods used to monetise these goods and services differ in perceived validity. Therefore each of the steps made within this research can be arguably made in a different and "better" way.

The long process undertaken to actually be able to assess costs and benefits with a CBA (i.e., PT, Impact Model, and IA) required much effort in both collecting and analysing data. Considering the limited time and resources available, it was not always possible to fully perform each stage[76]. Making the three methods coherent without losing track of the research objective was also very challenging. Moreover, the fact that a social perspective was chosen adds extra effort in terms of the time taken for measuring different effects and costs. In fact, in order to be able to measure economic, environmental and social costs and benefits, data needed to be collected from different stakeholders through both interviews and questionnaires.

When applying a CBA all data about costs and benefits must be complete and reliable. Due to the variety of data collected, it was not always possible to use direct measures; for that reason, some proxies have been used[77]. For example, there were no previous measurements or even reliable methods on how to estimate, monetise or measure illegal dumping and waste tourism, and the data collection was limited by the fact that different accounting systems were used within the different municipalities. The interview with Zulliger from the cantonal office of waste management helped to partially clarify the different accounting systems of the municipalities.

It is also acknowledged that the choice of a case study may result in lower external validity and generalisability, especially if compared to research with high numbers of observations.

[75] Allers & Hoeben (2010); Dijkgraaf & Gradus (2003).
[76] See for example Program Theory or limited variables assessed within the impact assessment.
[77] See trucks' emissions or enforcement costs in Caslano or operating costs of the incinerator.

Last but not least, due to the high complexity of the WMS of a municipality and the high number of endogenous and exogenous variables involved in the determination of quantities and costs of MSW, it was sometimes difficult to isolate the effects. Despite the fact that the most similar municipalities employing different schemes were selected, many important variables were different (e.g. the composition of neighbouring municipalities, population, number of households, the fact that costs of collection may depend a lot upon the geography, traffic situation, collection system adopted, the presence of businesses on the territory and the extent to which they use the public service). Despite methods to account for and reduce this influence, it is acknowledged that the results may be partially under- or overestimated within some variables.

10.3 Contribution to the existing literature

The majority of the scientific literature on waste deals with WMS or MSW in general, and only to a limited extent with financial incentive schemes for MSW reduction. Of these studies, not many applied a CBA and almost none assessed social efficiency; they were more focused on cost-effectiveness (see Dijkgraaf & Gradus, 2003; Ferrara & Missios, 2012). Thus the research offers a different lens to view financial incentive schemes for MSW reduction, and increases the knowledge base about CBA on this theme. This is especially important since, by focusing on a social perspective, the research may add information about the extent of indirect (not just direct) and external effects within different financial incentive schemes for MSW reduction. For example, it provides insights on the level of efficiency of both traditional general tax systems and PAYT systems (Bilitewsky, 2008). Considering Thogersen's (1994) research, it also provides specific empirical evidence on real (and not perceived) social costs and benefits of different "garbage fees"; for example the differences between "pay-by-weight" and "pay-by-volume".

Moreover, as stated by Allers & Hoeben (2010), previous studies about PAYT schemes can be divided into household-level studies and community-level studies. Each level has different advantages and disadvantages. This research brings the two levels together by considering both the community level, with interviews to the municipalities, and the household level, with surveys to the different households.

It is also important to notice that guidelines on how to perform a CBA exist, such as those provided by Eijgenraam et al. (2000) and the European Union (2008), but they are focused mainly on big infrastructural projects and less on social programs. Therefore, this research provides a practical example of the challenges and factors to consider when performing a SCBA for a social program (specifically here, a financial incentive scheme for MSW reduction).

In general, information about waste tourism is very scarce. The research presents a method that helps to account for the impact of waste tourism, thus contributing to present knowledge about the negative effect of PAYT schemes on neighbouring municipalities.

REFERENCES

Agence de l'Environnement et de la Maitrise de l'Energie (ADEME, 2011), *Enquête sur les prix de l'incinération des déchets municipaux.* Retrieved from:< http://www2.ademe.fr/servlet/getBin?name=5A7013F2A96D2B27CE58730B07BE967C_tomcatlocal1332323331442.pdf >. Used: 15.04.2013.

Allers, M. A. & Hoeben, C. (2010), Effects of unit-based garbage pricing: A differences-in-differences approach. *Environ Resource Econ 45*, pp. 405-428.

Asease, M., Yanful, E.K., Mensah, M., Stanford, J. & Amponsah, S. (2009), Comparison of municipal solid waste management systems in Canada and Ghana: A case study of the cities of London, Ontario, and Kumasi, Ghana. *Waste Management,* Volume 29, pp. 2779-2786.

Autorità regionale per la vigilanza dei servizi idrici e di gestione dei rifiuti urbani Regione Emilia Romagna (2004), *Relazione annuale sullo stato dei servizi idrici, di gestione dei rifiuti urbani e sull'attività svolta*. Retrieved from:< http://www.astrid-online.it/Riforma-de2/L-OSSERVAT/Regolatori/RegioneER_2003_idrici.pdf>. Used: 15.04.2013.

Azienda Cantonale dei Rifiuti (ACR) (2012), *Rapporto Ambientale 2011*. Retrieved from: <http://www.aziendarifiuti.ch/pagina.asp?pagina=1100>. Used: 01.02.2013.

Azienda Cantonale dei Rifiuti (ACR) (2013), Interview to Bergomi Tatiana. 05.03.2013.

Baggio, C. & Zulliger, D. (2005), *Analisi dei dati del censimento rifiuti 2004.* Ufficio della gestione dei rifiuti, Dipartimento del territorio.

Baroni, A. (2013), Interview Capo Sezione of the Servizio Manutenzione, Dicastero Opere Pubbliche e Ambiente Bellinzona .Bellinzona, 21.02.2013.

Bartoli, M. (2009), *Iniziativa parlamentare per l'introduzione della tassa sul sacco cantonale*. Retrieved from:<http://www.ti.ch/CAN/SegGC/comunicazioni/GC/inizelaborate/pdf/IE309.pdf>. Used: 09.05.2013.

Batllevell, M. & Hanf, K.(2008), The fairness of PAYT systems: Some guidelines for decision-makers. *Waste Management,* Volume 28, Issue 12, pp. 2793-2800.

Bellinzona (2006), Relazione di maggioranza della commissione dell'edilizia sul messaggio municipale no. 2913. Retrieved from:< https://www.google.ch/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CD0QFjAA&url=http%3A%2F%2Fwww.bellinzona.ch%2Fdowndoc.php%3Fid_doc%3D691%26lng%3D1%26rif%3D661badbfcf&ei=L1OnUeob7bTtBomjgPgE&usg=AFQjCNG85tAmhfkkbtyJB1cBiEP8QUs0uw&bvm=bv.47244034,d.ZGU>. Used: 20.05.2013.

Bellinzona (2012), Osservazioni del municipio sulla mozione no. 278 di Luca Buzzi e Nadia Solari relativa alla gestione rifiuti ingombranti. Retrieved from:<http://www.bellinzona.ch/downdoc.php?downdoc=9279&rif=522d3ea25a>. Used: 16.06.2013.

Bellinzona (2011), Messaggio Municipale numero 3633. Retrieved from:< https://www.google.ch/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCwQFjAA&url=http%3A%2F%2Fwww.bellinzona.ch%2Fdowndoc.php%3Fdowndoc%3D8822%26rif%3D996bf8d773&ei=hlOnUZ2WAq6Q7Abp7YCYBw&usg=AFQjCNHIZTLRWkwWx5TaD2MSMNxkDFS6_A&bvm=bv.47244034,d.ZGU>. Used: 29.05.2013.

Bellinzona (2013), Regolamento per la raccolta e smaltimento dei rifiuti. Retrieved from: < http://www.bellinzona.ch/downdoc.php?id_doc=9273&lng=1&rif=1319b63cf8>. Used: 29.05.2013.

Beychok, M.R. (1987), A data base for dioxin and furan emissions from refuse incinerators. *Atmospheric Environment* 21 (1), pp. 29–36.

Bischof, R., Chardonnens, M. & Huegi. M. (2003), *La taxe au sac, vue par la population et les communes.* Office fédéral de l'environnement, des forêts et du paysage (OFEFP). Retrieved from :< http://www.bafu.admin.ch/publikationen/publikation/00521/index.html?lang=fr&download=NHzLpZig7t,lnp6I0NTU042l2Z6ln1ae2IZn4Z2qZpnO2Yuq2Z6gpJCGdn5,gWym162dpYbUzd,Gpd6emK2Oz9aGodetmqaN19XI2IdvoaCVZ,s-.pdf >. Used: 04.05.2013.

Bilitewski, B. (2003), *PROJECT "PAYT": Variable Rate Pricing based on Pay-As-You-Throw as a Tool of Urban Waste Management.* Fakultät für Forst-, Geo- und Hydrowissenschaften, Institut für Abfallwirtschaft und Altlasten, TECHNISCHE UNIVERSITÄT DRESDEN.

Bilitewski, B. (2008), From traditional to modern fee systems. *Waste management*, Volume: 28, Issue: 12, pp. 2760-2766.

Bruyn de, S., Korteland, M., Markowska, A., Davidson, M., Jong de, F., Bles, M. & Sevester, M. (2010), *Shadow Prices Handbook, Valuation and weighting of emissions and environmental impacts*. Delft. Retrieved from: < http://www.cedelft.eu/?go=home.downloadPub&id=1032&file=7788_defMainReportMaKMV_1271765427.pdf&PHPSESSID=dad8b505d4d9bbb9b52358c639accbe8>. Used: 02.02.2013.

Bucciol, A., Montinari, N. & Piovesan, M. (2011), Do not trash the incentive! Monetary Incentives and Waste sorting. Working Paper 11-093. Retrieved from:< http://www.hbs.edu/faculty/Publication%20Files/11-093.pdf>. Used: 06.06.2013.

Callan, S. J. & Thomas, J. M. (2001), Economies of scale and scope: A cost analysis of Municipal Solid Waste services. *Land Economics,* Volume: 77, No: 4, pp. 548-560.

Campo, M. (2004), L'occhio elettronico ti scruta. Retrieved from:<http://switzerland.indymedia.org/it/2004/10/26815.shtml>. Used: 23.05.2013.

Carr, D.J., Gotlieb, R.M., Lee, N.J. & Shah, D.V. (2012), Examining Overconsumption, Competitive Consumption, and Conscious Consumption from 1994 to 2004 : Disentangling Cohort and Period Effects, *The ANNALS of the American Academy of Political and Social Science* 644: 220.

Carroll County Times (Bruce Holstein, 2011), *Bruce Holstein: Incinerator project too costly*. Retrieved from:< http://www.carrollcountytimes.com/columnists/opinion/other_voices/bruce-holstein-incinerator-project-too-costly/article_078a2205-c29e-524e-8a09-775b14b3d693.html?mode=story>. Used: 15.04.2013.

Caslano (2011), Messaggio municipal n. 1004. Retrieved from:< https://www.google.ch/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&ved=0CEQQFjAD&url=http%3A%2F%2Fwww.caslano.ch%2Fdowndoc.php%3Fid_doc%3D183%26lng%3D1%26rif%3D884daef968&ei=cmenUcjQLdGf7AbynYGoCQ&usg=AFQjCNFbAA5XnB1E4acV1CDbyk0kAI0TuA&bvm=bv.47244034,d.ZGU>. Used: 29.05.2013.

Chang, M.B., Jen, C.H., Wu, H.T. & Lin H.Y. (2003), Investigation on the emission factors and removal efficiencies of heavy metals from MSW incinerators in Taiwan. *Waste Management & Research* 21, pp. 218–224.

Chen, T-C. & Lin, C-F. (2010), CO2 Emission from municipal solid waste incinerator: IPCC formula and flue gas measurement*. J. Environ. Eng. Manage.,* 20(1), pp. 9-17.

Confederazione Svizzera (2010), RS 814.01 - *Legge Federale sulla protezione dell'ambiente (LPAmb).* Retrieved from:< http://www.admin.ch/ch/i/rs/c814_01.html>. Used: 04.04.2013.

Dahlen, L. & Lagerkvist, A. (2010), Pay as you throw: Strengths and weaknesses of weight-based billing in household waste collection systems in Sweden. *Waste Management* 30, pp. 23–31.

De Jaeger, S. & Eyckmans, J. (2009), Do households export their recyclable waste ?. Hogeschool Universitei Brussel; Centre for Economics & Management (CEM) and Katholieke Universiteit Leuven (KULeuven); Faculty of Business and Economics. Retrieved from:< http://www.webmeets.com/files/papers/WCERE/2010/1032/waste_export2.pdf>. Used: 14.06.2013.

Department Environment, Food and Rural Affairs (DEFRA) (2007), Economies of Scale – Waste Management. Optimization Study by AEA Technology. Final Report. Retrieved from:< http://archive.defra.gov.uk/environment/waste/localauth/partnerwork/documents/economies-scale.pdf>. Used: 05.06.2013.

Dicastero Opere Pubbliche e Ambiente Bellinzona (2013), *Tasse e costi*. Retrieved from: < http://www.bellinzona.ch/index.php?node=278&lng=1&rif=9f154b0e8d>. Used: 07.05.2013.

Di Gianfrancesco L. (Ing.) (2013a), Preliminary Interview Capo Sezione of Dicastero Servizi Urbani Lugano. Lugano 01.02.2013.

Di Gianfrancesco, L. (Ing.) (2013b), Interview Capo Sezione of Dicastero Servizi Urbani Lugano. Lugano, 25.03.2013.

Dijkgraaf, E. & Gradus, R.H.J.M. (2003), Cost savings in unit-based pricing of household waste. The case of the Netherlands. *Resource and Energy Economics* 26, pp. 353-371.

Dijkgraaf, E. & Vollebergh, H.R.J. (2003), *Burn or Bury? A social cost comparison of final waste disposal methods*. Nota di lavoro 46.2003. Sustainability Indicators and Environmental Valuation (SIEV). Erasmus University Rotterdam and OCFEB, Rotterdam.

Dipartimento Federale dell'Economia (DFE) (2010), *Le tasse dei rifiuti in Ticino. L'impatto del nuovo impianto di termovalorizzazione di Giubiasco sulle tariffe per lo smaltimento dei rifiuti per il 2010*. Sorveglianza dei prezzi (SPR). Retrieved from: <http://www.preisueberwacher.admin.ch>. Used: 09.05.2013.

Dipartimento Federale dell'Ambiente, dei Trasporti dell'Energia e delle Comunicazioni (DATEC) (2013), *Prices for electricity in 2012*. Retrieved from:< http://www.uvek.admin.ch/dokumentation/00474/00492/index.html?lang=it&msg-id=40988>. Used: 22.04.2013.

Dipartimento del Territorio Bellinzona (DTB), Divisione dell'ambiente (2013), *Piano di gestione dei rifiuti*. Retrieved from:< http://www4.ti.ch/dt/da/spaas/ugr/temi/gestione-rifiuti/gestione-rifiuti/piano-di-gestione-dei-rifiuti-pgr/>. Used. 08.05.2013.

Dubin, J. A. & P. Navarro (1988), How Markets for Impure Public Goods Organize: The Case of Household Refuse Collection. *Journal of Law, Economics, and Organization,* 4 (2), pp. 217-241.

Durham Environmental Watch (Gasser, L., 2011), *Durham-York Incinerator Project Costs Overview.* Retrieved from:<http://www.durhamenvironmentwatch.org/iPresentations/LG-FINAL%20%20Info%20Session%20-March%2023%202011_white_slides.pdf>. Used: 15.04.2013.

Economist's View (2008), *Trash Talk: Pay-As-You-Throw Systems* <http://economistsview.typepad.com/economistsview/2008/07/trash-talk.html> . Used: 25.11.2012.

Eijgenraam, C. J. J., Koopmans, C. C., Tang, P. J. G. & Verster, A. C. P. (2000), Evaluation of infrastructural projects; guide for cost-benefit analysis. The Hague/Rotterdam: CPB Netherlands Bureau for Economic Policy Analysis/Netherlands. *Economic Institute*. Vol. 10, Issue 2, pp. 19-58.

Environmental Protection Agency (EPA) (1994), Pay-as-you-throw lesson learned about unit pricing. Retireved from:< http://www.epa.gov/osw/conserve/tools/payt/pdf/payasyou.pdf>. Used: 11.05.2013.

European Union: Regional Policy (2008), guide to cost benefit analysis of investments projects. Retreived from:<http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf>. Used: 05.05.2013.

Federal Chancellery (2013), *The Swiss Confederation a brief guide.* Retrieved from: <http://www.bk.admin.ch/dokumentation/02070/index.html?lang=en>. Used: 10.04.2013.

Ferrara, I. (2008), Waste Generation and Recycling. *OECD Journal*: General papers.

Ferrara, I. & Missios, P. (2012), A cross-country study of household waste prevention and recycling: assessing the effectiveness of policy instruments. *Land Economics, Volume 88, number 4, pp. 710-744.*

Fullerton, D. & Kinnaman, T.C., (1996), Household responses to pricing garbage by the bag. *American Economic*. Review 86, pp.971–984.

Hallas-Burt, S. & Halstead, J.M. (2004), Pay-as-you-throw trash pricing. *New Hampshire Outlook*. BioCycle.

Harry Clarke (2006), Municipal waste – I just love it. Commentary on economics, politics & other things. Retrieved from:< http://kalimna.blogspot.ch/2006/05/municipal-waste-i-just-love-it.html>. Used: 11.06.2013

Hogg, D. for Eunomia Research & Consulting Ltd (2002), *Financing and Incentive Schemes for Municipal Waste Management. Case Studies. Final Report to Directorate General Environment, European Commission*. Retrieved from: <http://ec.europa.eu/environment/waste/studies/pdf/financingmuncipalwaste_management.pdf> Used: 09.01.2013.

Hogg, D. (2006a), *Working Group on Waste Prevention and Recycling. Impacts of Unit-based Waste Collection Charges*. Organisation for Economic Co-operation and Development. Environmental Policy Committee. ENV/EPOC/WGEPR(2005)10/FINAL. Retrieved from:< http://search.oecd.org/officialdocuments/displaydocumentpdf/?doclanguage=en&cote=env/epoc/wgwpr(2005)10/final>. Used: 09.05.2013.

Hogg, D., Wilson, D., Gibbs, A., Astley, M. & Papineschi, J. (2006b), *Modelling the impact of household charging for waste in England*. Department for Environment Food and Rural Affairs (defra). Eunemia Research and Consulting ltd. Retrieved from: <http://archive.defra.gov.uk/environment/waste/strategy/incentives/documents/wasteincentives-research-0507.pdf> . Used: 10.01.2013.

Huang, J., Halstead, J.M. & Saunders, S.B. (2011), Managing Municipal Solid Waste with unit-based pricing: Policy effects and responsiveness to pricing. *Land Economics* 87, pp. 645-660.

Intergovernmental Panel on Climate Change (IPCC) (2000), *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. 5.3* Emissions from waste incineration. Retrieved from: < http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_3_Waste_Incineration.pdf> Used: 25.01.2013.

Jaeger de, S. & Eyckmans, J. (2012), Do households export their recyclable waste?. HUB Research papers 2012/21. Economics & Management. Retrieved from:< https://lirias.hubrussel.be/bitstream/123456789/6203/1/12HRP21.pdf>. Used: 10.06.2013

Kinnaman, T.C. (2006), Policy watch: examining the justification for residential recycling. Journal of Economic Perspectives, Volume 20, pp. 219–232.

Laerhoven van, F. (2012), lecture 2: Establishing causal claims in social science. Governance for Sustainable Development: Advanced Methods (GEO4-2305). Room 11.22, Utrecht University, 27.04 2013.

Lave, C. A., & March, J. G. (1975), An introduction to models in the social sciences. *New York: Harper & Row*.

Le courrier des maires (1998). Retrieved from:<http://www.bouesducon.org/incineration1.htm>. Used: 15.04.2013.

Lega dei Ticinesi (2013), Aboliamo le tasse sul sacco. Retrieved from:< http://www.legaticinesi.ch/index.php?option=com_content&task=view&id=1234>. Used: 16.05.2013.

Linderhof, V., Kooreman, P., Allers, M. & Wiersma, D. (2001), Weight-based pricing in the collection of household waste: the Oostzaan case. Resource and Energy Economics 23, pp. 359 – 371.

Lugano.ch (2013), Aggregazioni Comunali. Retrieved from:< http://www.lugano.ch/aggregazioni/>. Used: 10.05.2013.

Motostat (2013), Fuel Consumption – Renault Maxity. Retrieved from:< http://www.motostat.eu/vehicle-stats/38807>. Used: 22.05.2013.

NEEDS (2007), *Value transfer techniques and expected uncertainties*. Retrieved from: <http://www.google.ch/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CDIQFjAA&url=http%3A%2F%2Fwww.needs-project.org%2Fdocs%2FNeeds_Rs3a_D2.1.doc&ei=VQUNUaWSJs_Wsgb444Fo&usg=AFQjCNG9swuJQVkGSHRTWf05taNDyb_Axg&bvm=bv.41867550,d.Yms>. Used: 02.02.2013.

Nylund, N. & Erkkila, K. (2005), *Heavy-duty truck emissions and fuel consumption. Simulating real-world driving laboratory conditions.* VTT Technical Research Centre of Finland. 2005 DEER Conference Aug 21 – 25, Chicago, Illinois, USA. Retrieved from:<http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2005/session5/2005_deer_erkkila.pdf>. Used: 22.03.2013.

OKKIO - Osservatorio per la gestione ecosostenibile dei rifiuti (2011), *Comunicato stampa nr. 25*. <http://www.okkio.ch/index.php?option=com_docman&task=doc_download&gid=108&Itemid=79> Used: 11.09.2012.

OKKIO - Osservatorio per la gestione ecosostenibile dei rifiuti (2013), *Mappa delle tasse causali*. <http://www.okkio.ch/images/okkio%20oro%20nero/OKKIO%20-%20Mappa%20tassa%20causale%20Ticino%202013.pdf> Used: 11.06.2013.

Patti Chiari (2012), "*Con le mani nel sacco*", 17 February 2012. Retrieved from:< http://www.rsi.ch/pattichiari/node/2743?page=2>. Used: 07.05.2013.

Pembina Institute (2007), *Incineration of Municipal Solid Waste, Understanding the Costs and Financial Risks.* Fact Sheet 4. Retrieved from:<http://www.pembina.org/pub/1448>. Used: 15.04.2013.

Per Caslano (2011), *Domanda di Referndum*. Retrieved from:< http://www.percaslano.ch/Documents/REFERENDUM%20COMUNALE.pdf>. Used: 25.04.2013.

Pires, A., Martinho, G. & Chang, N.B. (2011), Solid waste management in European countries: A review of systems analysis techniques. *Journal of environmental management*, Volume: 92, Issue: 4, pp. 1033-1050.

Price, J.L. (2001), The landfill directive and the challenge ahead: demands and pressures on the UK householder. *Resources, Conservation and Recycling* 32, pp. 333–348.

Puig-ventosa, I. (2008), Charging systems and PAYT experiences for waste management in Spain. *Waste Management* 28, pp. 2767–2771.

Rapporto Mozione Stojanovic No. 3442, (2010). Consiglio Comunale Lugano, 20 maggio, 2010. Retrieved from:< http://www.lugano.ch//Cc/mozioni.ns4/(www-rapporti-id)/6F3623C12D2E6B68C125772F002458FD/$FILE/RapportoMozione_%203442_Petizioni.pdf>. Used 15.04.2013.

Reichenbach, J. (2008), Status and prospects of pay-as-you-throw in Europe – A review of pilot research and implementation studies. *Waste Management* 28, pp. 2809–2814.

Reppublica e Cantone Ticino (2004), 9.2.1.1 - *Legge cantonale di applicazione della legge federale sulla protezione dell'ambiente (LALPAmb)*. Retrieved from:< http://www.lexfind.ch/dta/14521/4/09_21.htm>. Used: 05.05.2013.

Reppublica e Cantone Ticino (2005), 9.2.1.1.1 - *Regolamento generale della legge cantonale di applicazione della legge federale sulla protezione dell'ambiente (RLaLPAmb)*. Retrieved from:< http://www.lexfind.ch/dtah/73248/4/09_22.htm>. Used: 05.05.2013.

Repubblica e Cantone Ticino (2011), *Censimento Rifiuti 2011*. Retrieved from: <http://www4.ti.ch/dt/da/spaas/ugr/temi/gestione-rifiuti/gestione-rifiuti/censimento-rifiuti/>. Used: 01.02.2013.

Repubblica e Cantone Ticino (2013), Informazioni Generali. Retrieved from: < http://www3.ti.ch/index.php>. Used: 22.03.2013.

Rogge, N. & De Jaeger, S. (2012), Measuring and explaining the cost efficiency of municipal solid waste collection and processing service. *Omega* 41, pp. 653 – 664.

Rolph Schneider, D., Lončar, D. & Bogdan, Ž. (2010), *Cost Analysis of Waste-to-Energy Plant*. Retrieved from:< http://hrcak.srce.hr/file/96613>. Used: 15.04.2013.

Rossi, P.H., M.W. Lipsey & H.E. Freeman (2004), *Evaluation, a systematic approach* (7th ed.), Thousand Oaks: Sage.

Rossinelli, R. (Arch.) & Sormani, C. (2013), Interview Ufficio Tecnico Comunale (UTC) Caslano. Caslano, 20.02.2013.

Rudin, M. (2010), *Proposta per i rifiuti a Lugano: Una soluzione "salva ul bursin e l'ambient dal nos tisin"*. Osservatorio per la gestione ecosostenibile dei rifiuti (Okkio). Retrieved from:< http://www.ticinolibero.ch/wp-content/uploads/2010/11/OKKIO-Proposta-x-RSU-a-Lugano-v0.3.pdf>. Used: 09.05.2013.

Runhaar, H. (2011), lecture 4: cost benefit analysis. SUSD-Policy Analysis (GEO4-2306). Utrecht University, 19.12.2011.

Sakai, S., Ikematsu, T., Hirai, Y. & Yoshida, H. (2008), Unit-charging programs for municipal solid waste in Japan. *Waste Management* 28, pp. 2815–2825.

Šauer, P., Parizkova, L. & Hadrabova, A. (2008), Charging systems for municipal solid waste: Experience from the Czech Republic. *Waste Management* 28, pp. 2772-2777.

Skumatz, L.A. (2002), Variable-rate or "Pay-as-you-throw" Waste management: answers to frequently asked questions. *Policy Study* No. 295. Reason Foundation.

Skumatz, L.A. (2008), Pay as you throw in the US: Implementation, impacts, and experience. *Waste Management* 28, pp. 2778-2785.

Stevens, B. J. (1978), Scale, Market Structure, and the Cost of Refuse Collection. *The Review of Economics and Statistics* 60, pp. 438-448.

Swissinfo (2013a), <http://www.swissinfo.ch/ita/economia/Caccia_al_tesoro_nellimmondizia.html?cid=32795636>. Used: 02.05.2013.

Swissinfo, (2013b) <http://www.swissinfo.ch/ita//Speciali/Il_segreto_bancario_nella_tempesta/Attualita/La_piazza_finanziaria_ticinese_pronta_a_reagire.html?cid=1072262>. Used: 02.05.2013.

Taylor, D.C. (2000), Policy incentives to minimize generation of municipal solid waste. *Waste Management & Research* 18, pp. 406-419.

Themelis, N. J. (2003), An overview of the global waste-to-energy industry. *Waste Management World*, pp. 40–47.

Ticino Libero (2012), Okkio si scaglia contro la Lega, "un vero e proprio insulto". Retrieved from:<http://www.ticinolibero.ch/?p=118874>. Used: 16.05.2013.

Ufficio della gestione dei rifiuti (2013), Gestione Rifiuti. Retrieved from:<http://www4.ti.ch/dt/da/spaas/ugr/temi/gestione-rifiuti/gestione-rifiuti/piano-di-gestione-dei-rifiuti-pgr/>. Used: 10.06.2013.

Ufficio Federale dell'Ambiente (UFAM) (2003), Retrieved from:*<http://www.news.admin.ch/message/index.html?lang=it&msg-id=1646>.* Used: 10.01.2013.

Ufficio Federale dell'Ambiente (UFAM) (2013), Retrieved from:< *http://www.bafu.admin.ch/abfall/01495/01498/index.html?lang=it>.* Used: 10.06.2013.

Ufficio Federale dell'Ambiente, delle Foreste e del Paesaggio (UFAFP) (2004), *Direttiva Finanziamento conforme al principio di causalità dello smaltimento dei rifiuti urbani*. UFAFP, Berna. Retrieved from:< http://www.bafu.admin.ch/publikationen/publikation/00450/index.html?lang=it>. Used: 09.05.2013.

Ufficio Federale dell'Ambiente (UFAM) (2012), *Smaltimento dei rifiuti: e adesso ci resta il lavoro di rifinitura*. Retrieved from:<http://www.bafu.admin.ch/dokumentation/umwelt/12035/12047/index.html?lang=it>. Used: 15.03.2013.

Ufficio Cantonale di Statistica (UStat) (2013), *Dati per singoli comuni. Repubblica e Cantone Ticino.* Retrieved from: <http://www3.ti.ch/DFE/DR/USTAT/index.php?fuseaction=dati.comuni>. Used: 10.02.2013.

Ufficio Federale di Statistica (UST) (2013), *Average Salary in Switzerland*. Retreived:<http://www.bfs.admin.ch/bfs/portal/it/index/themen/03/04/blank/key/lohnstruktur/nach_grossregion.html>. Used. 18.04.2013.

Ulli-Beer, S., Andersen, D.F. & Richardson, P. (2007), Financing a competitive recycling initiative in Switzerland. *Ecological Economics* 62 , pp. 727–739.

United States Environmental Protection Agency (EPA) (2000), *IDEA cost estimating model*. Retrieved from: <http://epa.gov/region5/waste/illegal_dumping/downloads/ideausersguide.pdf>. Used: 06.02.2013.

Verschuren, P. & Doorewaard, H. (2010), *Designing a research project*, Eleven International Publishing.

Volvo Trucks (2013), *Emissions from Volvo trucks according to EURO Standards*. Retrieved from:.<http://www.volvotrucks.com/SiteCollectionDocuments/VTC/Corporate/About%20us/Environment-2012/Emis_eng_20640_08003.pdf>. Used. 18.04.2013.

World Bank (1999), *Municipal Solid Waste Incineration. Technical guidance report*. Washington D.C. Retrieved from: < http://www.worldbank.org/urban/solid_wm/erm/CWG%20folder/Waste%20Incineration.pdf > Used: 05.05.2013.

World Bank (2012), *Total Population*.<http://data.worldbank.org/indicator/SP.POP.TOTL> Used: 12.11.2012.

World Bank (2013), *Data on GDP adjusted per PPP*. Retrieved from: < http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD>. Used: 02.02.2013.

Zamboni, A. (2013), Interview Ufficio servizi tecnici della citta di Locarno. Locarno, 26.02.2013.

Zulliger, D. (2013), Interview (Online) to the Dipartimento del Territorio, Ufficio della gestione dei rifiuti Bellinzona. 28.02.2013.