The Establishment of a New Recycling System for the Historical Center of Venice

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Abstract

This project, sponsored by the City of Venice – Environment Department, analyzed Venice's waste management system in logistical and financial terms, and proposed a new recycling system for Venice. The group recommended new methods of financing the waste management system, implementing recycling, and revising the current collection process to maximize efficiency. The team arrived at its conclusions after collecting data on the waste management system and conducting interviews with key city officials.

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The team realizes tha t this project would not have been a success without the generous assistance provided by so many people.

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Authorship Page

This project was completed with the equal participation of all four team members. Without the diverse talents contributed by each group member, the project would not have achieved its current form.

Table of Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

In Venice, there currently exists a waste management system that encompasses th e entire island city. The city's recycling system, however, is not as complete as the garbage collection system. Whereas there exist 185 garbage collection locations throughout the city, there are only 50 locations where people can recycle, most of which a re concentrated in the Cannaregio sestiere. Consequently, most of the waste generated by the city does not get reused, and thus ends up incinerated or dumped after it is disposed.

For its size, Venice produces considerably more garbage than comparable cit ies in Italy. Aside from the 65,000 residents that make up the Historical Center, over 12 million tourists visit the city each year. According to VESTA officials, in terms of garbage generation, the tourists produce the equivalent of 100,000 additional per manent residents.

The problem is aggravated significantly by the fact that Venice resides on a series of interconnected islands where automobiles are scarcely used. As a consequence, the waste management process for the city is more complicated and expens ive than it would be if the city was located on the mainland. The cost of using boats and specialized machinery and personnel to collect garbage on a daily basis from the city costs four times more than it would for mainland cities with roads.

The additional costs create a persistent burden on the city's residents. Given that tourists generate a large proportion of the garbage, it has proven difficult to create an adequate accountability system to fairly distribute the colossal cost of waste management in Venice. Therefore, the problem of recycling in Venice cannot be addressed without taking the unique nature of the city into account.

The city currently employs the services of VESTA (VEnezia Servizi Territoriali Ambientali), the local waste management age ncy, to carry out the task of keeping the city clean. Among VESTA's duties are to maintain a fleet of boats and barges to be used for the transportation of garbage, employ hundreds of workers to sweep and clean the various streets and *campi*, and collect th e garbage throughout the city using door -to-door collection routes as well as centralized *autoconferimento,* or self-service, dumpsters. Finally, VESTA also manages the limited recycling system currently in place.

As opposed to mainland collection systems, where the garbage is collected swiftly by garbage trucks and driven directly to the dump or incinerator, in Venice there are many more intermediate steps to complete the same process. First, the workers must pick up garbage at each door and deposit the re fuse into their carts. Once the carts are full, the workers walk back to their respective boats to empty their cart into the boat's compactor. The process is repeated until all garbage on the island has been collected. The boats then travel to the Secca S. Biagio Island on the Giudecca, where a crane takes the garbage boat's cargo compartment and empties it onto a barge. Once the barge is full, it is attached to a tugboat and pushed across the lagoon to Fusina, where the mainland waste processing plant is l ocated. Once in Fusina, a large crane slowly scoops

the garbage out of the barge and drops it into a truck one scoop at a time. The truck makes repeated trips to unload the garbage at the plant to be processed.

At the plant, garbage is either incinerated or converted into CDR (Combustibile Da Rifiuti). The CDR is then sold to power plants and other plants designed to burn biomass. Garbage from the Historical Center is not converted into CDR; rather, it is either burnt or shipped to the local recycling plant.

Part of the problem leading to a lack of recycling in Venice is local participation. The recycling systems that have been previously attempted have had little success because it has never proven convenient or otherwise beneficial for people and businesses to recycle. Secondly, adding a citywide recycling system has always presented the prospect of expanding the already overpriced waste management system in Venice, which would lead to an even greater burden for the residents to pay.

The garbage system is currently financed through a tariff called the TIA (Tariffa Igiene Ambientale). The tariff's effectiveness as a financing scheme has been brought into question in the past, as it has seen itself reformed numerous times. As it stands, the tourism industry derives an unfair benefit through the TIA, while businesses that cater to local needs see themselves paying inequitable sums for the amount of garbage they generate. Aside from the inequity of the tariff, it fails to cover the cost of waste management each year, leading to a ten million Euro deficit that must be compensated using general taxpayer funds.

As a result of a European Union mandate, all manufacturing companies in its member nations (including Italy) are required to dispose of packaging once its use has expired. The purpose of the mandate is to encourage more responsible work by packaging companies. Currently the City of Venice does not enforce the mandate, but doing so would cut down on garbage collection costs to a high degree, compensating to a degree for the increased costs associated with managing recyclables.

Our objectives in completing this project were, in order: examine the existing garbage collection mechanisms in place throughout the city, to analyze the limited recycling system existent in certain parts of the city, to determine the impact of tourism on the volume of garbage generated across the city, and to analyze our findings and draw a set of conclusions that would lead to our final recommendation.

While analyzing the current garbage collection system, we observed and studied the daily collection and disposal of waste in the city. In addition, we visited the various sites where the garbage is transported and processed. In the mainland processing plant at Fusina, we received a firsthand look at the steps taken in the processing and disposal of waste from Venice.

Having familiarized ourselves with the citywide garbage collection system, we focused our attention on the current limited recycling system in place. We noted and documented the location of all the recyclable dumpster sites, allowing us to get an idea of which areas are serviced by recycling, and the extent of the service provided.

With a solid foundation of knowledge about the existing recycling system, we examined the potential scope of a citywide recycling system by determining the waste composition of the various businesses in Venice.

We examined the garbage collection system, including collection route maps, and compiled databases detailing the various aspects of each collection area. We studied the number of personnel and the types of equipment used for the various collection areas across the city. We interviewed officials from the city's Environmental Department, as well as the people in charge of VESTA's garbage collection program.

In studying the current recycling system, we similarly compiled the results of our observations into a database and converted them to a visual format using MapInfo. We also interviewed Alessandro Bassi, the VESTA official in charge of running the recycling program, to aid us in examining the pitfalls involved with a citywide recycling system.

After interviewing the officials and visiting the mainland plant of Fusina, we conducted a detailed and exhaustive analysis of garbage composition for the various types of businesses present in the city of Venice. Our methods involved late night and early morning inspections of garbage near the respective businesses, as well as the distribution of surveys among the managers of each business. The surveys allowed the managers to detail how much waste their business produced, as well as providing a general estimate of the various types of recyclable waste they created on a regular basis.

As a result of our analysis of the completed business surveys and collection information, we were able to devise a new system for collection that improved accountability for the residents and businesses alike. Our system of city-approved bags and recycling bins will allow each person to pay according to how much waste he/she produces, while providing an incentive to recycle.

Our proposal also included a change to the scheduling system to compensate for the fact that recycling collection has to be treated differently from garbage collection. Our second shift of collection is proposed as 5pm in the afternoon, when the collection boats will induce the least interference to the locals.

Additionally, our proposal called for the observation of the December 1994 European Union Mandate concerning packaging material waste and how it needs to be collected. Observing this mandate will permit the city to save a significant amount of money it can then apply towards promoting the new recycling system in the city.

Finally, our final proposal observed the impact the reengineering of the waste disposal system would have on the residents and their respective businesses. Throughout our project, we gave prime consideration to making the transition to recycling easy and beneficial to the residents. Indeed, they now have the opportunity to be compensated for responsible behavior and using recycling as an alternative to throwing their waste away. Ideally, our recycling system, if implemented, will lead to other groundbreaking environmental initiatives within the City of Venice.

1 Introduction

Recycling as a citywide program is widespread and commonly embraced by the various municipalities in Western Europe. Venice, being a city built on water, is bereft of such a recycling program. The logistical impediments posed by the city's unique transportation network have caused it to be left behind in the wake of mass municipal recycling movements all over the continent. Several attempts in the past had been made to implement recycling in Venice, and all have met with limited success. The objective of our project group was to evaluate the city's waste management system and devise a new recycling program that met the city's needs.

The City of Venice – Environmental Department had engaged in past attempts to create a citywide recycling system, but their systems met with marginal success. The lack of success could be attributed to the limited space available on the island as well as the lack of participation on the part of the local residents.

In order to succeed where others have failed, an appropriate incentive program for participation in the system needed to be included. Additionally, a means of implementing the system on a door-to-door basis will help to overcome the inherent limitations on space that is typical of the Historical Center. Finally, a means of financing the system to distribute the cost fairly across the residents, businesses and tourists needed to be devised.

As such, in addressing the problems presented by the city's waste management system, the group approached the project by focusing on four distinct objectives. Our first objective in approaching the problem was to analyze the intricacies of the city's garbage collection system and understand its unique nature. Secondly, we focused on studying the past and current recycling systems present in the Historical Center, and determine their respective strengths and weaknesses. Our third objective was to examine the impact of tourism on the Historical Center's garbage generation, and thus determine how much of the system should be financed through tourism revenue. Or final objective consisted of analyzing the information gained through the execution of the first three objectives to come up with a comprehensive plan for implementing a recycling system in the Historical Center.

2 Background

In attempting to initiate a new recycling program in the Historical Center of Venice, it was of paramount importance to familiarize ourselves with programs implemented elsewhere in order to use the knowledge gained from the successes and failures of others to our advantage. Similarly, a good understanding of the citizens, background, and government of Venice meant the difference between proposing a potentially successful recycling system and a failure. In consideration of these topics, this section has been designed to provide the background information that we utilized throughout the duration of the project.

2.1 Venice and its Waste

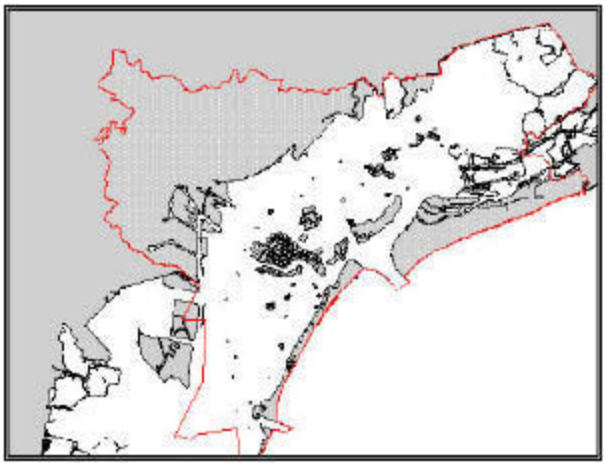

Figure 2.1: The Municipality of Venice (shown in red)

Venice is a municipality spanning both the mainland and the historical islands of the lagoon. While the entire municipality had a population of 275,000 people in 2001, the islands of the lagoon provide a home for a mere 65,000 people according to the 2001 Italian Census data, and that number is decreasing every day.[1]

The islands of Venice have their own methods of dealing with the necessities of modern urban life, including municipal waste and recycling systems. Unfortunately, the layout of the islands has made it difficult for the City of Venice to implement an effective recycling program in the heart of the Historical Center. A combination of tight winding waterways that have in the past been prone to very low (or very high) water levels, high congestion, and high tourist traffic during the summer months, all add to the difficulty of recyclable material separation, storage, and collection in the oldest part of the city.

[1] Italian 2002 Census Data, © 2002 ISTAT

Venetians are in a struggle to keep their city at pace with the rest of the world. In their attempt to adapt the things that make life comfortable on land to their aquatic culture, such as running hidden pipes for gas, electricity, cable, and internet access, while simultaneously wo rking to preserve their artistic and architectural heritage, many residents find that life on the islands is increasingly inconvenient and expensive. Current trends show that, while the islands are losing inhabitants, the average age and financial wealth of the Venetian islanders continues to rise. The rising average income is primarily due to the tremendous number of tourists that crowd their way through the historic Venetian lagoon every year, eager to spend money on gondola rides and souvenirs.

Figure 2.2: A Venetian garbage collector

Tourism is the primary reason the municipality of Venice produces significantly more trash per capita than the other cities, as shown in **Table 2.1**. By analyzing the data in **Table 2.1**, we can see that the average amount of waste generated in Venice per person is approximately 330 kg more than the average of the other cities. We can attribute most of this waste to the 12 million tourists that visit Venice every year.

ENVIRONMENTAL INDICATORS IN SOME MUNICIPALITIES

1999

	Waste		Parks and gardens		Cars*	
	Municipal waste kg per inhabit.	Separate waste collection kg per inhabit.	% of municipal area	m² per inhabit.	per 100 inhabit.	per km²
Torino	530.7	100.1	10.2	13.6	65.0	4,515.4
Aosta	–	–	1.4	8.7	–	–
Milano	557.2	154.9	7.1	9.8	61.0	4,348.0
Bolzano	519.0	112.3	3.5	17.3	56.3	1,046.7
Trento	592.7	80.5	1.4	20.9	58.3	387.1
Venezia	721.9	143.9	0.9	12.1	42.8	287.5
Trieste	457.6	44.9	3.0	10.3	52.4	1,342.2
Genova	499.3	43.0	5.9	21.7	47.7	1,245.1
Bologna	575.5	104.9	8.1	28.9	56.9	1,541.1
Firenze	624.6	102.9	–	–	56.8	2,090.4
Perugia	701.1	168.0	1.4	40.2	67.3	234.3
Ancona	503.4	68.1	2.3	25.4	61.7	490.5
Roma	563.9	30.0	2.7	12.2	68.4	1,407.6
L'Aquila	493.8	36.2	0.1	6.7	62.5	93.4
Campobasso	428.3	14.1	0.5	5.1	56.6	523.2
Napoli	556.4	4.1	1.8	2.1	60.4	5,165.8
Bari	560.3	43.3	0.8	2.9	52.7	1,504.1
Potenza	463.5	50.0	0.4	10.1	59.0	236.6
Catanzaro	466.1	27.7	4.5	51.2	54.1	470.2
Palermo	647.9	–	7.3	16.8	56.6	2,436.1
Catania	590.5	4.1	1.0	5.5	59.5	1,111.2
Cagliari	565.2	2.7	4.6	23.2	65.1	1,264.1

** provisional data*

Table 2.1: Environmental indicators in key Italian cities[2]

These figures present a number of interesting challenges to the design of a recycling system in Venice. Since vacationers travel away from home to leave their worries behind, their general attitudes include the idea that it is up to someone else to worry about cleaning up after them. However, because they contribute so much to the waste collected in Venice, we felt it was important to propose a system that would encou rage both tourists and

[2] Mean based on the sum of "Municipal Waste", and "Separate Waste Collection", only for those cities in which both data types were given.

permanent residents to recycle. The second challenge was that the Venetian islands required a recycling system that would blend with the Historical Center 's aesthetically pleasant surroundings, while providing a reliable and flexible program to meet the needs of both the visitors and the inhabitants.

2.2 VESTA

Venice's waste management system is handled entirely by VE STA, VEnezia Servizi Territoriali Ambientali. VESTA is a waste management and public works company owned primarily by the city of Venice. VESTA's duties in the city include, but are not limited to, sweeping the city early each morning, collecting the city' s garbage, managing Venice's limited recycling system, and putting up emergency wooden planks over flooded areas of the city to allow people easier passage in their travels.

Figure 2.3: VESTA's office headquarters plaque

VESTA collects garbage on a regular schedule six days a week, omitting Sundays. T he daylong gap in collection generally results in an accumulation of waste by tourism -related businesses that continue to operate at full capacity on Sundays, as well as the Venetian residents. The result in many cases is abandoned garbage on the city stre ets, left to rot in alleyways or next to bridges, where rats, seagulls, and dogs have ready access to them. Despite the fact that this practice is blatantly illegal, more and more residents and businesses have begun to take part as it becomes increasingly aware that the city is at a loss when it comes to prosecuting offenders. The biggest problem is that short of sting operations, it is very difficult to determine exactly where any of the trash actually came from once it has been abandoned. There are leg al alternatives for residents and businesses that don't want to keep their trash around for an extra day, however. According to the laws currently in place there are only 2 legal ways that home and business owners may dispose of their waste. Upon arriva l, the garbage collector is supposed to notify the residents of his presence by knocking or ringing a doorbell, at which point the residents may either let him in to collect garbage from an area just inside the door, or they may bring items to the cart and transfer them directly. To comply with these rules while also managing large amounts of trash, many larger hotels and restaurants actually have private contracts with VESTA for Sunday pickups, and a number of apartment buildings provide their residents w ith waste containers located just inside the front entrance.

VESTA is funded by the TIA (Tariffa Igiene Ambientale), a tariff based on the total mass of waste produced by the city and distributed between its residents and businesses.

Whatever deficit rema ins after the TIA is collected by VESTA is covered through taxpayer appropriations. Paolo Cacciari, the political head of Venice's Environmental Department, believes that residents end up paying a disproportionate sum for the city's waste management as a result of the TIA's structure.

VESTA handles garbage collection, its primary task, through a combination of land and water-based collection units. It has approximately 60 reconfigurable boats available for waste collection. The boats stop at reserved docki ng spaces while personnel with carts collect refuse from their designated area of the city, which may span several islands or only a small portion of one island, depending on waste production. It is important to note that while collectors may need to collect waste from a number of islands, it is forbidden for them to cross over a bridge with anything in their carts due to the risk of injury; this means that a boat must dock on each island, further complicating collection schedules and routes.

VESTA also ma nages the city's limited recycling program, which primarily serves the Cannaregio district. The recycling system utilizes the same barges as the waste collection system with a different container inserts, and various types of collection bins scattered thro ughout the city supporting the collection of plastic, glass, tin, aluminum, paper, and organic compost.

VESTA has recently completed construction of a modern (designed in the 1980s, first operated in 1996) incineration plant for the disposal of solid wast e. Although the incineration plant features state -of-the-art technology, it nonetheless generates air pollution and ash as a byproduct of its incinerated material. While much of the air pollution is filtered out through chemical and mechanical scrubbers, e missions still occur and the ash is composed of such hazardous materials that it must be dumped in special landfills. VESTA is looking for alternatives however. One such alternative is a coal -substitute fuel pellet produced from waste paper and wood, but problems with separation of waste materials from the paper and wood, such as plastic, which creates more harmful chemicals when it is burned than coal does, still threaten the viability of the final product. Skeptics of such "Waste to Gold" endeavors also worry that such a product may cause VESTA to stop traditional paper recycling altogether – a move that would not reduce the number of trees logged every year for a marginal -at-best reduction in harmful exhaust emissions. Still others are excited at the prospect of a large company being interested in collecting differentiated waste.

2.3 Garbage Collection in Venice

In years past, garbage collectors in Venice acted as citywide alarm clocks, walking through the streets blowing horns, reminding people to wake up and bring yesterday's trash out. This process was a daily occurrence, with only Sunday being a day of respite. In those days people relied on garbage collectors to wake them for work and take their trash away before any food waste began to spoil. Trash was kept off the streets (away from dogs and vermin), and was collected often enough to avoid spreading disease within the household.

Today the system remains nearly the same, but the garbage collectors have given up their horns, and collectors and citizens alike have become less strict in their adherence to the old routine. Today, according to sources in the City of Venice Environmental Department, garbage collectors do not necessarily follow the precise schedule for which they were once known, and citizens are more likely to leave their garbage out overnight where it can be torn open and scattered by animals. Why citizens have become so apathetic about waste disposal is unknown, but the results of their actions are obvious. The City of Venice is becoming increasingly concerned with sanitation issues associated with trash left in the streets, and frequent 'acqua alta' incidents (high tides) that sweep the bags away from doorsteps and into main thoroughfares only add to the problem.

Figure 2.4: Trash left in an alley

Figure 2.5: Sweeping in St. Mark's Square

The city is divided into work-zones for the collection workers, usually comprising one or two islands, depending on size and volume of waste produced. Collectors still work every day of the week except Sunday, beginning at 6:30 am, when garbage collectors from each island (or set of islands) manually sweep the streets while workers in some plazas use high-pressure hoses to remove the accumulated pigeon droppings. Sweeping is usually finished by 8, at which time door-to-door collection begins. Collectors retrieve large (900 L) carts that are stored on the island, and proceed along pre-determined paths through the streets and alleys of their designated campo (island), picking up the trash residents and businesses have left out for them. Where space permits, businesses and apartment complexes keep the trash inside until the collector rings the doorbell and is buzzed in.

Once a cart is full, the worker pulls the cart to a designated spot along a canal (never crossing bridges for worker safety concerns), where a garbage boat equipped with a crane is docked and waiting. The collector wheels the cart into position and guides the crane's hook into place on the cart, which is hoisted into the air and dropped onto a platform on the boat that allows the bott om of the cart to swing open on hinges and deposit the trash into a compactor.

Figure 2.6: Garbage collection boat & cart

The dumpster into which the trash is deposited on the boat has a volume of 10 m3 (10000 L), or 10 cartloads. The capacity of the boat is increased, however, by compactors on t he boat, which compress the garbage at a 3 to 1 ratio, allowing over 30 cartloads to be dumped in each garbage boat. Once the cart is emptied, the collector resumes his round where he left off, and repeats the process until the whole island has been servic ed.

Figure 2.7: Location of garbage stops in Venice

The collection process is usually completed in two to three hours depending on the day. (Garbage volume is heaviest on Mondays and lightest on Tuesdays). After the collection has been completed , the boat, which remained anchored in one spot throughout the entire day, travels to a larger barge anchored in the lagoon, where the trash is transferred and transported to a mainland processing plant.

No trash co llection occurs in the afternoons, and only in select plazas do workers continue to sweep up in order to maintain a clean appearance throughout the day. While no regular garbage pickup is offered on Sunday, some large hotels and restaurants are willing to pay an extra fee to have Sunday pickup of the waste generated on Saturday, a prime tourist day.

A major headache facing the City of Venice is the financial strain that 12 million tourists per year put on the garbage collection system in this small city of 65,000 permanent inhabitants. The cost of waste disposal is currently financed by fees charged to residents of the city, much like in most cities of the United States. Unfortunately, this tax collection formula (known as TIA) fails to adequately consider the cost of waste generated by the tourists who flock daily to hotels, bars, and restaurants. The result, according to the City of Venice, is a significant overpayment for garbage collection by the average citizen of Venice, and a gross underpayment by restaurants, hotels, and other centers of tourist activity. Each year, the city of Venice must pay $10 million to VESTA, the agency in charge of waste disposal, to cover the deficit between tax revenue and expenditures to collect and process the garbage. Some of this yearly cost is covered by fines charged to tour buses entering the city. However, this money could be allocated for other maintenance and beautification projects around the city, rather than for compensating a faulty tax law.

Figure 2.8: Trash outside a hotel

2.4 Recycling in Venice

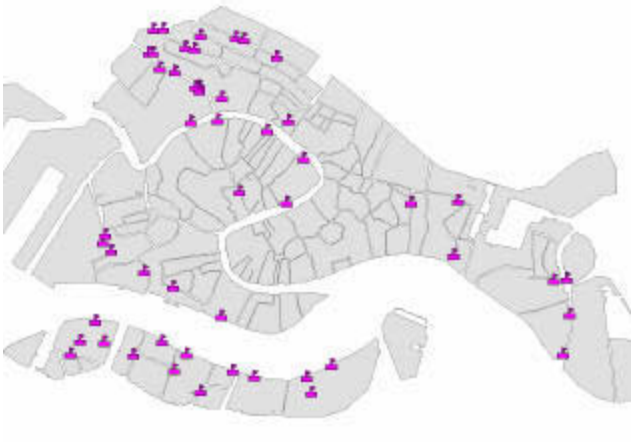

Figure 2.9: : Location of recycling dumpsters

Recycling in Venice is limited in both spatial cov erage and success. While Venice does have locations around the city where residents can take their bottles, cans, paper, cardboard, batteries, grease, and even medication to be recycled, these dumpsters are located around the rim of the city, and are often difficult to find. The dumpsters are in remote and obscure locations because of two important considerations regarding Venice and its inhabitants: there is no space for dumpsters in most streets, and the people of Venice object to unsightly refuse contain ers even in those places where they would fit. Residents have been known to complain about the trash cans located in the heavily traveled Piazza San Marco . The result is a collection of dumpsters scattered around the edge of the city, often with two or thr ee dumpsters in one location, and none in the surrounding areas. This grouping of dumpsters in a central location forces residents to trek – sometimes across a number of islands – to deposit their recyclables. Even the most dedicated environmentalists may be discouraged by the prospect of carrying their recyclables such distances. It seems obvious that the convenience factor associated with a recycling system will have dramatic effects on the participation rate, and therefore the success of the current Vene tian recycling program must be questioned.

The greater problem with a dumpster-based system is the expected lack of participation by the tourists. Visitors to the city are often there for a short time, sometimes only hours, and will rarely take time out o f their vacations to familiarize themselves with the recycling procedures of their host cities. Even if such a well -meaning tourist were to go looking for a recycling dumpster, most dumpsters are located far from tourist centers, and can be difficult to fi nd.

Figure 2.10: Clean brown compost containers

Currently, 7 boats (same type of boat as is used for garbage, without the compactor insert) are used throughout the city to empty the existing mini-dumpsters. Since there are three different types of receptacles used for recyclables, different types of boat configurations are necessary. Mini -dumpsters are emptied in the same manner as the garbage carts described previously, while recycli ng bells

are hoisted manually by one cable onto the barge, and then the cable is switched to a second hook that allows for the bottom of the bell to drop down, dumping the contents into the barge. Recycling bells are anchored to the ground, making them less prone to vandalism (such as being pushed into the canals) than the wheeled mini-dumpsters, but are unpopular with city officials because the anchors require holes in the pavement. The last type of container used by the current recycling system is a bin, much like a standard garbage can, which is used for compost and paper recycling in large businesses. The paper containers are collected on a weekly or monthly basis, or when requested by the owners. Of all the containers used for recyclables, only the brown compost containers are loaded on the boat and replaced with new, clean containers. This is done for sanitary purposes, to keep the biological waste from spoiling and spreading disease among residents.

The final, recent addition to the recycling system is a boat that docks at certain locations throughout the city at a pre-appointed time, where residents can take their recyclables. This boat is divided into two compartments (bottles/cans and paper products), which are open on top for easy access, and has no special machinery like the other boats.

Figure 2.11: A mobile recycling station

According to city officials, this latest attempt at an expanded recycling system has seen limited success, much like its predecessors.

2.5 Government Actions to Promote Recycling

Like any other venture, one must always consider the legal and political actions and repercussions that accompany the initiation of such a large-scale project as a municipal recycling project. We would therefore be negligent if we had not explored the legislative precedents and any previous government actions prior to our arrival in Venice. This section is devoted to research conducted regarding such laws or initiatives, not only to prevent infringement upon said actions, but also in the hopes of utilizing those regulations to our advantage. A pre-established government position in favor of recycling was expected to greatly expedite the implementation of a project designed with the pre-existing legal parameters in mind. Three governing bodies pertinent to the project are:

- The European Union
- The Italian Government
- The Venetian City Council

The European Union plays a key role in setting benchmarks for international environmental regulation.[3] As its multinational political presence extends its roots across the continent, European nations are finding that their laws are beginning to meld together. The United Nations has also been a source of environmental laws, as its resolutions have prodded European nations into action to protect their environment. One such resolution is the "World Charter for Nature,"[4] issued in 1982.

Western European countries have similar recycling programs, whereas the United States stands in sharp contrast to the progress made in Europe. In Europe, national governments help set the guidelines for how and when a recycling program is instituted within municipalities. In the United States, the federal government exercises virtually no involvement in such initiatives. Most environmental government policy-making is relegated to the states, and barring a select few, most states have placed recycling initiatives at the bottom of priority lists. One state program we will examine is that of Pennsylvania, which has just recently launched a statewide program to implement and expand its ability to recycle materials.

For the most part, government actions to promote recycling are limited to positive reinforcement rather than coercive regulation. Although instances of the latter do exist in cities such as Chicago, it is much more common for city governments to provide incentives to the inhabitants to recycle, such as through tax breaks. One other idea that is gaining popularity is the Pay-As-You-Throw concept. Although there are several variations of the program, it essentially

[3] European Union Nature Conservation Policy and Legislation. 2002. European Union (Europa online)
[4] World Charter for Nature. 2002. Center for International Earth Science Information Network (CIESIN)

revolves around the idea of citizens avoiding costs associated with trash disposal by sorting through their refuse and preparing the recyclable materials for pickup.

The US and Europe differ considerably when it comes to environmental policy, as evidenced by their constant disagreements concerning international conservation agreements. In an incident regarding the Kyoto Treaty of late, the United States was condemned by the EU for departing from the treaty's previously established parameters regarding annual greenhouse gas emissions limits. There are ethical as well as legal gaps between our two cultures, and therefore an approach we may consider logical may be interpreted as inappropriate in Italy. In creating our proposal we must take such differences into consideration.

Although most legal and regulatory material regarding specific Italian initiatives is in the Italian language, we eventually translated enough of the essential data to gain an understanding of how the government and the people of Italy regard recycling as a comprehensive system. Since this aspect of recycling is likely to differ vastly from that which exists within the United States, studying it carefully and adapting our approach to our findings aided us in devising a more appropriate and palatable scheme for the government of Venice.

2.6 Recycling Methods

In order to see this project through to fruition, we needed to have at least an elementary understanding of the processes involved in recycling discarded materials. This section describes the basic steps taken to recycle materials once they've reached to the recycling facility. The most commonly recycled materials are:

- Plastic
- Paper
- Metal
- Glass

The following sections describe how each of the above materials is recycled.

2.6.1 Plastic

Plastic being a relatively new material, the recycling industry for this omnipresent polymer is likewise a recent development. Despite its relative youth, the recycling of plastic has had significant growth since its implementation. The United States alone recycled almost 2 billion pounds of post-consumer plastic in 2000. This figure includes plastics from beverage containers, detergent bott les, health care containers, plastic bags, and shrink-wrap.[6]

Figure 2.12: Plastic containers[5]

The plastic recycling process begins with collection, either curbside collection or community drop -off dumpsters. The plastic is then taken to a sorting facility where the plastic is sorted by co lor, type, and quality. All recyclable plastics are *thermoplastics* meaning that they become malleable with heat and can be melted down and formed into new products. *Thermosets*, on the other hand, do not lose their strength with heat, and burn rather than m elt. Thermosets are both less commonly used, and infrequently recycled due to the complexities associated with their structures.

The most commonly recycled plastics are PETE (PolyEthylene TerEphthalate), most commonly found in soda bottles, peanut butter c ontainers, and detergent bottles, and HDPE (High Density PolyEthylene), found in milk bottles, large bottles of water, and grocery bags.[7] Both PETE and HDPE may be colored, which has no effect on the recycling process, although it must be separated by color to avoid mixing.

Figure 2.13: Flaked Plastic[8]

After being collected and sorted, the plastic is chopped into flakes and immersed in a bath to remove any imp urities and allow any labels to be peeled off. This stage may be accomplished with regular water or heated water with chemical detergents to facilitate the process. The plastic is then sent to a floatation tank where HDPE floats to the surface and impurities are carried away from below. PETE sinks due to its higher density, so the process is reversed, floating the contaminants away and isolating the plastic at the bottom.[8]

In some cases the flakes are the final product and are shipped off to manufacturers f or production. Otherwise the flakes are further processed by melting them down and forming them into high -purity plastic pellets. The pellets are then boxed and sold to manufacturers for the production of toys, bags, fabric, siding, bottles, and other plastic products.

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[5] Containers. 2002. Reagents, Inc.
[6] 2000 Recycling study. 2002. Plastics Resource
[7] Plastics Identification Guide. 2002. Spokane Regional Solid Waste System
[8] Mechanical recycling process, The. 2002. Plastics Resource

2.6.2 Paper

Figure 2.14: Tumbler making paper pulp[9]

As with any other recycling process, the paper process begins with sorting. Paper must be isolated from contaminants (paper clips, glossy paper, plastic), and then sorted by paper quality. High-grade paper like laser printer paper and office paper is separated from newsprint and lower grade commercial paper, usually by hand. The sorted paper is then dumped in a vat of water and chemicals to remove the ink from the paper fibers. The chemicals added are known as surfactants, and are used in conjunction with bubbles created with compressed air. The surfactants attach themselves to the ink, but need the bubbles to rise to the surface, where the ink can be skimmed off the surface. Additionally, shredders are used to churn the water and cut the paper into smaller pieces, as well as rub the paper together to expedite the removal of the ink. [10]

The shredding stage often involves a number of harsh chemicals, sometimes including bleach, in order to remove all of the ink from the paper. However, an emerging technology from the University of Florida could revolutionize the paper recycling industry. Instead of surfactants and compressed air, which can be expensive, the process utilizes a combination of inexpensive chemicals which, when mixed, release their own bubbles. The chemicals are also more efficient than current surfactants, allowing more of the waste paper to be recycled at a lower cost. A final advantage is the ability of the University's method to increase the number of times paper can be recycled. Standard recycling processes damage the fibers of the paper, which limits the number of times the pulp can be recycled to about seven, where each process results in a lower quality of paper. The new method should be able to extend the number of cycles almost indefinitely, thanks to the change in chemicals. [11]

After the ink has been removed, the wet pulp is forced through heavy rollers that squeeze the water out, and form the pulp into a sheet of fibers. The fibers can then be dried and shipped out to paper manufacturing plants, where they undergo the same process that pulp from virgin wood undergoes in order to make paper. [12]

All told, the recycling of a ton of paper rather than land filling and using raw materials saves roughly 14 trees, 3 cubic feet of landfill, and over 7,000 gallons of water. [13]

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[9] System of waste reduction and materials recover. 2002. International Environmental Technology Center
[10] Paper recycling process. 2002. Paperfox
[11] UF developed recycling method could benefit forests, industry. 2002 University of Florida
[12] Paper recycling process. 2002. Paperfox
[13] UF developed recycling method could benefit forests, industry. 2002 University of Florida

2.6.3 Metal

Figure 2.15: Molten metal[14]

Metal is the oldest of the recyclable materials known to man, and the idea and method of recycling metal has been around since the dawn of metallurgy. The most commonly recycled metals today are composed of either aluminum (beverage containers, aluminum foil, car parts, siding, construction materials) or steel (canned goods, car frames). The sorting of metal is the only one that can be done in large part by a machine. Steel being a ferrous metal (attracted to magnets), it can be sorted from a stream of metal waste with a large magnet, leaving the non-ferrous aluminum on the conveyor belt. The aluminum must still be monitored as it goes down the line to avoid contamination from foreign objects, but the steel has been sorted. Once sorted, the metals both go through a washing stage to remove any labels, dirt, or leftover contents in the case of containers.[15]

Aluminum has the most direct process, as it is pure enough to be chopped up and sent to a kiln where any remaining imperfections are burned out, and an ingot or sheet of aluminum can be easily obtained.

Steel, on the other hand, is often coated and welded with tin, which must be removed prior to melting. Even though a ton (2,000 pounds) of tin cans only contains about 5 pounds of actual tin, this is enough to warrant a separate process including chemical and electrical methods of removing the tin layer from the steel can. Once this step has been performed, the tin and the steel proceed along their separate paths to their respective furnaces, where they are melted down and formed into ingot in the same manner as aluminum.[16]

Finally, the ingots are sent out to manufacturers for the production of more car frames, soda cans, screen doors, cat food containers, construction materials, and other metal products.

[14] Inmetco high temperature material recovery process. 2002. Inmetco
[15] Recycling process after collection. 2002. Department of Environmental Quality
[16] IBID.

2.6.4 Glass

Figure 2.16: Remanufactured glass[17]

Glass recycling is relatively straightforward as recycling goes. Standard container glass (not windshield, cooking, or other specialty glass) is broken into small pieces called cullet, washed thoroughly, and sent through a series of magnets, screens, and vacuum devices to eliminate any unwanted metal, plastic, or labeling that may have remained. The cullet is then mixed with silica sand, soda ash, and limestone and sent to a kiln where it is melted down into molten glass. The molten glass is cooled and formed into rods or cubes and shipped out to manufacturers for production. [18]

2.7 Recycling in the United States

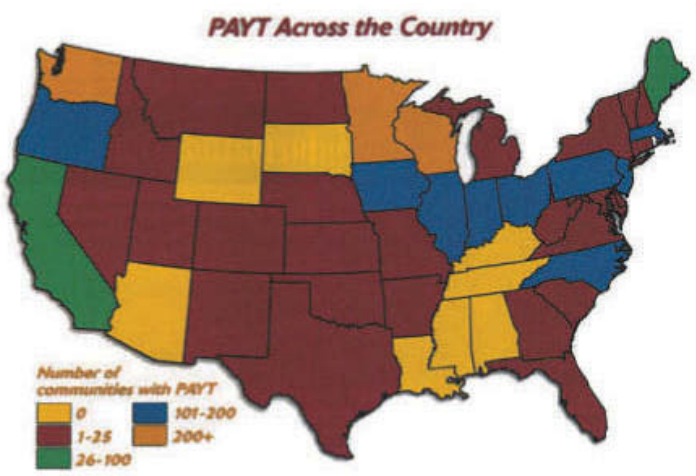

Figure 2.17: Concentration of PAYT communities[19]

Households in the United States generate a substantial amount of waste every year. The United States accounts for only 4.6% of the world population [20] but consumes more than 25% of the world's total resources used per year [21]. Therefore, it is no surprise that Americans produce a great deal of garbage. Policy makers in communities across the country are implementing ways to promote waste reduction. One popular method is the 'Pay-As-You-Throw' (PAYT) program, which is also known as Unit-Based Pricing, Variable-Rate Pricing, or Pay per Bag.

The main concept behind unit-based pricing is that instead of paying a flat monthly or annual fee, each household must pay per unit of waste that it generates. The idea is to provide a direct economic incentive for residents to reduce the amount of overall waste that they generate. Households are charged only for the amount of waste that they throw away, a concept very

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[17] Recycling glass. 2002. Recycling don't just dump it
[18] Recycling process after collection. 2002. Department of Environmental Quality
[19] *Pay-As-You-Throw Continues To Grow*, Waste Age Magazine, p. 34 May 1999.
[20] US Census Data,© 2000 United States Census Bureau.
[21] National Wildlife Federation, 2002.

similar to how electricity, gas, and phone utilities are billed. As of 1999, there were more than 9,000 communities with recycling programs; 4,032 of them employed some variation of a unit-based pricing program[22].

Figure 2.18: PAYT curbside pickup bins[23]

For example, Pay-As-You-Throw programs in New Hampshire work on a per-container basis; households pay for each container of waste they generate. In all but one program, households can recycle for free. Some communities even charge twice as much for the second container of garbage. As a result, residents are motivated to not only increase the amount of garbage they recycle, but also to develop ways to generate less waste to begin with. This is precisely the advantage of the PAYT programs. They offer fairness and greater control over costs within individual households, and everyone is directly rewarded for recycling.

On the national scale, municipalities that have adopted PAYT programs have typically reported a 20 to 35 percent reduction in solid waste generation[25]. This leads to less frequent pick-ups of municipal solid waste and, in most cases, increased participation rates in the recycling programs. In fact, according to the Waste Reduction Record Setters Project for the U.S. Environmental Protection Agency (EPA) conducted by the Institute of Local Self-Reliance (ILSR), over half the programs that achieved recycling rates of 50% or more credit their success to PAYT[26].

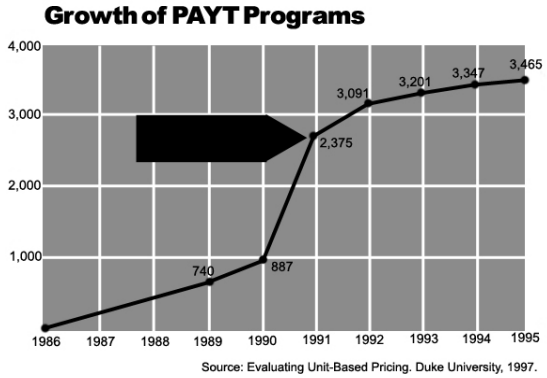


Figure 2.19: Growth of PAYT programs[24]

In 1997, the EPA funded a research project with Duke University to analyze the effectiveness of PAYT programs. The study found that by complementing the PAYT programs with source reduction education as well as recycling and yard trimming services, in most communities, municipal solid waste (MSW) collection and disposal costs were lowered substantially.

[22] *Pay As You Throw Communities* , US EPA – Office of Solid Waste, 2002.
[23] *Pay-As-You-Throw Trash Disposal*, State of New Hampshire, 2002.
[24] *Idem.*
[25] *Pay-As-You-Throw*, MSW Management Magazine, p. 31. November/December 1997.
[26] *Idem.*

2.7.1 Reducing Collection Costs Using PAYT

In Dover, New Hampshire (population 27,000), the PAYT program helped the city save almost $300,000 in annual solid waste costs; $200,000 came from reduced collection costs alone[27]. Instead of using three trucks for trash collection, the city cut back to only using one truck. The amount of trash collected in Dover decreased from 11,000 tons in 1991 (before the PAYT program was implemented) to 4,000 tons in 1998 [28]. For each ton of trash reduced, the city saved $45 in disposal fees. Increased recycling rates and greater waste reduction not only decreases the amount of trash collected, but also decreases the frequency of collection.

Figure 2.20: Dual collection truck[29]

In Mount Vernon, Iowa (population 3,700), once the PAYT program reached a recycling rate of 50%, the collection company was able to switch its collection fleet over to "dual collection" trucks. Instead of using separate trucks for collecting garbage and recyclables, the company invested in split side-loading dual collection trucks that had the capability to collect both while keeping them separated. Commingled recyclables are collected on one side of the truck and MSW is collected on the other. Gene Freiburger, President of Waste Services, which operates Mount Vernon's solid waste program, stated that, "One of the benefits we see as a contractor is that unless you have a volume-based system (such as PAYT), your recycling equipment does not get fully utilized. The incentive isn't there to recycle." [30] Freiburger was initially very reluctant to invest in new equipment when the PAYT program was first implemented considering the inconsistencies in recycling participation and the tendency for residents to just throw everything away under the old disposal system. However, over a short time the PAYT program has made people much more conscientious about what they dispose of and therefore, their behavior is much more predictable from a collection standpoint.

Besides less garbage to collect, another factor that has helped reduce collection costs is the reduction in time it takes to complete a collection route. The use of standardized containers, whether they are cans or bags, has helped speed up collection because recyclables and garbage pre-sorted for the collection workers to simply throw into the designated truck compartment. Officials in Dover, New Hampshire even established a drop-off recycling center to co-exist with their curbside pickup to further encourage residents to save money. If residents decide to drop off their garbage and recyclables, they don't have to purchase the designated PAYT sorting bags

[27] *How to Succeed with PAYT*, Biocycle Magazine, p. 32. December 1998.
[28] *Idem.*
[29] *Idem.*
[30] *Idem.*

required to cover the collection costs. A cheaper membership fee to use the recycling cent er would counter-balance their slight inconvenience of having to drop it off.

2.7.2 Typical PAYT Pricing Systems[31]

- **Linear Pricing:** Households pay a set price for the standardized bags they use to set out their garbage on the curb for pickup. The cost of collecti on and disposal is covered by the sale of such bags.
- **Two-Tiered Pricing:** Similar to Linear Pricing except the fixed costs of a community's MSW program are financed by a flat fee or through taxes. Residents pay a set per-container fee that covers disposal c harges and other variable costs of the program. In some communities, the fixed costs include some level of trash collection per week before the per-container fees are levied.
- **Multi-Tiered Pricing:** As with two-tiered pricing, residents pay a fixed cost plus a per-container fee for each bag or can collected. Multi-Tiered systems also charge different fees for containers of different sizes. In some communities, residents will be charged increasing more for every additional container of garbage that exceeds the standard quota per pickup.

2.7.3 Skeptics of PAYT

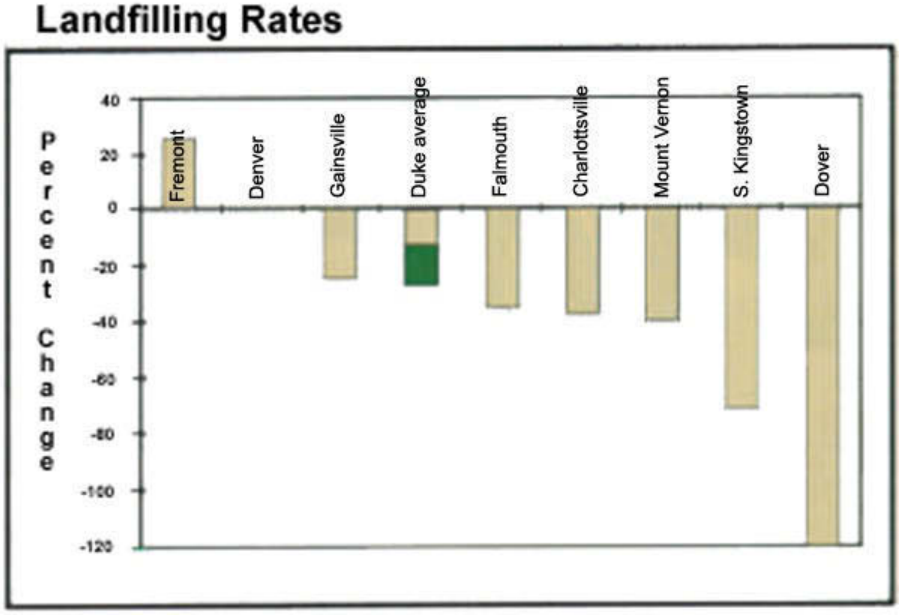


Figure 2.21: Waste reduction achieved by PAYT programs[32]

[31] *Pay-As-You-Throw*, MSW Management Magazine, p. 34. November/December 1997.
[32] *Environomic$*, MSW Management Magazine, p. 57. 1999.

Despite its economic benefits after implementation, many PAYT skeptics wonder if all the costs associated with implementing a new PAYT program, complemented with other additional programs, will cause solid waste costs to rise even further. However, many communities that have implemented a PAYT program have shown that this is not the case. In Dover, New Hampshire, the solid waste budget in 1990 was $1.2 million. In 1991, the year that PAYT was implemented, the city only spent $878,000. [33] In fact, many communities consider PAYT in order to justify closing a landfill by reducing waste production as well as lowering disposal costs. Even though PAYT is designed to discourage waste production, if residents should produce more waste, they will have to pay more for additional disposal bags or cans and therefore, compensate for the additional disposal costs to the city. Under a non-PAYT program with a flat tax or monthly/yearly fee, if residents generate more waste, the city's revenues remain constant despite increasing disposal costs. Most cities that are uncertain if increased PAYT revenues will fully compensate for increased disposal costs will use some type of tiered pricing system instead of a linear pricing system. As a result, revenue will increase somewhat exponentially instead of linearly in order to cover the disposal costs.

2.7.4 PAYT and Illegal Dumping

Although a PAYT program has many economic and environmental benefits, there are also some potential drawbacks. One in particular is the possible increase in illegal garbage dumping. Since residents have to pay more to throw away excess garbage, some may resort to dumping their garbage in secluded un-monitored areas. Most illegal dumpers are profiled as construction or landscaping contractors, waste management contractors, scrap collectors, and automobile repair and tire shops. In other words, the majority of illegal dumping is done in bulk by businesses looking to cut disposing costs in order to increase their profit margin.

Figure 2.22: Illegally dumped tires[34]

[33] *Idem.*
[34] *Illegal Dumping Guidebook*, United States Environmental Protection Agency, p. 3. 1998.

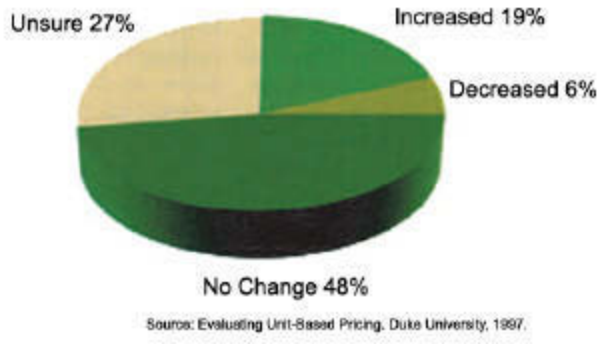


Figure 2.23: Opinion poll - change in illegal dumping after PAYT[35]

The major factors that contribute to illegal dumping are the demographics and the physical characteristics of the area. Illegal dumping typically occurs in areas with limited access to convenient and affordable waste disposal facilities and/or recycling programs or services. Many of these low-income areas have gang or drug related activities and a high crime rate; therefore, the problem of illegal dumping often receives a low priority among law enforcement officials. Since illegal dumping significantly decreases property values in the vicinity, the problem tends to be worse in areas with a high population of renters who have less invested in the local community and property. On the contrary, illegal dumping occurs mostly in vacant areas with low population because of the reduced potential for dumpers to be seen. Vacant areas include abandoned structures, undeveloped or unsecured properties, and unused industrial facilities.

Nevertheless, PAYT communities have developed strategies to combat and prevent illegal dumping in order to ensure the success and acceptance of the new disposal program. In Dover, New Hampshire, the PAYT staff worked with the police department to prepare officials for increased illegal dumping offenses, even though it was not an issue after implementation. Having a convenient PAYT program makes it more of a hassle for residents to find a place to dump their garbage illegally. Also, to help low income families, the city worked with federal, state, and local agencies to create a special allowance in welfare checks for the purchase of PAYT bags. Such measures and accommodations have proven to successfully offset the temptation for illegal dumping in these communities.

Figure 2.24: Illegally dumped roof shingles[36]

[35] *Environomic$*, MSW Management Magazine, p. 54. 1999.
[36] *Illegal Dumping Guidebook*, United States Environmental Protection Agency, p. 4. 1998.

2.7.5 Gaining Public Support for PAYT

In general, the public resists switching to a PAYT program at first. Besides fears of illegal dumping, most people are resistant to a new program that replaces what they view as a "free" service, even though it was paid for through local taxes. To overcome this hurdle, many communities stress the need to achieve a sense of community ownership to the program by holding public meetings and securing the support of local newspapers. Ultimately, by combining public input with an aggressive outreach campaign, the groundwork for widespread acceptance of PAYT is set.

For example, in San Jose, California, they developed a comprehensive public education campaign called *Recycle Plus* to explain the new PAYT program to single family households. The public was also included in the design of the PAYT program through the use of surveys and questionnaires delivered by mail to the residents. Now, the city sends out annual public opinion surveys to gauge local satisfaction of the system and also gives residents the opportunity to suggest ways to improve the program.

Back in Mount Vernon, New Hampshire, the public was originally resistant to the proposed PAYT program. However, when the need for a new landfill arose in public meetings, residents became more open-minded about PAYT since no one wanted to open another local landfill.

2.7.6 Relevance of PAYT to Venice

We researched extensively on the PAYT program in the U.S. since we strongly recommended applying similar methods of recycling in the Historical Center of Venice. Since PAYT has been so popular and successful in the United States, we investigated if the incentives that it offers are applicable to Venice and its constituents. Considerations included the need for an outreach campaign as well as ways to combat a potential rise in illegal dumping. The people of Venice had expressed some concern about the growing excess of garbage as a result of mass tourism and commercial traffic. We believe the economic and environmental benefits of PAYT can be realized in Venice by implementing our proposed recycling system.

2.8 Economics of Recycling

As with any venture, financial considerations will ultimately decide the success or failure of the proposed recycling system in Venice. We therefore made investigation of the price of waste disposal and the costs recycling would create a priority. There are a number of ways in which finances come into play with the proposed recycling system; and while not all costs were foreseeable at first, due attention was given to them nonetheless.

The financial factors that were considered in this project are:

- Salaries
- Recycling Fees
- New Facility Construction Costs
- Revenue from the Sale of Recycled Materials
- Other Disposal Methods

For each of the aforementioned factors, we have utilized US data as a basis of comparison. Information more pertinent to Italy and Venice will be discussed later in the results section of this report.

2.8.1 Salaries

Figures for the United States indicate that sanitation engineers (garbage collectors/drivers) earned on average $14.33 per hour, with an average workweek of slightly less than 40 hours in the year 2000. This rate is just above the national average for all blue-collar workers ($13.41).[37] Assuming that the data are indicative of relative wages in other countries, this information may be extrapolated to estimate labor costs in Italy.

The average wage paid to Italian working class citizens in 2000 was 2,573,000 Lire ($1188) per month, which equates to roughly $7.43 per hour.[38] This means that for every additional worker hired would earn a yearly wage of $14256 ($1188 US * 12 Months). This is merely the wage *earned by* the worker; the cost to the employer is likely to be more than twice that, the difference going to taxes, social security, medical insurance, and other paycheck deductions. Therefore, a more useful number was obtained by multiplying the earned wage by 2.5 in order to achieve a worst-case-scenario expenditure for each additional worker. Of course this number may be higher or lower depending upon the area of the country, the actual taxes and deductions, and the typical salary of Italian sanitation engineers. However, for our purposes a number like $38000 (per additional worker per year) makes for a good starting point when calculating the overall cost to the project.

2.8.2 Recycling Fees

One benefit of recycled material is its ability to pay for itself (at least partially). As we will discuss in section 2.8.4, the material recovered after processing the waste is sold to manufacturers, sometimes for significant sums of money. The cash flow generated by the recycled material is used to cover a portion of the operational costs of the facility. This is in direct

[37] National Compensation Survey. Bureau of Labor Statistics. 2000
[38] LABORSTA. Bureau of Labor Statistics. 2001

contrast with most forms of waste removal, which have no source of revenue other than the fees charged for the use of the facility. Of course, whatever costs the recycling facility cannot recover from the sale of the recycled material will have to be covered by the government of the locality (and eventually the taxpayers).

For example, the City of Chicago has implemented a "blue bag recycling" initiative, where citizens sort their waste into regular garbage bags (for biomass and non-recyclable waste), or blue bags (for recyclables) prior to collection [39]. Waste Management Incorporated (WMI) is in charge of waste pickup, disposal, and recycling, and has agreed to a contract with the city wherein WMI must recycle 25% of the garbage collected per month, or stand to be fined by the city. For this service the City of Chicago pays WMI $19.85 per ton of blue bag waste recycled (with the agreement that whatever revenue is generated by the recycled material goes to WMI), and $34.50 per ton for disposal costs of material deemed un-recyclable.[40] The implication is that the sale of the recycled material more than compensates for the lower tipping fees (fees charged to the city to dispose of the waste). If this were not the case, WMI would not have agreed to such a contract.

Figure 2.25: Blue bag pickup in Chicago[39]

Of course, recycling centers vary in efficiency, meaning that the costs and benefits of recycling will inevitably vary. Some examples of the costs associated with an already established plant range from $25 per ton (for exclusive glass recycling) [41], to $80 per ton (for a facility designed to handle 100% of the waste created). [42] The actual cost per ton is a function of the technology adopted, the range of materials in question, and the marketability of the recovered material. These variables make it difficult to assign a more specific cost to this essential component of a recycling system; so for simplicity sake, we must assume the highest cost when estimating the overall cost of the final project.

[39] *What happens to your blue bag?* 2002. City of Chicago. 2000
[40] *Frequently Asked Questions about Chicago's Blue Bag Recycling Program*. City of Chicago. 2000
[41] Cost Benefit Analysis for Glass Recycling. Andela Products.
[42] Gorback, Sarah. *Proposed Center could Recycle all of SB's Trash*. 29 Jan 2002

2.8.3 New Facility Construction Costs

In the event that the current recycling facility in Venice was unable to expand, or was otherwise unable to handle the additional recyclable material, the city could opt to transport the recyclables to a processing facility in a different location. Unfortunately, shipping out waste often results in high transportation costs, large tipping fees at the destination, and the loss the taxable revenue generated by the sale of the recovered material. Alternately, the city may decide to make a large initial investment by building a new facility within the municipality in the hopes of keeping the tax revenue and jobs created by the facility within its jurisdiction. The initial investment would also allow the municipality to tailor the recycling process to meet any specific needs the city may have. A new facility has the added benefit of obtaining the latest technology and machinery, which could reduce the per-ton cost of recycling, and increase overall throughput of the system. Of course, the type of facility built would be dictated by the needs of the community, as well as the available capital. A new recycling facility has no fixed price, or even a range of prices, due to the countless variations available. Case in point, a recent facility built in New York State to handle 200 tons per day cost $10 million[44], while a plant built in the United Kingdom designed exclusively for paper cost over $400 million[45]. Obviously there is a middle ground that must be determined on a case-by-case basis, but there are a potentially limitless number of configurations suitable for almost any requirements.

Figure 2.26: Artist's rendering of a recycling facility[43]

[43] *Materials recycling facility.* 2002. Magna Environmental Services
[44] Governor's Waste Reduction and Recycling Awards. NY State Department of Environmental Conservation. 2001
[45] *Market Alternatives to Ancient Forest Destruction*. Greenpeace. November 1999

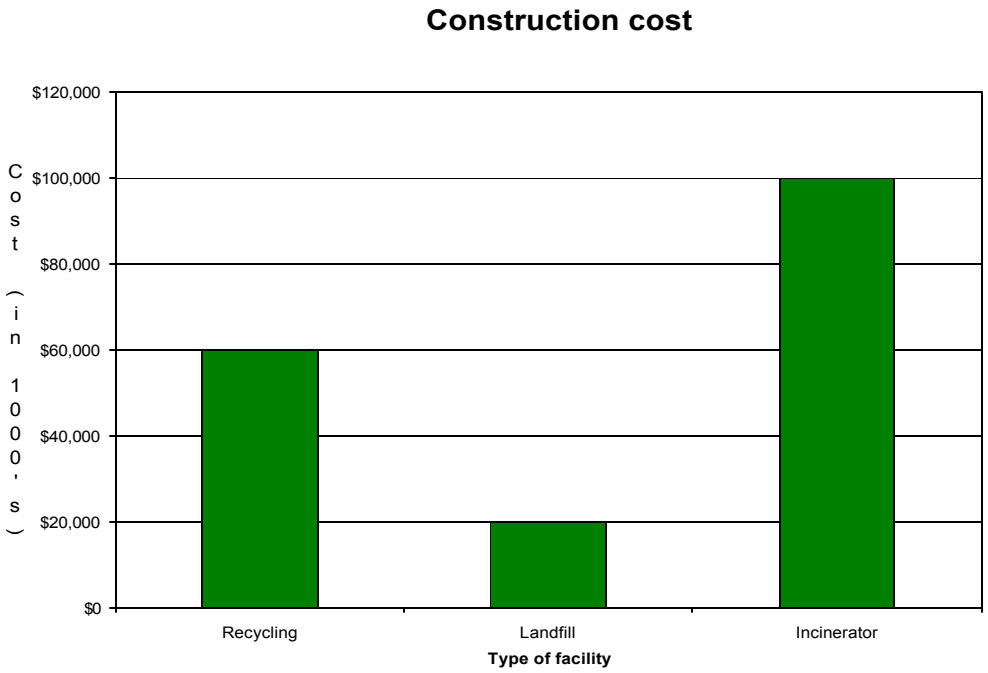


Figure 2.27: Estimated cost of construction by facility type

2.8.4 Revenue from the Sale of Recycled Materials

One of the advantages that recycling has over many convent ional disposal methods is its 'value added' characteristics. Whereas landfills and incinerators gain nothing from the waste processed, recycled materials become a source of revenue for the processing facility. This unique ability will be able to compensate for some of the processing costs, thereby alleviating some of the financial burden from the taxpayers. Although the exact dollar amount will vary by availability of the raw material and quality of the recycled material produced, it is extremely useful to have some understanding of the ballpark figures for the range of products we can expect to be recycling. **Table 2.2** outlines the market price per US (short) ton (2000lbs) of different recycled materials.

As evidenced by **Table 2.2**[46], these values are in no way fixed or pred ictable. The fluctuation of value is a potential hazard facing any recycling firm. As displayed in the table, even a span of one year can have a significant impact on the value of the recycled goods. This consideration is something for the government to be aware of, as decreases in revenue from the sale of recovered materials are likely to translate into increased tipping fees – a cost that is passed onto the taxpayers.

	Cost/USTon 2002	Cost/USTon 2001
Glass		
-Clear Glass	$30.00	$39.00
-Green Glass	$9.00	$14.00
-Brown	$17.00	$24.00
Baled Plastic		
-Clear PET	$220.00	$240.00
-Green PET	$200.00	$220.00
-Mixed PET	$140.00	$180.00
-Natural HDPE	$180.00	$260.00
-Mixed HDPE	$100.00	$200.00
Metal		
-Steel Cans	$56.00	$59.00
-Aluminum Containers	$960.00	$1,060.00
Post Consumer Paper		
-Corrugated	$46.00	$42.00
-Newspaper #6	$36.00	$44.00
-Colored Ledger	$80.00	$108.00
-White Ledger	$127.00	$193.00
-Computer Laser	$153.00	$171.00
-Computer no Laser	$165.00	$186.00
Pre-Consumer Paper		
-White Ledger	$153.00	$170.00
-Colored Ledger	$121.00	$135.00

Table 2.2: Value of recycled materials[46]

[46] *Recycling Manager Pricing Menu* . 2002. Recycling Manager

2.8.5 Other Disposal Methods

As a basis for comparison, we have included the range of number s typical for standard land filling. A typical US corporation charges anywhere from $20 to $100 per ton in tipping fees just to landfill material, depending on the size of the landfill, location, regulations, and volume of waste handled. [47] This makes recycl ing a viable and sometimes even attractive alternative. Recycling can also extend the life of the existing method of disposal, which may save those responsible a considerable sum of money. [48] Constructing a new landfill often costs upwards of twenty million dollars; depending upon size and geological complications that number can be much higher. [49] Similarly, closing a landfill down when it has become full or obsolete costs $80,000 to $500,000 per acre to 'cap', or cover permanently. [50] In this manner, the expans ion and use of an existing recycling center to accommodate a larger volume could pay for itself through the sale of the goods, as well as in savings passed on to the community by extending the life of the landfill/disposal center.

These are merely the most obvious and easily analyzed aspects of the financial implications of an expanded recycling operation. However limited they may be, they do serve as a useful guide when planning out preliminary steps towards the final goal of a comprehensive recycling system in Venice.

Figure 2.28: Trash in a landfill[48]

[47] *Improving Solid Waste Management in Hawaii*. Recycle Hawaii. February 1999
[48] *Waste*. 2002. Friends Of the Earth
[49] *Solid Waste Agency in Iowa Adopts Integrated Solid Waste Management System* . 2002. NCEDR
[50] *Estimated Cost of Landfill Closure* 2002. Maryland Department of the Environment

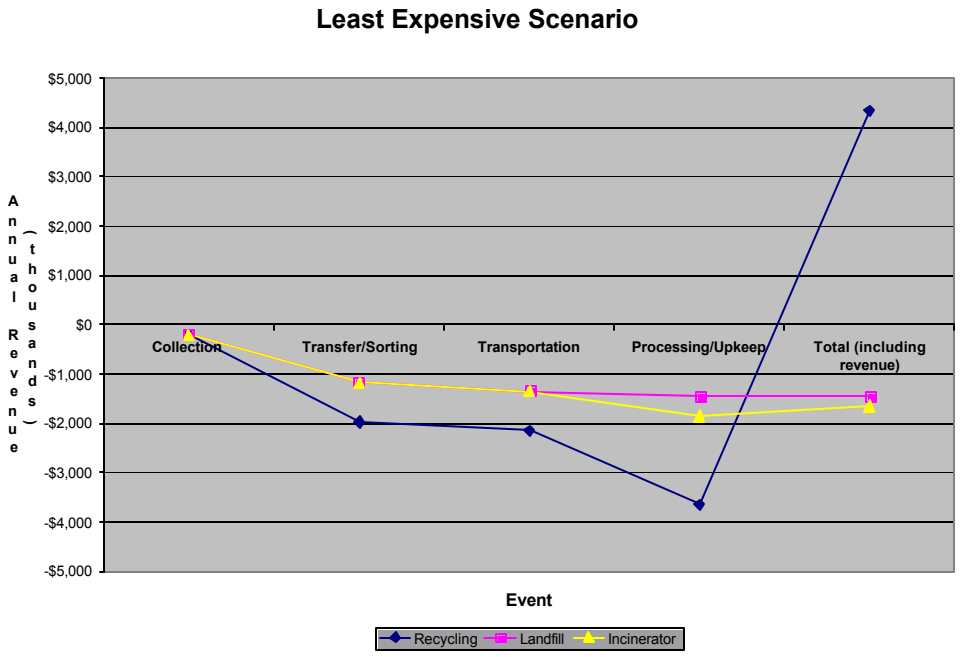


Figure 2.29: Best case scenario for three disposal methods

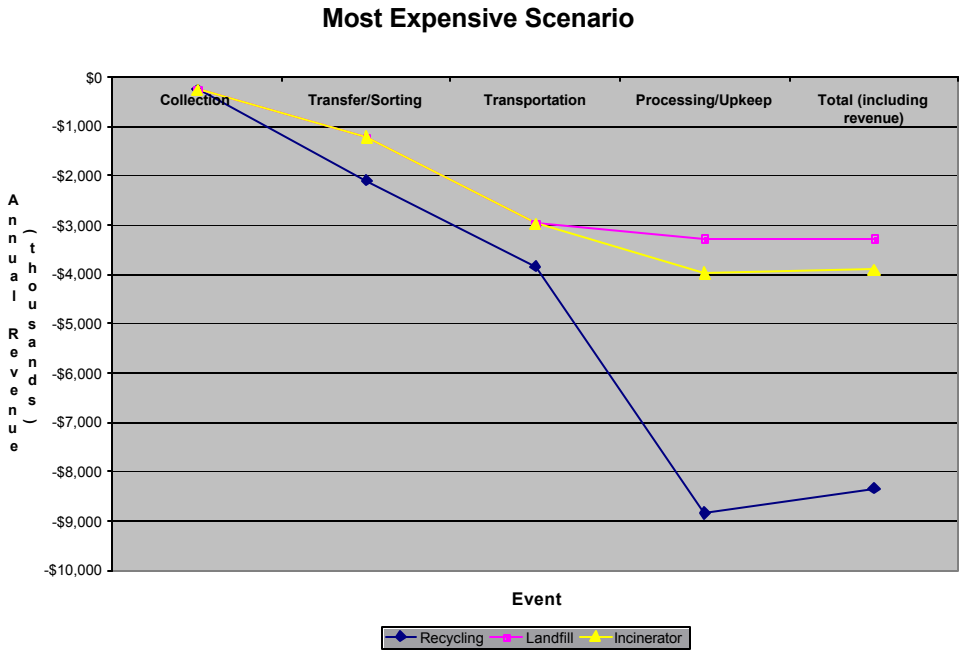


Figure 2.30: Worst case scenario for three disposal methods

3 Methodology

The mission of our team was to devise a new, more effective, recycling system for the Historical Center of Venice. Our primary consi derations in this endeavor were the methods of collection, transportation, and management of recyclable materials. After analyzing these areas thoroughly, we explored various recycling system options, and developed a recommendation for a system that we pre dicted would achieve the highest recycling rates while minimizing complications and costs.

The primary objectives of the project were:

- To examine the current solid waste collection process in the Historical Center of Venice.
- To obtain an understanding of the recycling system already in place in Venice.
- To determine the percentage of Venetian waste that is generated by tourism.
- To use the data collected to develop and propose a recycling system to be implemented in the Historical Center of Venice.

This section of the report provides a description of the ways in which the group collected the data necessary for analysis. It outlines the overall objectives that we needed to accomplish in order to complete our project, and explains what kind of tasks were req uired to complete each objective.

Our domain of inquiry was limited to the study of methods available for the sorting, transporting, and disposing of recyclables originating from the Historical Center of Venice. The team was exclusively interested in wha t is referred to as 'solid waste', which is comprised of numerous varieties and classifications of trash or rubbish. For the complete definition of 'solid waste' and its constituents, please re fer to Appendix A .

The spatial coverage of the team included the entire Historical Center of Venice (excluding the Giudecca) , which resides in the middle of the Venetian lagoon and is considered the heart of the Municipality of Venice. (Venice proper includes parts of the mainland outlined in red in **Figure 3.1** below.) Further coverage areas included any water or land routes that are required to transport the solid waste and recyclable material to the mainland for processing or disposal. However, since our mission was to propos e a recycling system for the Historical Center, our focus was on that area.

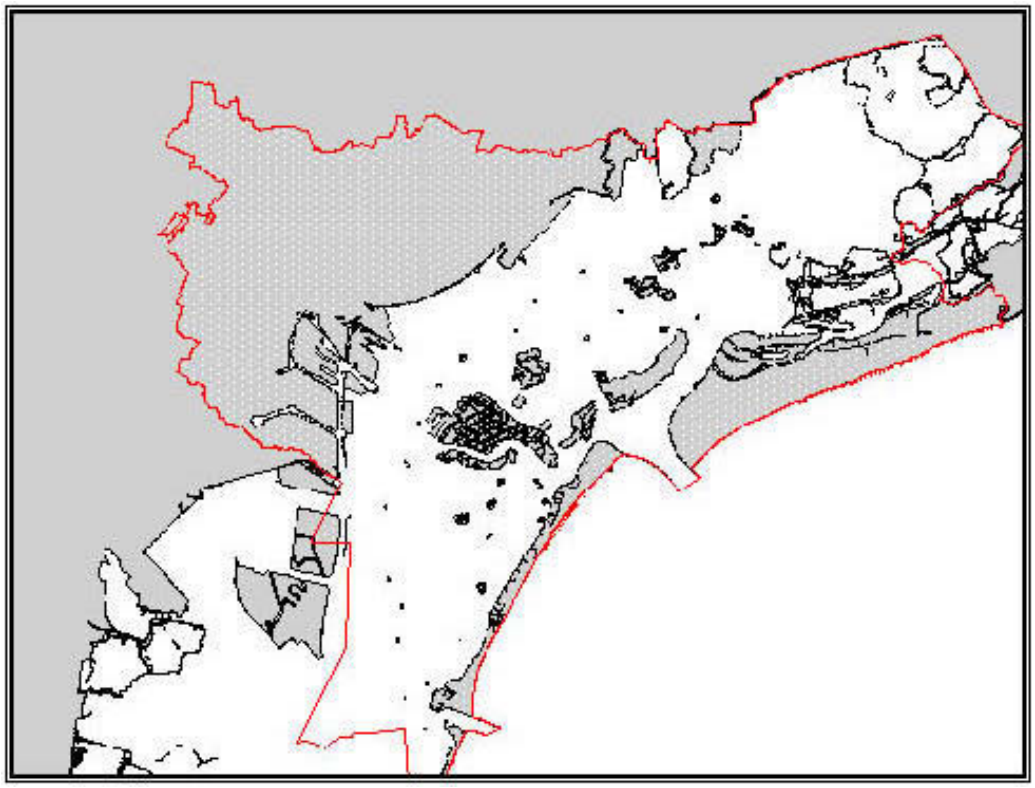


Figure 3.1: The Municipality of Venice (outlined in red)

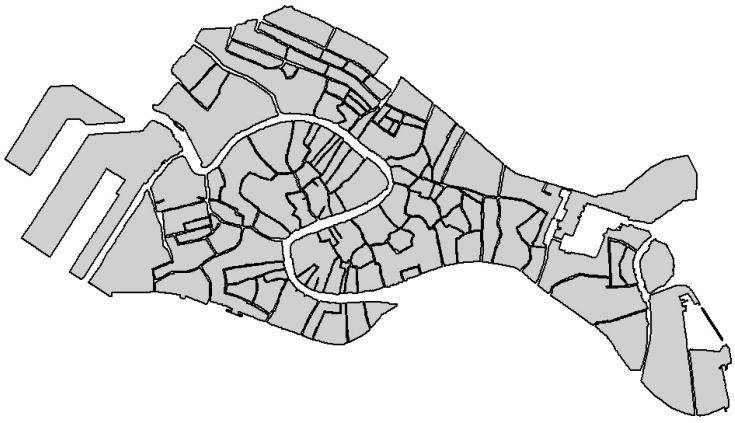


Figure 3.2: The Historical Center of Venice (excluding the Giudecca)

The information gathered by the team was collected from June 3rd, 2002 to July 25th, 2002. Due to expected variations in tourist activity throughout the year, the data collected during this limited time period are not likely to reflect the average amount of waste produced during any given month. However, numbers are more likely to be higher than average, since tourist activity approaches its peak at this time of year. Therefore, it is reasonable to assume that the data collected during this time period corresponds to the peak in solid waste production, and thereby creates an accurate representation of the maximum volume that the proposed system will need to accommodate on a daily or weekly basis.

The remainder of this chapter is divided into the following subchapters:

- **Section 3.1** – Discusses our methods of data acquisition for the existing garbage collection infrastructure of the Historical Center of Venice. Examining the transportation and management methods in use on the islands was of primary importance to us, so our spatial coverage for this objective did not extend to the Venetian mainland.
- **Section 3.2** – Pertains to the methods we used in our examination of the current Venetian recycling system. We attempted to find correlations between the current recycling system and the current garbage collection system to determine whether the recycling system could be expanded and incorporated into the garbage system without major alterations to either system.
- **Section 3.3** – Evaluates the role that tourism has on the waste generation rate in the City of Venice. Attempts are made to link tourist-driven businesses with the waste created by their clients to ascertain the need for a separate residential and commercial recycling system.
- **Section 3.4** – Presents the process of analyzing the resulting data from the previous three sections and drafting a recommendation for the City of Venice's Environmental Department.

3.1 Current Solid Waste Collection Process

Adequate knowledge of the current garbage collection system was essential to the development of ideas for a future recycling system in Venice. Data about the garbage system tells us how the Venetians handle their unique transportation system, the manpower required to service the city, the equipment utilized, and how the entire system is organized and managed.

3.1.1 Focus Area

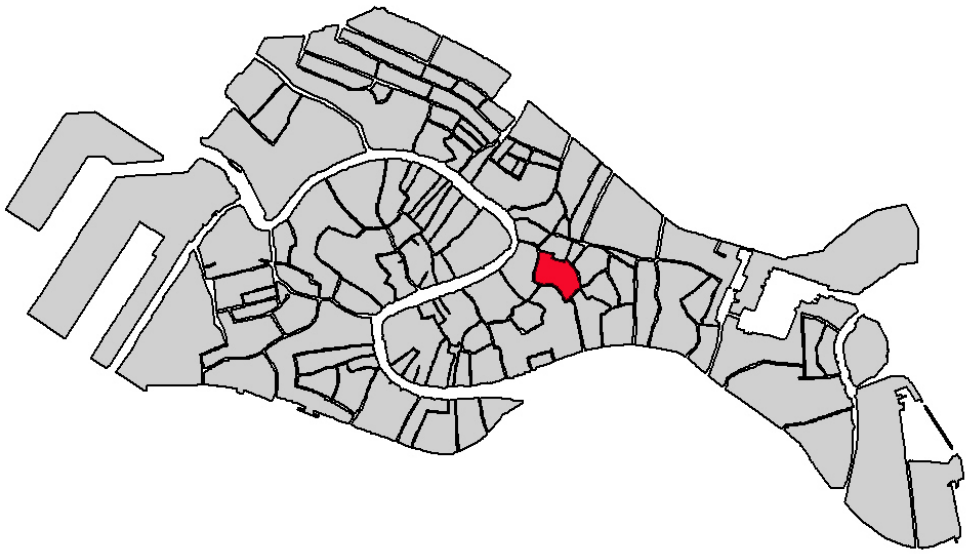


Figure 3.3: The Island of San Lio (highlighted in red)

The focus of the data collection was on the Historical Center of Venice, with special attention paid to the San Lio area (shown in **Figure 3.3** above), where the team followed garbage collectors and observed the entire collection end of the waste management system from the sweeping of streets, to the door-to-door collection of trash, to the emptying of carts into garbage boats. San Lio was the perfect choice for our data analysis because it uses only one boat, is home to a broad range of businesses, and, being in the vicinity of San Marco, attracts a large number of tourists. The fact that San Lio is hybrid between a residential and a tourist zone allowed us to apply our observations of the garbage collection to many of the city's other regions. The 'collection end' of the garbage spectrum is the portion of the waste management system that takes place on the individual islands, as outlined in Appendix F.

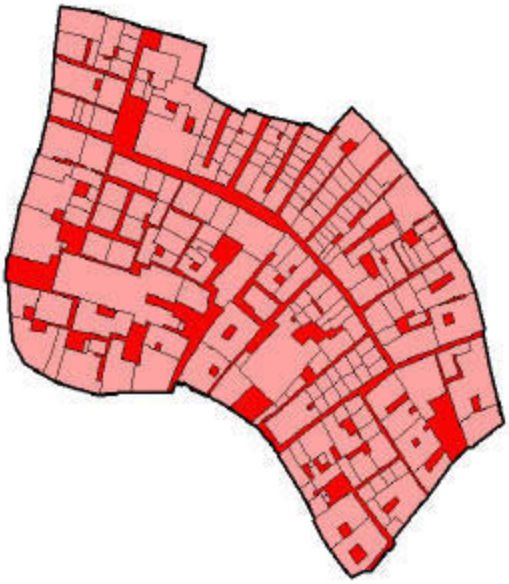


Figure 3.4: The Island of San Lio (with buildings)

3.1.2 Information Requirements

Logistical data was the first consideration of the team upon arrival in Venice. The manner in which garbage was collected, the location of the garbage boat docks, the manpower needed to clean the city, and the equipment utilized for these purposes were all pieces of information the team needed before any further progress could be made.

Once the observation of the logistical aspects of the Venetian garbage system was completed, we focused on the financial aspects. The financial information was used to determine how much, if at all, the waste management system would have to be expanded to suit the needs of a citywide recycling program.

3.1.3 Meeting with Environment Department

The meetings with the Environment Department answered many questions that we had about what really needed to be done to help the city institute an effective recycling system. Paolo Cacciari, the political head of the environment department, provided us with a brief history of garbage collection in Venice, and some financial data related to garbage collection and taxation laws. He also provided a fresh perspective to the information gained elsewhere. Due to linguistic differences our project advisor, Professor Fabio Carrera, acted as an interpreter for both the questions delivered by the team, and the information provided by Mr. Cacciari.

3.1.4 Meeting with VESTA Spa

Mr. Claudio Lanza, the man in charge of garbage collection for the city -owned company VESTA, agreed to meet with us to discuss garbage collection. Mr. Lanza provided data, which included maps of the collection routes used by the garbage collection boats , collection schedules for the entire Historical Center of Venice and the number of collection personnel per island. This meeting also required the assistance of Fabio Carrera for translation between the VESTA officials and our project group. The data provided by VESTA proved to be the most valuable tool in examining the logistical considerations the water -based Venetian garbage collection program faces, which carried over into our r ecycling system considerations.

3.1.5 Observation of Garbage Collection

Figure 3.5: The team at an early morning meeting in San Marco

To see firsthand how garbage collection takes place in Venice, we arranged a guided tour with Mr. Lanza at 6:30 am one morning, which is precisely when garbage collectors begin their day by sweeping the streets. At the appoin ted time, accompanied by Mr. Lanza, Professor DiBiasio, and Professor Carrera, we met at San Bartolomeo and walked to Piazza San Marco to observe VESTA workers sweeping and hosing down the square to remove litter and pigeon guano in preparation for the day's visitors. We met Davide Da Lio, the superintendent of the garbage collection in San Marco, who honored us with a special demonstration of the only mechanized street sweeper that the City of Venice uses. By 8 am, we had moved on to San Lio, where VESTA h ad given us permission to follow the three collectors assigned to this region for as long a period of time as we required. The team was introduced to Mr. Rino Vio, a senior garbage collector assigned to the San Lio section, who indicated that he would be willing to answer any questions that we might want to ask him related to our project. We remained with Mr. Vio until 10:30 am, noting the frequency with which carts were filled and emptied, the fullness of each cart, and the process used to empty the carts. We continued this data collection for a period of one week so that we could ascertain how full a garbage boat might be on any given day of the week.

Figure 3.6: The only mechanized street sweeper in Venice

As part of our observation of the current Venetian garbage system, we collected data on waste composition for a wide variety of businesses. We began by following the garbage pickup crew around San Lio for one week, noting their procedures and observing the quantity and type of garbage thrown out by the island's citizens. Once we had become acquainted with the garbage pickup process and the layout of the island of San Lio, we drafted surveys for local businesses to fill out. The surveys were designed to determine the composition of waste that each business produces so that the team could associate different types of businesses with the compositions and quantities of waste they produce. We distributed the surveys to businesses in the San Lio area and also a few to select locations in the rest of the Historical Center. Over one hundred copies of the survey were distributed, and approximately sixty were returned to the group. A copy of the business survey can be found in Appendix J.

After noting the results of the 60 surveys we retrieved from the businesses, we proceeded to verify the accuracy of the survey's results by making firsthand observations of the garbage composition of the area for a day, and comparing garbage production quantities with the known cargo delivery quantities to each type of business – provided by a previous project. We found through our examination that the surveys reasonably reflected the waste composition data we collected firsthand. Knowing this, we proceeded to make additional copies of the surveys for distribution.

While passing out the surveys, we encountered several obstacles. Firstly, the group knew little Italian, and adequately conveying our intentions became difficult with certain people. Additionally, a few individuals would not deal with our group unless we could present official documentation from the City of Venice validating our purpose. To counter these problems, we enlisted the help of native Venetians, including advisor Fabio Carrerra, boat driver Luigino Vianello, and restaurant owner Federico Giuge. These individuals aided the team by agreeing to hand out surveys to selected businesses throughout the city on our behalf.

Once we had gathered sufficient waste composition data, we recorded our results and analyzed them by classifying the various businesses into several categories. Our categories focused on both business type and variety of garbage produced. Our business categories included the types listed in Appendix E. We used our classification scheme to compare the business deliveries of each business type to their waste generation in order to get an idea of how much packaging waste they are responsible for producing. It also allowed us to associate quantities of waste and recyclables with different types and sizes of businesses, which proved very useful when it came time to develop new recommendations for the waste management system.

Given the unusual nature of Venice's transportation system, we took the time to adequately study the entire process of waste collection from start to finish to better understand the overall mechanics of the logistical setup, and also to have a broader perspective of the problem facing the city so that we could plan accordingly.

The details of the entire garbage collection process can be found in the **Results** section of this document. We began our observation of the process in San Lio, where the garbage workers made their rounds and unloaded their carts onto the boat. One of us stood near the boat, observing the process of loading and unloading, and noting the functionality of the compacting unit in the boat's cargo bay. In analyzing the boat's functionality during the normal course of its work, we were able to picture which aspects of the boat would need to be altered if it was to be modified for collection of recyclables.

The other three members followed the garbage collection crew as they did their work, noting the amount of time taken for each cartload, and how the workers dealt with businesses and residents in different ways. We also noted the sheer amount of recyclable material that was being thrown into the carts not to be recycled. In observing the work of the garbage crew, we were able to record the amount of man-hours it took to service an island the size of San Lio, and the number of cartloads that a typical island produced.

After having examined the San Lio collection process, we met with Alessandro Bassi, the head of the Venetian recycling system, to take us by boat on a tour of VESTA's island on the Giudecca where they keep their fleet of boats. There we observed the process of garbage transfer from the collection boats to a much larger barge as cataloged in Appendix L. Before we observed the process, we were not certain how the cargo bays in each boat were handled when they were emptied. By observing the transfer process, we gained a valuable understanding of the process of waste transport and the scheduling of barge trips to the mainland processing facility at Fusina.

Figure 3.7: The team observing the Fusina Waste Disposal Facility

VESTA's boat then took us to the mainland processing plant at Fusina to analyze the garbage processing and disposal procedure, and to inquire about detailed financial data concerning the garbage system. Upon arrival at Fusina, we had a meeting with the facility managers. During the meeting, various financial considerations for the waste management system were discussed. Through this meeting, it was discovered by the group that expansion of the current recycling system in the Venetian Historical Center would prove to be difficult for VESTA's current system, given the costs involved.

The facility managers also provided the group with a tour of the plant, explaining the functional aspects of each facility. Through the guided tour, we learned both the capacity of the waste processing plant and the kind of waste that is accepted by its facilities. Through inquiries, we found that the facility has an automatic sorting system handled almost entirely by machines, and that inappropriate waste is filtered out prior to processing.

Through the study of the various st eps involved in managing Venice's waste, the group was able to understand the complexities involved in collecting garbage and recyclables from an island city, and thus was able to better refine the final recommendation with this new perspective.

3.1.6 Problems with the Current Garbage System

During our meeting with our sponsor, Mr. Cacciari, we were informed of the problem posed by illegal dumping in the city. To understand the nature of the problem and any potential repercussions it may have on our proposed re cycling system, we chose to conduct a weeklong study of illegal dumping on the island of San Lio.

We conducted the study by making trips to San Lio late at night (10 -11pm). Each street and alleyway was examined, and any trash sitting outside at that time was recorded. Special attention was paid to areas that were marked by signs prohibiting illegal dumping.

In recording the illegal dumping in the area, the number of bags or stray pieces of trash was recorded. Along with each record, a note was made detaili ng the size of the garbage bag involved to keep the measurements consistent and accurate. At the end of the study, the results were recorded into a spreadsheet and organized into a comparative format to be used for reference when we drafted our recommendat ions.

3.2 Current Recycling System

The team needed to know what recycling approaches had already been attempted in Venice to get an idea of what might work, and what certainly does not. To do this, we once again met with VESTA officials who provided us with information regarding systems that have been tried in the Venetian Historical Center, but have ultimately proven either too costly or have seen minimal success.

3.2.1 Focus Area

The Venetian Sestiere of Cannaregio, and some of its outlying zones, comprised the spatial coverage for this objective. Cannaregio is the region with the highest number of recycling containers, and thus was used as a model of what the entire city would be like if the current recycling system was expanded to cover the rest of the Histori cal Center.

3.2.2 Information Requirements

Logistical information was collected upon first arrival in the City of Venice because we felt that a basic understanding of the type of system used, the location of key components in the

system, and the manpower and equipment needed to collect and dispose of the recyclables was needed before more detailed analysis could begin. Once this information had been gathered, we tried to quantify the success of the current recycling system in the form of total volume and weight of material recycled annually, which was provided by VESTA.

3.2.3 Sponsor's Position

During the same meeting outlined in **Section 3.1.3**, Mr. Paolo Cacciari also responded to questions posed by the group regarding the city's view of a successful recycling system, and what goals the city had for our project. Mr. Cacciari expressed the city's interest in a zero-waste system. Mr. Cacciari also agreed to sign a letter drafted by us indicating our status as students assisting the City of Venice in an examination of the current garbage and recycling systems. The letter proved useful in establishing the credibility of our team while interviewing or otherwise interacting with people around the city. A copy of the original (English) letter, and the translated (Italian) letter is available in Appendix M.

3.2.4 Type of Recycling System in Use

Upon arrival in Venice, we began to casually see evidence of a recycling system already in place on the islands. Dumpsters along certain canals were obviously meant for recyclables by their shapes and labeling. However, the true extent of the system was difficult to ascertain from such unguided observations, leaving us without details regarding the distribution of these dumpsters, the collection methods, or even if this was the only recycling system available on the islands. A meeting with Mr. Alessandro Bassi, the head of the recycling department of VESTA, proved to be the greatest contributor to our understanding of the entire recycling system. In speaking with Mr. Bassi, we acquired a broad overview of the various attempts that VESTA has made at recycling systems in the past, a map of dumpster locations throughout the city, and Excel spreadsheets with collection times of each set of dumpsters. Further information regarding the specifics of collection was obtained through firsthand observation of the emptying of the dumpsters in a tour of the collection process arranged by Mr. Bassi.

3.2.4.1 Tour of Collection Process

We were invited to spend a morning with Mr. Bassi, who led us around the Cannaregio sestiere of Venice and showed us the different boats and containers used in different locations around the city. This tour provided valuable question and answer time between the team and Mr. Bassi, as well as opportunities for photographic documentation of the boats and equipment used

in emptying the containers. Examples of the boats and equipment documented can be seen in Appendix L.

Later on we were given a tour of the waste collection transfer point, as described in section 3.1.5. As part of our observations, we witnessed the process of emptying a garbage boat's cargo bay into one of the large barges, and later at the Fusina plant we also made note of the organic compost facility and the machines used to separate different components of trash before incineration. Our study and documentation of this process helped us understand the kind of equipment that could be used in an expanded recycling system.

3.3 Percentage of Waste Created by Tourism

Given the enormous impact tourism has on Venice, both financially and physically, the team was interested in an estimate of the impact tourists have on the waste disposal system in Venice. More than just a point of curiosity, such information proved crucial to our decision-making process regarding the separation of residential and commercial waste disposal. It was our opinion (and echoed by Mr. Cacciari of the Environmental Department) that the major drawback of all previous recycling attempts was the oversight of tourists when calculating participation rates. Since tourists rarely spend more than a few days (and sometimes only a few hours) visiting the city, the motivation to go out of their way to recycle is lacking. We realized that this fact was the greatest obstacle to the success of a newly proposed recycling system, and decided that gathering this information was important enough to warrant the creation of a separate objective.

3.3.1 Focus Area

Since the Historical Center of Venice is what most tourists think of when they hear Venice, the overwhelming majority of tourists to the Municipality of Venice spend their vacation on the islands of Venice. While it would presumably have been a suitable substitute to examine waste production of tourists in other locations, both in the Municipality of Venice and Europe in general, there was no need to make such assumptions and risk inaccurate data collection since we were living in the Historical Center. For in-depth purposes mentioned before, the island of San Lio was chosen as representative of the tourist areas, and was easier to analyze than an island like San Marco would have been.

3.3.2 Information Requirements

To get a sense of the overall percentage of solid waste produced by tourists, we needed to get a sample of waste generated by different types of businesses commonly associated with

tourists. Those numbers were then combined with the number of different types of businesses throughout Venice to yield a 'total' for waste generated by the dif ferent types of businesses.

3.3.3 Tourist Waste Generation

To gain some quantification of tourist waste generation, we drafted and distributed a survey to a sampling of local businesses, as described in **3.1.5**, aski ng them to estimate the amount of garbage they produced on a given day. For complete data on the survey, please see the following section (**3.3.3.1**). The data collected from the survey was then extrapolated to the rest of the city, with extra care taken to match up businesses of similar sizes and similar locations to obtain the most accurate results possible. A past Worcester Polytechnic Institute project (Re-Engineering the City of Venice's Cargo System), which ca taloged most of the businesses throughout the Historical Center, was used as a primary data source for business sizes and types. The resulting information is the total waste generated by tourism, which was combined with VESTA data of the total waste genera ted in the Historical Center, to find the percentage of waste generated by tourism-related industries. Viewing the results in MapInfo provides island-by-island and regional data for the production of waste, and also the concentration of tourist-created waste.

3.3.3.1 Survey of Businesses

To approximate the amount of waste generated by businesses of various sizes, we conducted a survey of a sampling of businesses in the categories shown in Appendix E. These categories were taken from a previous project to ensure accurate data crossover between information collected last year, and our waste data this year. A copy of the survey used is available for review in Appendix J, and denotes at the top our role as students working with the City of Venice. In an attempt to keep the survey as simple as possible, it was restricted to one (A4 size) page, asking only four questions. The survey, conducted among business owners, was then analyzed for trends in business size and location. It must be noted that the survey relied on perception of composition of waste generated, which does not provide absolute data, but can be used to accurately show trends among the business types.

The survey was distributed to businesses throughout the Historical Center, but the study primarily focused on the San Lio area. San Lio was chosen once again to ensure that we had an accurate picture of waste production there, which we then hoped to extend to the rest of the Historical Center. The reason for surveying businesses outside of San Lio was simply to make sure that we had accurate data for businesses outside of the touristy area near San Marco.

3.3.4 Total Waste Generated

Once we found the total waste generated by tourist -related businesses in the city, we needed to know the total amount of waste dispos ed of by the entire Historical Center to determine the percentage that resulted from tourism. The team again turned to VESTA, which was most helpful in providing the requested information, allowing us to examine data VESTA had collected about the amount of waste collected, transported, and processed at its waste processing and disposal plants.

3.4 Recommendation for a New Recycling System

The synthesis of the information gathered throughout the 8 weeks in Venice allowed us to achieve the ultimate goal of this project: to propose a new recycling system for the Historical Center of Venice that was most feasible given its current situation . The recycling system had to fit within physical, aesthetic, political, financial and practical constraints imposed by the ci ty and citizens of Venice. This objective ensured that all available data was utilized when developing the new recycling system, thereby avoiding oversights that might have adversely affected the success or acceptance of previously attempted recycling syst ems.

3.4.1 Financial Analysis

Using the financial data collected from the garbage system and the recycling system, the team looked for places where underpayment could occur, resulting in the staggering deficit the city faces each year. Accomplishing this requi red extensive reading of legal documents and regulations, including the current and previous waste disposal tax legislation (TIA and TARSU, respectively). The fee schedules described in the legislation were then applied to our estimation of garbage produce d by type of business, to see how much revenue the city should have been receiving.

3.4.2 Current Garbage System Analysis

Using all of our observations of the collection process on the island of San Lio, the transfer station on the Giudecca, the processing pro cedure at Fusina, and all the data provided by VESTA as well as data gathered by the team, we analyzed and brainstor med ways to improve the efficiency at all points of the current garbage collection system. Most brainstorming sessions centered on reducing equipment needed, personnel needed, collection time and/or transfer time required. All of the recommendations that were made involved modifying these logistical features of the current garbage system. We believe if the suggested improvements are made, the money that is saved can be invested into implementing the new recycling system that we proposed.

3.4.3 Recycling System Development

With all the financial information and garbage system analysis in mind, our team started by brainstorming 3 basic recycling systems with each founded on one particular criteria. One system was developed with the primary goal of achieving the highest recycling rate possible. Another was devised to implement recycling but with the lowest startup and operation costs as its primary goal. These first two systems were created with only their primary goal in mind regardless of most of the other criteria involved in our initial analysis. Once these two systems were drawn up to meet their primary goals, other logistics and considerations were filled in while keeping the individual primary goals in mind. Finally, a third recycling system was designed to be the most practical and feasible that considered all possible criteria available. This third proposed system was the one we made in our final recommendation presentation for the City of Venice – Environment Department and VESTA.

The rationale behind the approach we used to develop our final proposed recycling system was to first consider both of the main extremes: high recycling and low cost. We had already concluded that a new recycling system could not be implemented without any initial costs. However, through our research, data collection, and interviews with city officials, we also realized that a system with the highest recycling rate also came attached with a very high implementation cost. As expected, a low cost system would achieve minimal recycling rates and therefore, poorly satisfy the main goal of our project. As a result, we used the two extreme systems to devise a practical solution that would be a moderate compromise between the two extremes.

4 Results

The following results were acquired through a variety of sources, which include research by the team, interviews with officials, observation of processes, and field data collection. The chapter is divided into the following topics:

- **Garbage System** - summarizes the quantitative data the team amassed regarding the process and mechanics of collecting garbage in the Historical Center. Additional information includes the collection schedules, composition of waste in the Veneto region, and the rate of illegal dumping in the Historical Center.
- **Recycling System** - displays equipment data provided by VESTA, as well as a map of the locations of recycling dumpsters.
- **Financial Data** - provides information on the sources of funding for the garbage and recycling process, and comparative costs of collecting garbage in the Historical Center versus a city on the mainland.

4.1 Garbage Collection System in the Historical Center

The team gathered a large amou nt of information regarding the cur rent garbage collection system. M uch of it was obtained from interviews with VESTA officials who proved quite helpful and cooperative. The following sections present data related to the current collection system , garbage composition, and financial aspects of garbage collection in the Historical Center.

4.1.1 Collection of Garbage Process

Garbage collection in the Historic al Center is a far more complicated process than collection in any mainland city. A community of 4500 people takes one garbage truck and one worker on foot an hour and a half to collect all the garbage. A comparably sized community in

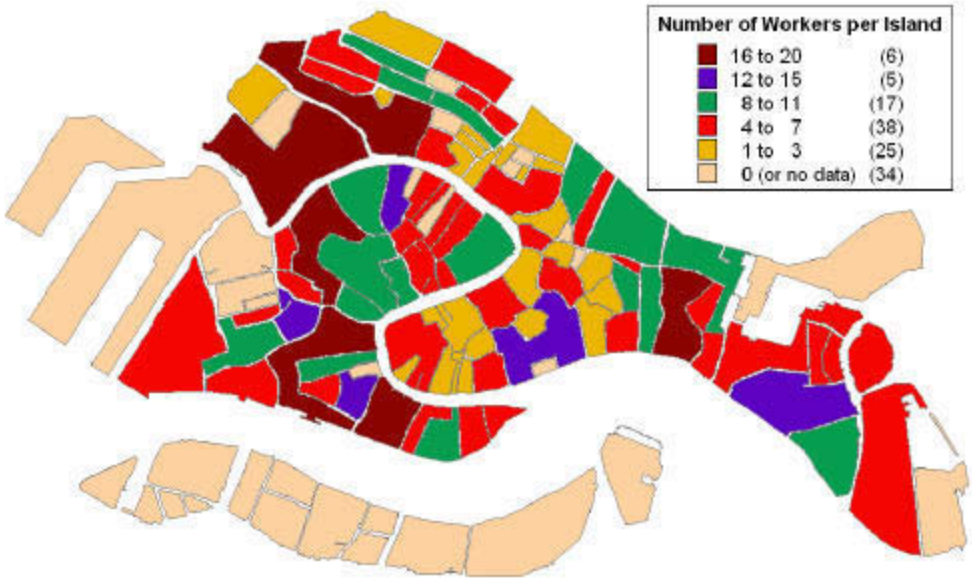


Figure 4.1: Number of VESTA collection workers per island

the Historical Center takes seven workers on foot and two boats (with one driver each) over five hours to service. An additional three hours of travel time are required to get to and from the transfer station every day. The complexity and manpower required to collect garbage in the Historical Center can be seen from **Figure 4.1**, which shows the number of workers assigned to each individual island.

There are over 400 VESTA workers responsible for garbage collection on any given day, including the drivers of 48 garbage boats. Those 48 boats service nearly all 120 islands in the Historical Center (except the Giudecca which is done separately) at close to 200 unique boat stops (or 'postade') seen in **Figure 4.2**.

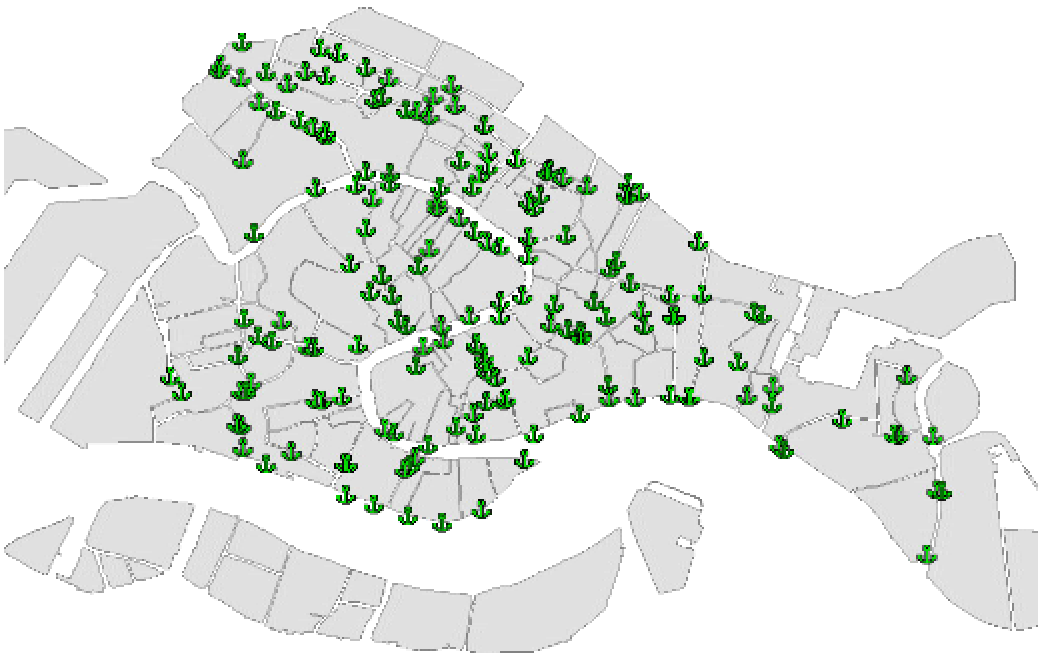


Figure 4.2: Location of all garbage boat stops in the Historical Center

The various stops are scheduled to cover the greatest area in the most efficient manner. Trash pickup begins early in the day before there is too much foot and boat traffic which slows down collection. The first boats moor to their stops by 7:30am. The last scheduled docking is at 11am.

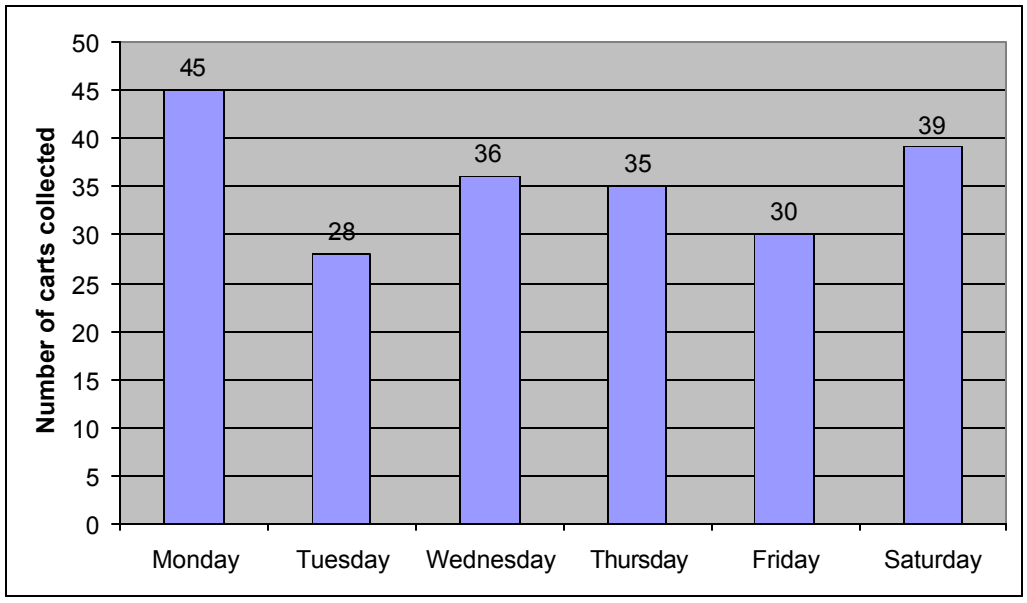
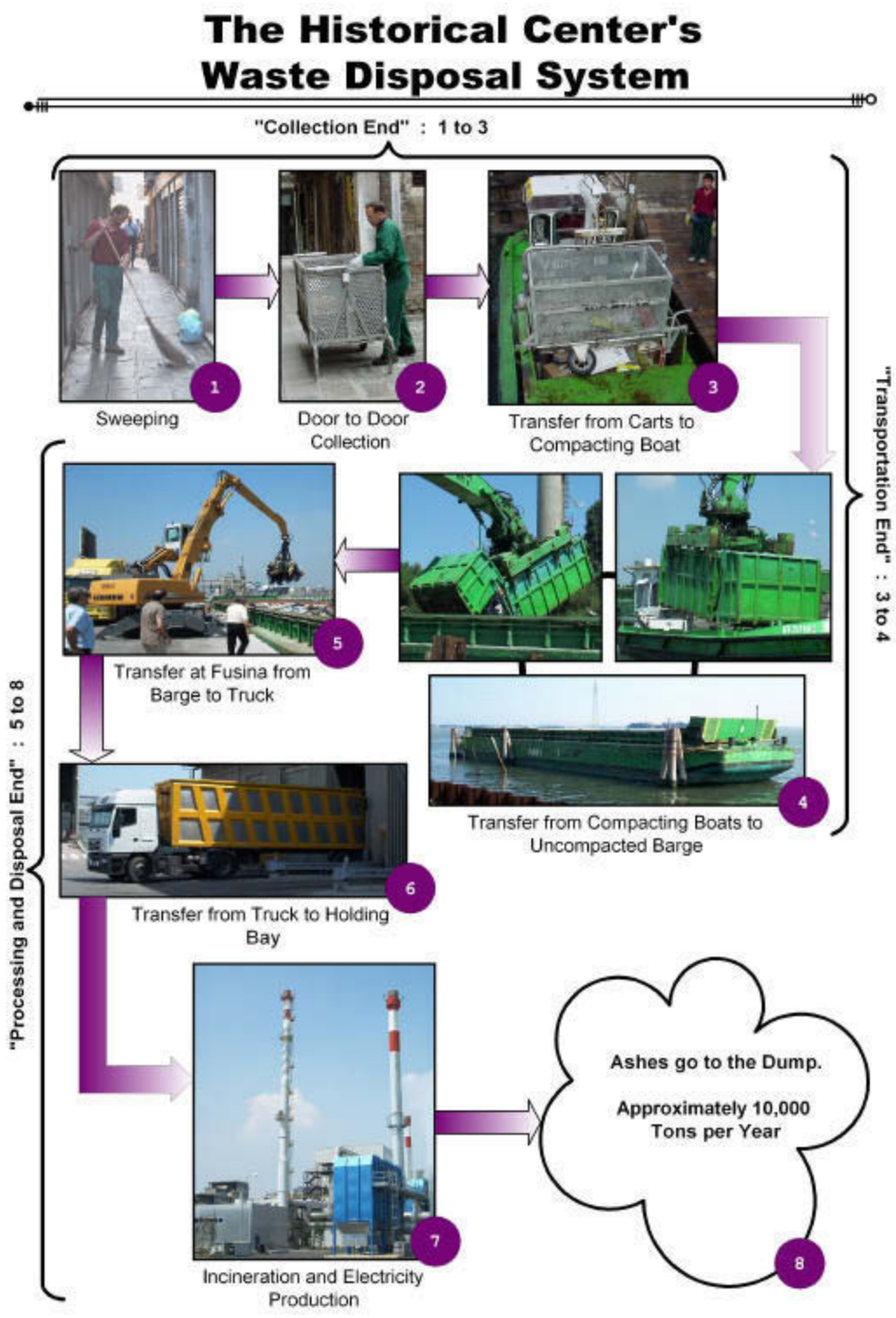


Figure 4.3: Number of carts collected in San Lio by day

Garbage is collected daily except on Sundays. Garbage volume is greatest on Mondays and Saturdays, and lowest on Tuesdays and Fridays, as seen in **Figure 4.3**. The total amount of waste generated by the Historical Center is over 50,000 tons per year, according to VESTA officials.



The above flowchart provides an overview of the collection process used in the Historical Center. Detailed information about each part of the process is prov ided in the following sections.

4.1.1.1 Sweeping

Starting as early as 6:30 am, VESTA workers begin sweeping the various streets and plazas in the Historical Center . While the y sweep the loose litter into piles that they collect later, the workers also replace the bags in any public trash cans on the island. There are roughly 900 public trash cans in the Historical Center , some 10% of which are in San Marco.

Figure 4.4: Street sweeper with replacement garbage bags

In a few select sq uares, where pigeons are a persistent problem, the workers use high -pressure water hoses to remove the hardened filth from the stones. Unfortunately, continuous use of these hoses can wear away the stone, causing pitting and requiring more frequent replace ment.

VESTA workers are also responsible for laying down the 'el evated walkways', which are planks of wood, in times of 'Acqua Alta', or high water. There are approximately 5.5 kilometers of planks available for use throughout the city, a whole kilometer being dedicated to San Marco. Sweeping and maintenance of the streets and public places is usually completed by 7:30 or 8 am, at which time the workers turn their attention to collecting the day's garbage.

Figure 4.5: Washing & Sweeping San Marco

4.1.1.2 Garbage Collection Carts

Once the streets have been swept, the garbage collectors retrieve their trash carts from the building or alley in which they are stored overnight. These carts can hold 900 liters and are specially designed for VESTA, with a hinged bottom panel which opens to dump the contents of the cart when picked up by the garbage boat. The cart itsel f weighs about 60 Kg, but is designed in such a way that it can still be pushed fairly easily even when it is loaded with 180 Kg of trash. The collectors follow a pre-determined route through the streets of their island, collecting the trash bags left in t he streets, knocking on doors of buildings which have trash bags or bins left inside, and entering businesses where necessary. When the cart becomes too full to pick up any more trash, the collector brings the cart to a designated boat dock where a garbage boat is waiting. Once the cart has been emptied (see the following section for more details), the collector resumes his route where he left off and repeats the process until his route has been completed.

Figure 4.6: Garbage cart used in the Historical Center

Along the way, the collector picks up any piles of litter he made earlier while sweeping, as described in the previous section.

4.1.1.3 Garbage Boats

When a collector arrives at the boat stop with a full cart, any over flowing bags must be thrown into the boat by hand to make room for the large handle, which is used to lift the cart onto the boat, to swing up into place. Since the average cart load is 1.3 times the capacity of the cart, the process of making room for the lifting arm can be considerable. Once the lifting arm is clear, the boat driver manipulates the onboard crane to lift the cart onto the garbage boat. The cart is placed on supports elevated above the insert which allow the bottom of the cart to open and t he garbage to drop into the compactor insert. The garbage boat's compactor runs off the boat's engine and is able to compress the garbage in a 3:1 ratio. (This allows the boat to carry about three times as much garbage by volume.) The boat can carry a maxi mum of 30,000 liters (30 m^3) of compressed garbage before it needs to be taken to the garbage transfer station on the westernmost end of the Giudecca where it is emptied onto a larger barge for transport to the processing plant on the mainland.

Figure 4.7: Garbage boat with compactor insert

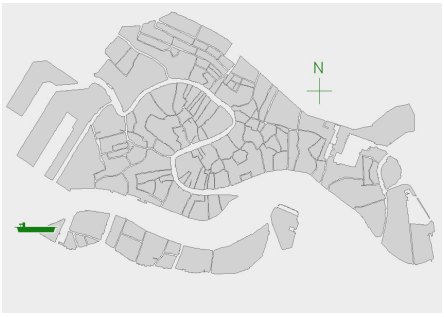


Figure 4.8: Map of Historical Center showing waste transfer station

4.1.1.4 Bulk Item Pickup

VESTA also runs a collection route for items too large for standard garbage boats. Items like stoves, refrigerators, toilets, construction materials, and oversize boxes are picked up separately from regular trash. The five ingombranti (large item) collection boats are distributed throughout the five collection zones VESTA uses, and are run on both scheduled pickups for businesses with consistent pro duction of large item trash, and on a request basis for other

Figure 4.9: Ingombranti boat loaded with cardboard

businesses or residents. Ingombranti pickups are scheduled in the mornings, like all other trash collection, and use separate stops from the standard trash boats to minimize interference.

4.1.1.5 Transfer Station

When a full garbage boat arrives at the transfer station, it pulls up to a line of pillars that serve as a waiting area for the boats. Since there is only one crane machine used for emptying the garbage boats, and many of the boats arrive at the transfer station simultaneously, there can be a backlog of boats waiting to be emptied, and some are actually docked and not emptied until after the drivers take their lunch break.

Figure 4.10: Crane lifting insert from garbage boat

The crane used to empty the inserts has a large arm lifter with an attachment designed to latch onto the boat insert; it is capable of hoisting 26 tons. Once the crane has latched onto the boat insert, the garbage boat operator manually disconnects the hydraulic hoses connecting the compactor to the boat engine, and then replaces them with the hoses from the lifter. At this point, the insert is ready to be lifted out of the garbage boat and the crane operator has complete control of the hydraulic system in the insert. The insert is moved over a large open barge that is docked next to the crane and opens the hydraulic hatch on the front of the insert. The crane operator then activates the insert's compactor, which forces the remaining garbage to fall out into the barge. This operation takes over 90 seconds, not including the time needed to pull the boat up to the dock and swap the hydraulic hoses.

There are two different barge sizes used at the transfer station: large barges that can hold 1200 m^3, and small barges that hold 500 m^3. On most days, the waste generated by the Historical Center fills two small barges, or one large barge. Every afternoon, the barges are taken by tug boat to the waste disposal and processing plant located across the Venetian Lagoon at Fusina. Once emptied, the empty barges are taken back to the transfer station to be refilled every morning. There are a total of 2 large barges and 6 small barges for waste transportation to Fusina. The extra barges are used for garbage collection on the Lido (one small barge per day), and for replacing barges in case of maintenance.

Figure 4.11: A small (500 m^3) barge

4.1.1.6 Fusina Waste Processing and Disposal Plant

The garbage barges are pushed by tug boat to the Fusina processing and disposal plant which handles all 50,000 tons of waste generated by the Historical Center, plus 200,000 tons from the remaining Municipality of Venice and some surrounding communities. The plant was designed in the 1980s when it became clear that the old incinerator for the Historical Center (located where the garbage transfer process now occurs on the Giudecca) was outdated and could no longer handle the volume of waste that the Historical Center was generating. The old incinerator was shut down in 1984 for health reasons and garbage from the Historical Center was sent to a landfill for twelve years until the new disposal facility at Fusina became operational in 1996. The new Fusina processing facility is a joint venture between EcoProgetto Spa and VESTA Spa, and was designed by the German company Ladurner.

Once the barge is docked at Fusina , only a few hundred meters from the processing plant, the trash is removed by a crane with a bucket scoop type attachment , and transferred into the trailer of an 18 -wheeler truck with an open hatch on top. Each trailer can hold 100 m^3, which means it takes between ten and eleven truckloads to empty the 1,000 m^3 of waste generated on a typical day . Once full, each truck transports the garbage the few hundred meters to the entrance of the processing facility, where they dump the trash into a giant containment facility for storage until processing takes place.

Figure 4.12: Crane with bucket scoop emptying barge into a truck at Fusina

4.1.1.6.1 Processing

There are three separate disposal processes used at the Fusina plant, plus a wood chipping process. The three disposal processes are: incineration, composting, and the creation of CDR (Combusibile Dei Rifiuti) for sale to coal and biomass power plants.

4.1.1.6.1.1 Incinerator

The first waste disposal process in use at Fusina is the incinerator , designed to operate at less than 1/5 of EU emission standards. This disposal method handles all of the Historical Center's 50,000 tons of waste per year. The waste is driven by truck from the barge docking location to the entrance of a storage facility w here it is contained until there is room in the incinerator. The heat generated from the burning garbage is used to drive turbines which create 2.1 MW hours each year, which is sold for .14 Euro per KW, higher than the normal electricity rate thanks to nat ional subsidies and rewards for energy generation from waste. The incinerator reduces the garbage to ¼ of its former mass; the remaining material being in the form of toxic ash that must be disposed of in a special dump to prevent heavy metals and other to xins from seeping into the groundwater. The smoke from the incinerator passes through state -of -the-art filters, including active -carbon and wet -lime filters, to reduce the acidity of the smoke. The smoke itself is then burned to reduce emissions even further, so the resulting emissions of the plant are one fifth of the EU allowable rate.

Figure 4.13: Smokestacks of the Fusina incinerator

4.1.1.6.1.2 Compost

Compost collected from the Municipality of Venice is sent to a large enclosed warehouse with separated holding chambers for compost -able material. Very little mech anical intervention is required aside from occasionally turning the piles over to ensure that all the material composts completely. The building is kept warm to facilitate the bacterial growth necessary to break the material down to dirt. Once this process is complete, the compost is sold to farmers and greenhouses in the form of fertilizer for its high nutrient content. The compost containers collected in the Historical Center (see Section 4.4.2) are sent here along with compost from the rest of the municipality. In all, the facility composts 64,000 tons per year, ab out 80% of its current design capacity.

4.1.1.6.1.3 CDR

CDR, Combusibile Da Rifiuti, is compressed waste which contains material of high caloric value that is sold to power plants specially designed to burn biomass of its kind. It is produced from the 120,000 tons of undifferentiated waste received from the Municipality of Venice (none of the Historical Center's waste becomes CDR). When trucks carrying trash from the municipality arrive at the processing facility, they empty their trailers onto a conveyor belt that sends the waste through a shredder and a final sorting process (the waste is presorted by the residents since all CDR destined material is from areas with recycling programs) to eliminate any large objects or objects with hazardous burning properties. Roughly 10% of the waste entering the plant is weeded out in this sorting process, most of it being metals larger than 35 mm in diameter.

Figure 4.14: CDR baled and loaded on trailers for distribution

The shredded waste is then picked up via an automated overhead crane and dumped in a large cement storage area to await its final trip to drying 'cells' where it is dried for seven days by fans blowing hot air. The facility houses 15 of these cells, with about two cells filled per day. Once the material in the cells has dried for seven days it is placed on another conveyor belt and sent to a compactor which makes large cubes (roughly 1 m^3) of the CDR that are then shrink-wrapped in plastic. Finally, the CDR is shipped out and sold to power plants equipped to burn CDR. The Fusina CDR plant processes about 500 tons of CDR per day, with a staff of only 7 workers overseeing the entire operation at any time, thanks to a completely automated process.

4.1.1.6.1.4 Landfill

Any waste that cannot be burned, composted, or made into CDR is filtered out through the sorting process and is sent to a landfill. Roughly 20,000 tons of waste go to the dump annually, of which 10,000 tons is ash from the incinerator, and the remaining 10,000 tons is bulky items, construction materials, non-combustible materials, or hazardous waste.

4.2 Garbage Composition

Garbage composition for the Historical Center specifically was not available through census data, so the team conducted a survey of businesses to discover what types of businesses produce recyclable waste. The data gathered by the team was supplemented with garbage composition data for the Veneto Region found on the website for ARPAV (Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto), the Italian equivalent of the Environmental Protection Agency (EPA) in the United States .

4.2.1 Garbage Composition in San Lio

The composition of garbage generated by small businesses was observed by the team to be mostly cardboard. Among small businesses such as tourist shops (mask, trinket, and glass, souvenir stores), bookstores , clothing stores, and service locations (internet, cell phone, non-retail stores) - the most common small businesses on the island of San Lio - the volume of cardboard generated easily exceeded the other types of garbage produced. Our survey results confirmed our observations. The reported volume of cardboard and paper generated by these businesses as a

Figure 4.15: Paper/cardboard waste composition among small businesses

proportion of their total waste is shown in **Figure 4.15**. In regards to the amount of cardboard and plastic packaging found in the garbage from businesses, we were informed by both VESTA officials and City officials that packaging businesses are responsible for disposing of their respective packaging through an EU (European Union) mandate. However, there has yet to be widespread enforcement of this regulation (see SECTION ON IMBALLAGGI for more information).

During our examination of the San Lio area, the garbage generated by the SuVé supermarket was observed. The waste was observed to be almost exclusively packaging material (or 'imballaggio'), for which VESTA is not responsible since the implementation of the packaging producer law mentioned above. For complete results of the types of materials disposed of by businesses, please refer to Section 4.2.2.

4.2.2 Garbage Composition by Businesses for the Historical Center

The following figures were obtained through surveying a wide variety of businesses, mostly in the San Lio area. The observat ions of the team showed that 287 m ^{3} of waste is produced every day throughout the Historical Center, or roughly 20% of the total waste generated.

Our results from surveying businesses indicate that a vast majority of business waste comes from eateries and fruit stands. An average fruit stand disposed of several dozen fruit crates each day. Likewise, eateries (c afes, prepared food, and restaurants) showed a markedly higher garbage generation than most other business categories.

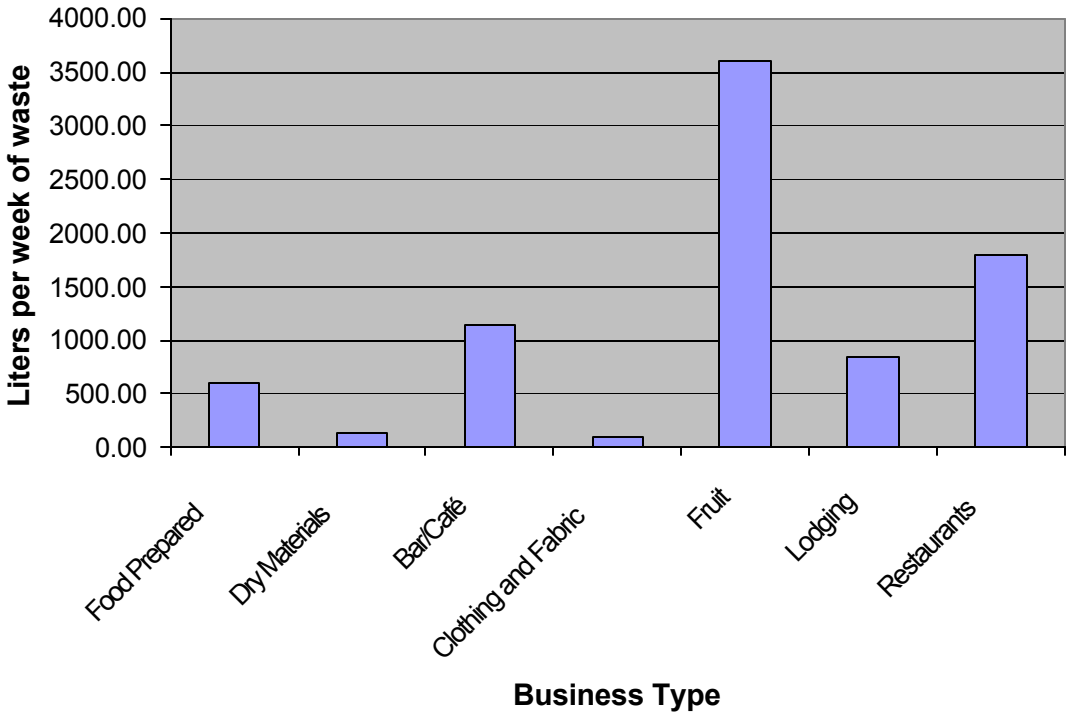


Figure 4.16: Waste generated per week by businesses surveyed in San Lio

In terms of garbage composition, stores that sell dry merchandise, such as hardware stores, mask stores, glass stores, and electronics st ores, generated very little waste. Additionally,

almost all their garbage is composed of paper and cardboard products, which are prevalent in packaging. The rest of their garbage is either plastic or employee -generated generic garbage.

Restaurants, fruit s tands and hotels showed a different composition than most other businesses; their garbage consisted of a wide variety of materials, such as disposed food, plastic bottles, metal cans, cigarette butts, wooden boxes, etc. Fewer recyclable materials are gener ated overall by these types of establishments.

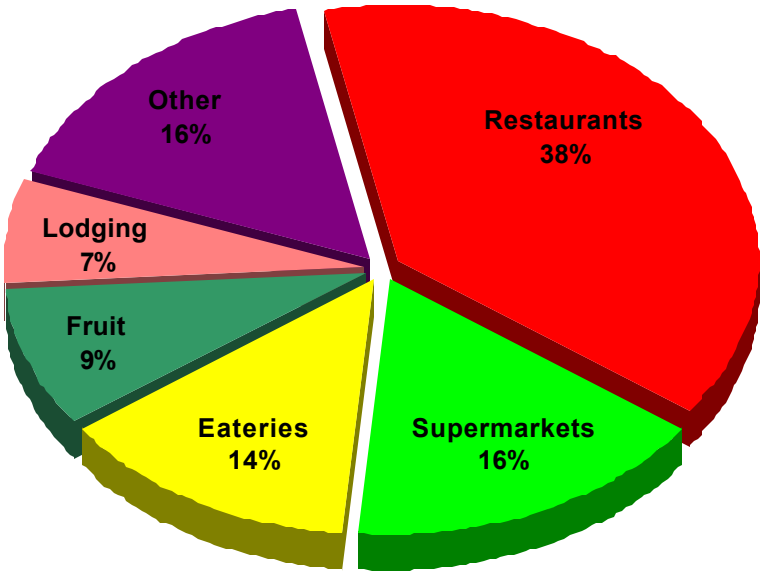


Figure 4.17: Percentage of total waste generated by business types

In our surveys we also included a parameter for the amount of packaging material present in the businesses' waste. Again, the numbers varied between retail stores and

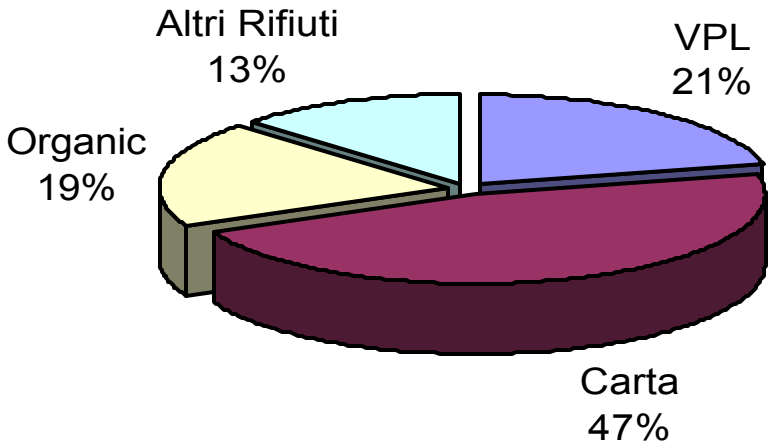


Figure 4.18: Garbage composition reported by businesses in San Lio

hotels/restaurants/fruit stands. On average, dry goods retail stores generate 90 -100% packaging, while the others generate 40-60% packaging.

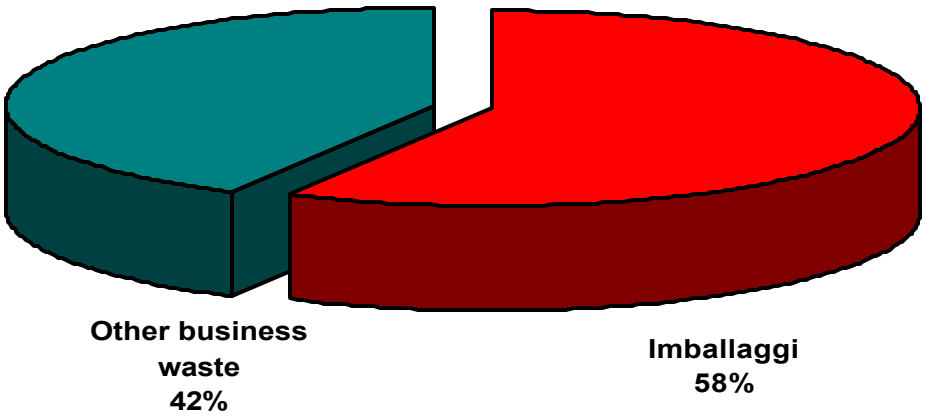


Figure 4.19: Percent of business waste comprised of imballaggi

Using a weighted average of the amount of garbage the businesses produce and comparing them to the business index created for the 2000 Cargo IQP, it was determined that among the waste produced by all businesses in the Historical District , approximately 60% (166 m^3) of it consists of *imballaggi,* or packaging material.

4.2.3 Garbage Generated from Tourism Related Businesses

Using business data gathered from a previous project (E01 – Cargo), we used our percentage of total waste generation by bu siness type and waste composition results to approximately calculate the total amount of tourism-related waste generated and how much of it is potentially recyclable. Below you see a breakdown of business types by island in the Historical Center.

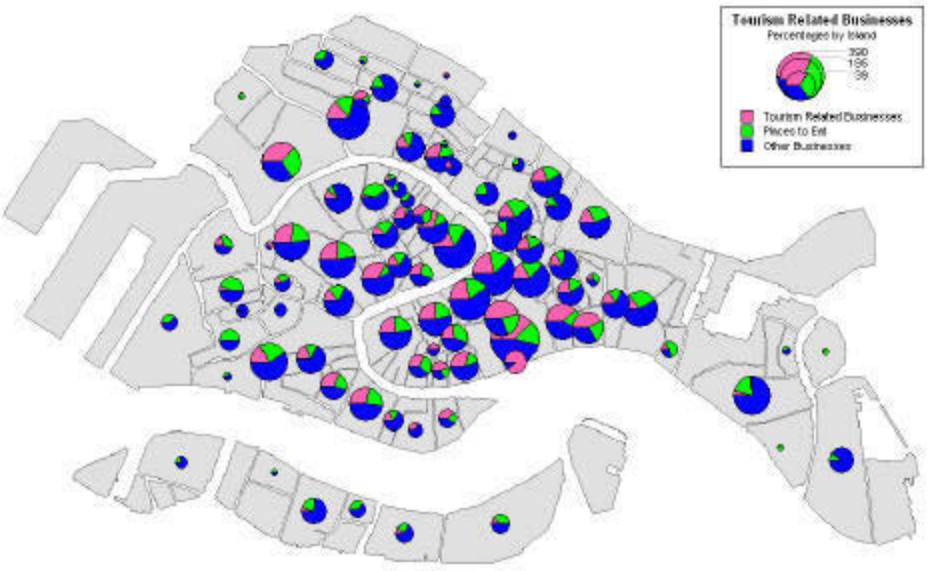


Figure 4.20: Percentage of tourism-related businesses by island

Interviews that were conducted with VESTA officials and restaurant owners revealed the observation that businesses may be falsely identified as the main culprits in waste generation since their waste accumulates in bulk. Businesses such as restaurants are merely a gathering point for residents and tourists that would otherwise collectively generate the same amount of garbage individually elsewhere. Therefore, the results of waste generated by tourism were deemed inconclusive.

4.2.4 Garbage Composition Data for the Veneto Region

The following figures were obtained through research on the ARPAV website and shows data collected during 2001. All numbers are in tons, except for population.

From **Table 4.1** one can see that the Municipality of Venice (bordered in red) has the third lowest rate of waste differentiation, which indicates a low recycling rate. Since the data is for the entire Municipality of Venice, it is not possible to determine the exact rate of waste differentiation for the Historical Center. However, it is known that Mestre, a large city located on the mainland of Venice, has a well established recycling system, which would raise the overall recycling rate of the Municipality.

Again, it is evident that the Municipality of Venice (VE 2) has the 3rd lowest differentiation rate of all the municipalities shown. The two regions with lower differentiation rates (VE 1 and VI 4) have peculiar circumstances which may limit their access to recycling. VE 1 is the easternmost municipality in Italy (SO WHAT??), while VI 4 is a municipality of just 21,000 inhabitants in the Italian Alps, where recycling is difficult due to terrain. The table also shows the extremely high rate of waste generation for this municipality (compare the 'Total Urban Waste'

columns of VE 2 to VR 5 or TV 1, two municipalities with similar populations), a fact which can be attributed to the 12 million tourists the Historical Center sees each year. VESTA considers the tourists as an additional 100,000 permanent residents for the municipality, a number which can be verified by looking at PD 2, which has 100,000 additional full-time inhabitants, but produces only 12,000 more tons of waste than the Municipality of Venice does.

Municipality	# of Residents	Non-differentiated Urban Waste	Total Differentiated	Total Urban Waste	% Differentiated
PD 2	391.267	161.021,1	60.585,0	221.606,2	27,3
TV 1	282.017	46.878,0	46.569,0	93.447,0	49,8
VE 1	90.950	54.289,6	13.501,9	67.791,5	19,9
VE 2	294.728	166.350,5	43.222,3	209.572,8	20,6
VI 4	21.511	11.594,5	1.446,5	13.041,1	11,1
VR 5	305.855	121.234,5	36.569,0	157.803,5	23,2

Table 4.1: Waste composition data by municipality

4.3 Illegal Dumping

The Municipal Hygiene Regulation for the Municipality of Venice forbids the abandonment of refuse at any time of the day except between 6 am and 8 am on the days where garbage collection takes place (daily except Sunday). Between those hours, residents and businesses are allowed to leave their trash directly outside their door, or in a spot where it will cause the least problems for pedestrian and cargo traffic in the city.

Despite this regulation, we observed a substantial amount of garbage left outside for entire days (in the case of weekends) and particularly overnight. The following tables and charts quantify the rate of illegal dumping as observed in the San Lio region over a weeklong time span.

The rate of illegal dumping observed on the island of San Lio by the team throughout a weeklong period is shown in terms of the percentage of the total waste generated. The total waste (legally and illegally dumped) generated for the San Lio island during a week was found to be 191,700 liters, or 191.7 m3. The waste generation data collected can be seen in **Figure 4.3**, where a cartload is equal to 900 liters.

We recorded the size and type of each instance of illegal dumping, and calculated the total volume of waste disposed of illegally. All data were collected between the hours of 10 pm and 3 am. The field data collection form used is available for review in Appendix S.

Results for the entire week of data collection are displayed in **Table 4.2** below.

Illegal Dumping in San Lio for Week of 8 - 14th of July, 2002				
Size of Illegally Dumped Item (Liters)	# of Bags	# of Boxes	# of Misc Items	Total Volume of Illegally Dumped Waste (Liters)
10	429	0	2	
20	0	40	2	
40 100	32 67	21 9	0 51	
150	0	0	0	
				19,970

Table 4.2: Chart showing illegally dumped items by container and volume

Figure 4.21 shows the percentage of waste dumped illegally in the San Lio campo. If the ten percent figure holds across the entire Historical Center, the volume of waste dumped illegally every year would fill Piazzale San Marco to a depth of over four meters!

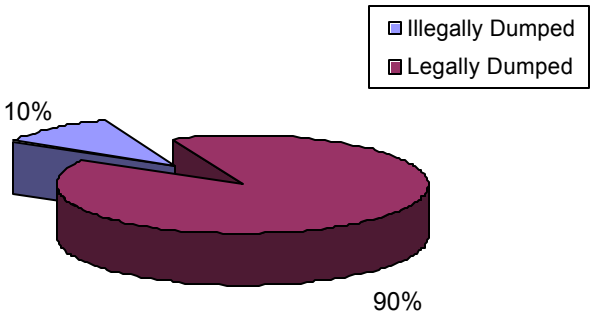


Figure 4.21: Percentage of waste dumped illegally in San Lio per week

The following table shows the fluctuations in the rate of illegal dumping. This chart only shows the dumping rates for bags, omitting boxes and other miscellaneous items. Of particular note is the number of bags dumped on Saturday night, since there is no garbage pickup on Sunday. Bags dumped on Saturday are therefore left out for two nights. The values for Sunday are the number of **unique** bags left out Sunday night; in other words, the values for Saturday were subtracted from the tallied number of Sunday bags.

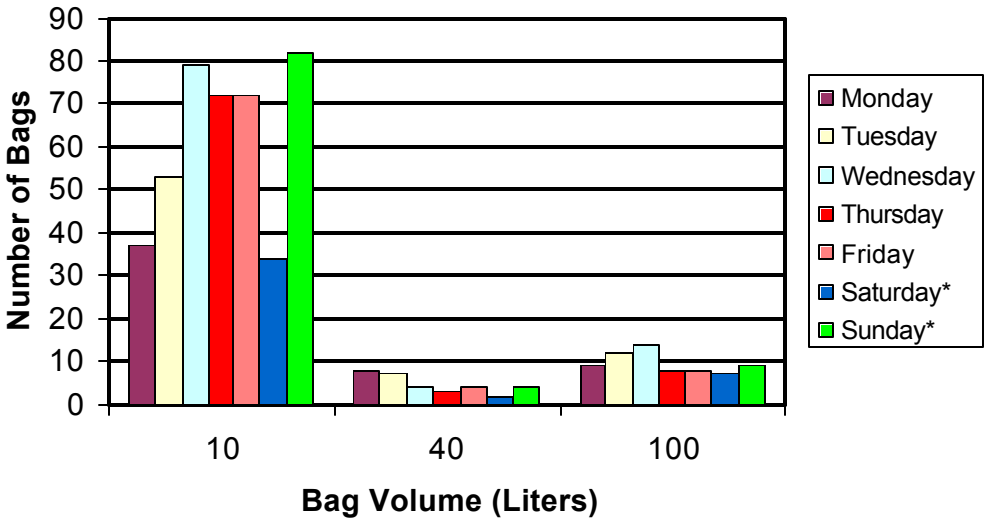


Figure 4.22: Number of bags dumped illegally by day and volume

4.4 Recycling Collection System in the Historical Center

The results of our investigation into the recycling system are shown below and are comprised of:

- Equipment
- Dumpster Locations
- Collection Schedules

4.4.1 Locations

Unlike the garbage collection of the Historical Center, the recycling of waste is done on a bring-your-own, or 'autoconferimento' basis. There are about 40 recycling locations throughout the Historical Center (including the Guidecca), with each location serving about 500 residents. These locations generally have some combination of three types of receptacles; plastic/glass/metal, paper, and organic. The plastic/glass/metal (PGM) and paper receptacles are small dumpsters, approximately the same size as a trash cart (900 L), which rest on four wheels and have lids that are colored to identify the type of recycling dumpster. Some businesses have their own paper recycling bins, which are yellow trashcan sized (around 150 L) containers that the businesses keep indoors and notify VESTA when they become full. There are 900 of these paper bins in 250 businesses throughout the Historical Center. The final type of differentiated material collected is the organic waste. Organic receptacles are bins very similar to those used for paper in businesses, except they are brown in color and have special lids to prevent animals from scavenging at any food remainders and also allow for ventilation to dampen the odor of the bins. A map showing the recycling locations is provided in **Figure 4.25**. Note the dearth of locations in the center of the city, where many of the largest restaurants and hotels are located.

Figure 4.23: Dumpsters for PGM

Figure 4.24: Organic compost bins

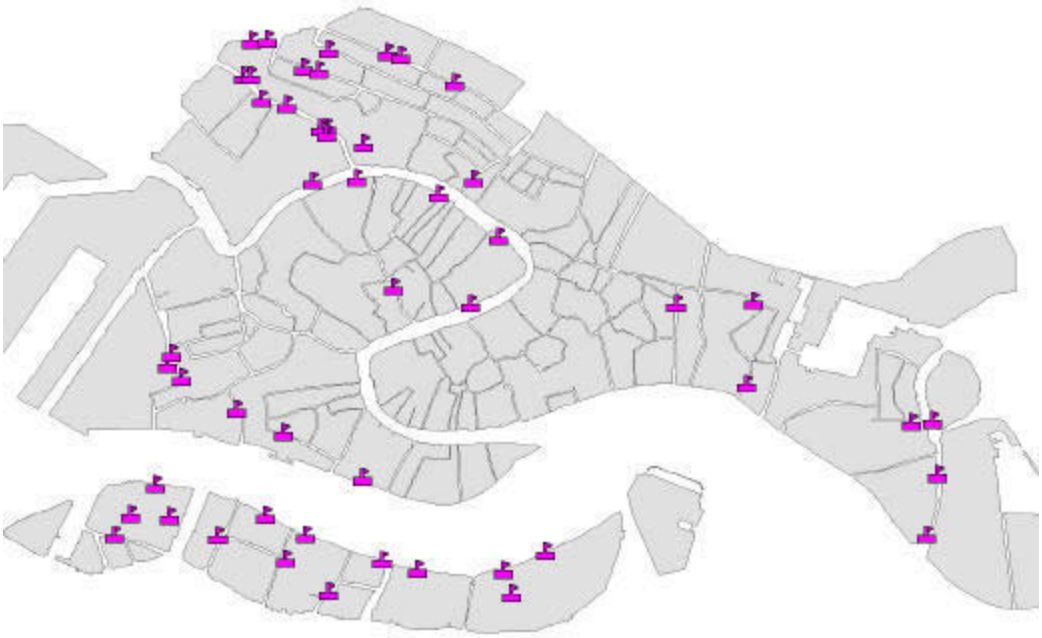


Figure 4.25: Map of recycling locations in the Historical Center

4.4.2 Collection of Recyclables

Recycling bins are collected according to their amount of use; therefore, a location that has a high participation rate will be emptied more often than a location with little participation. All recycling containers are emptied on a weekly, biweekly, or tri-weekly basis (as seen in **Table 4.3**), in accordance with the guidelines below. While PGM and paper material is simply dumped into the collection boat the same way garbage is, compost bins are actually taken aboard the boat

Contenitori	Quantità	Frequenza Raccolta
Cassonetti Raccolta Carta: Si	1	Bisettimanale
Bidoni Gialli Carta: No		
Campane Vetro Plastica Lattine: No		
Cassonetti Raccolta Vetro Plastica Lattine: Si	1	Bisettimanale
Bidoni Verdi Raccolta Vetro Plastica Lattine: No Biobidoni Raccolta Frazione Organica: Si	1	Trisettimanale
Cassonetti R.S.U.: Si		

Table 4.3: Example of recycling schedule data from VESTA

and replaced with clean bins. This reduces health and odor issues associated with leaving compost material left sitting too long outside. Recycling boats are the same type of boat used for garbage pickup except the compactor insert is replaced with an open bin (because compaction hinders sorting of the recyclable material). The open containers do not lose space to the machinery needed to run the compactor, but they do lose the ability to compact the load. For this

Figure 4.26: Boat with clean compost bins

reason, the open recycling inserts have a capacity of 18 m^3 (more than a garbage insert, but less than the volume of compressed garbage regular inserts can carry). The dumpsters used for PGM and paper are emptied in a manner very similar to that used for garbage carts. The dumpsters are equipped with a lifting arm and a false floor. The collection boats simply pick the dumpster up with the crane onboard the boat, and let the floor of the dumpster drop out above the boat insert. When yellow paper bins from businesses are emptied, the same open-topped inserts used to collect PGM are used. VESTA workers must dump the contents of the bin into the boat by hand. The boats used to pick up the compost are the only boats used without a container insert. In the place of the insert, the boat has a platform on which up to 24 replacement containers are carried. The boat's crane lifts the clean empty containers off the boat and places the full containers on the boat for transport to the composting facility.

Figure 4.27: A PGM collection boat

4.4.3 Processing of Recyclables

Unlike the garbage processing, all of the recycling processing is done by external companies, while Fusina receives only the compost portion of the differentiated material. Recycling boats for PGM and paper take their full loads to the transfer station just as garbage boats do. There the inserts are emptied in a manner similar to that used for garbage boats. The transfer station has a small (500 m3) docked barge that has three separate compartments; PGM, paper, and bulk waste (picked up separately, see Section 4.1.1.4). The inserts are emptied into their respective compartment of the barge and placed back on the boat. The barge is emptied every two weeks in the summer time, and every 10 days in the winter.

Figure 4.28: A recycling container being emptied into a barge

The compost bins are taken directly to Fusina, where they are emptied into the containment areas described in Section 4.1.1.6.1.2. The bins themselves are cleaned and used to replace the full bins during the next collection round.

4.5 Financial Data

The following information was either gathered through interviewing City of Venice and VESTA officials and/or obtaining documentation by request or research on the internet.

4.5.1 Cost of Garbage Collection

Venice's waste management system is considerably more expensive than systems based entirely on land municipalities. During our trip to Fusina, it was revealed by the managers there that the garbage collection process in the Historical Center is approximately four times more expensive per resident than servicing comparable populations on the mainland.

On the mainland, a single truck can service over four thousand residents in little more than one hour, using only a 2-man crew to do the job. On the island of Burano, which has a similar population, requires considerably more effort to service. First, a trip from the garbage plant to Venice takes 1.5 hours each way. Additionally, six people are needed to sweep and service the islands themselves. Furthermore, two boats are needed which adds the expense of two more boat drivers. The collection process itself takes a couple of hours among the entire crew.

4.5.2 TIA

When the TIA (Tariff for the Cleanliness of the Environment) was first introduced as a replacement for the earlier TARSU (Tax for the Disposal of Urban Solid Waste) formula, an introductory formula was presented, based on the TARSU [51]. This introductory formula was designed to ease the transition from the TARSU to the TIA by making a modification to the TARSU rather than eliminating it all together. (Please see Appendix N for complete TIA law documentation.) The TIA is now firmly established, and has lost all dependence upon the TARSU. The TIA was a response to concerns that the taxation for waste disposal was not based upon actual waste production, but area of the buildings. The TIA is designed to take the actual production into consideration through the use of constants of garbage production calculated from experience and surveys. The formula shown below is the formula currently in use by the City of Venice.

TF is the fixed portion of the tariff, charged to all residents and businesses as a 'flat fee', regardless of all other variable factors. This fixed portion is calculated by adding up the sweeping costs, administration costs, cost of limited recycling, miscellaneous community costs, other costs, and capital costs, plus a fixed constant times the sum of the cost of collecting recyclables plus the cost of waste treatment.

[51] Linee Guida per la Gestione della Tariffa dei Rifiuti Urbani. ARPAV

TV is the variable portion of the tariff, wherein location and size of household or business is taken into consideration. It is calculated by summing the cost of collection and transportation of waste, with the cost of treatment and disposal of t he waste, plus a pre-defined constant multiplied by the sum of the cost of collecting recyclables and the cost of treating recycled materials.

TF = CSL + CARC + CGD + CCD + AC + CK + quota (CRD + CTR)
TV = CRT + CTS + quota (CRD + CTR)

Legend:
TF = Fixed portion of tariff
CSL = Cost of sweeping and cleaning public roads and squares
CARC = Administrative costs of assessment, collection, and litigation
CGD = Cost of operating differentiated systems
CCD = Various common costs
AC = Other costs
CK = Capital costs
CRD = Cost of collection for differentiated material
CTR = Cost of treatment and recycling (to clean the proceeds of the sale of material and energy derived from the waste)

TV = Variable portion of tariff
CRT = Cost of collection and transportation of urban solid waste
CTS = Cost of treatment and disposal of urban solid waste
CRD = Cost of collection for differentiated material
CTR = Cost of treatment and recycling (to clean the proceeds of the sale of material and energy derived from the waste)

Other suggested formulas can be found in Appendix N.

While the accuracy of the TI A is disputable, as it is based upon square footage of the building, and not actual garbage production, a greater problem facing the City of Venice is the areas of waste collection and city maintenance that the TIA was never designed to account for. Every year, the City of Venice pays VESTA 10 million Euros out of general funds to account for the deficit between money brought in by the TIA, and the actual cost of collecting garbage in the Historical Center. There are at least four reasons for this under all ocation of funds:

- The TIA was intentionally designed to collect less than the full amount of money required to pay for the collection of waste, because of EU mandates which force the producers of packaging material to take responsibility for the recycling of such material.
- The fact that VESTA has responsibilities extending beyond simply collecting and processing garbage, including city maintenance and city beautification projects not covered by TIA funding.
- The high cost inherent in nearly all aspects of la rge-scale operations in the Historical Center due to the complexities brought about by canal transportation.
- The high rate of tourism in the Historical Center.

Each of the above factors is surmountable. However, in the Historical Center's case, everything accumulated to create the monumental deficit it now faces. The first problem is the enforcement of the EU packaging mandate. Since the EU mandate is considered a law in Italy, it was taken into consideration when drafting the TIA, with no consideration as to whether all the communities had methods or means of ensuring that the packaging producers really do pay for their share. Currently, imballaggio is collected from businesses along with any other sort of trash during the collection routes. Yet the businesses who generate this waste are not paying for the collection or disposal of it, increasing costs for VESTA (and eventually the taxpayers of Venice). There is much confusion about this packaging law, and it may be that many people do not even know it exists. So to place blame on any group would be unjust. Yet the fact remains that 12% of all of the Historical Center's waste is being disposed of without proper payment, as seen in **Figure 4.29**.

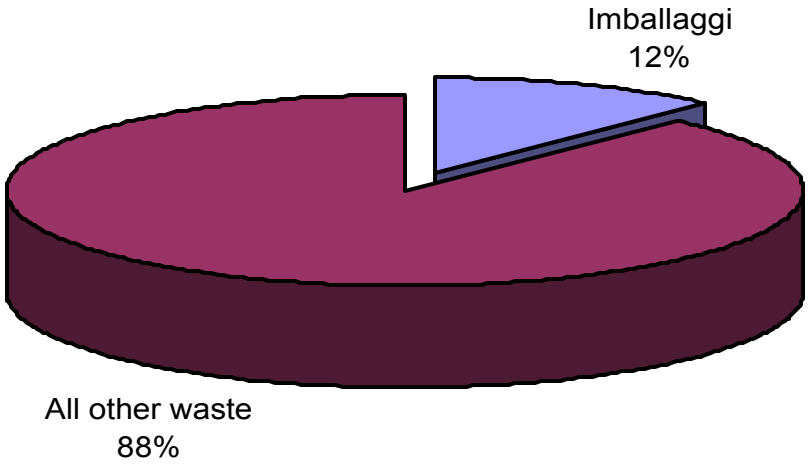


Figure 4.29: Imballaggi as percent of total waste

The second issue is the maintenance of public property which is not covered by the TIA. As discusses in Section 4.1.1.1, every morning for an hour or more, workers sweep and wash the streets and squares of Venice. This time consuming activity is not considered in the collection of waste, and is therefore unaccounted for by the TIA formula. Similarly with other public works projects such as park maintenance (for which VESTA is also responsible), they require manpower and capital to keep Venice an attractive tourist destination, but these activities are left out of the TIA calculations as well.

The final problem with waste collection in Venice is the transportation and logistical problem created by the canal system. As briefly mentioned in the beginning of section 4.1.1, two identically sized communities, one on the mainland and one in the Historical Center, can vary dramatically with regard to the amount of work required to service the area. In an example provided by VESTA officials, it requires 15 times the number of man-hours to serve the same sized community (in population and land area) in the Historical Center as it does on the

mainland, resulting in significantly higher costs to VESTA. Thus, it would be logical to assume that residents and businesses of the Historical Center pay significantly more for garbage collection (about four times as much, as previously mentioned). Nevertheless, this is not the case. Due to complaints and political pressure, the rate of taxation for garbage collection in the Historical Center, while it is higher than the mainland, is not correspondingly higher given the higher cost.

The final problem the city faces with garbage collection is the incredible impact that tourists have on the garbage production of the city. In a city dominated by the tourism industry, it should come as no surprise that much of the waste generated by the city is due to its visitors. VESTA has estimated (and is confirmed by the data in section 0) that the 12 million tourists who annually pass through Venice generate as much waste as 100,000 full-time residents would generate.

Part of the problem arises from the inability of the City of Venice to implement direct taxation on the businesses or residents of the city. All tax-related regulation must pass through the national level, which makes new or specialized taxation difficult to pass. Similarly, Venice has had limited success in its attempts to tax tourists to the city. While the Marco Polo airport on the Venetian Lagoon does have an airport tax, the revenue from that tax is not directly available to the City of Venice. The only source of revenue the city currently has which is directly derived from the thriving tourism industry is a bus tax, which charges 180 Euros per tour bus entering the City of Venice. **Figure 4.30** shows the nationality of the busses charged the ZTL (Limited Traffic Zone) fee as of July 11, 2002. Even this fee is avoidable, however. The fine is not imposed before 6 am, so tour groups looking for the cheapest rates arrive in the city before 6 am just to avoid being charged the extra fee.

ZTL BUS VENEZIA
NAZIONALITÀ BUS

(situazione all'11 luglio 2002)

Nazionalità	N. Bus	%
ITALIA	11.843	57,7
GERMANIA	2.987	14,6
POLONIA	794	3,9
FRANCIA	748	3,6
SPAGNA	723	3,5
BELGIO	497	2,4
AUSTRIA	349	1,7
INGHILTERRA	349	1,7
SLOVENIA	271	1,3
OLANDA	260	1,3
CROAZIA	193	0,9
SVIZZERA	187	0,9
GRECIA	147	0,7
UNGHERIA	135	0,7
BULGARIA	126	0,6
REP. CECA	126	0,6
PORTOGALLO	119	0,6
ROMANIA	119	0,6
SLOVACCHIA	98	0,5
LITUANIA	70	0,3
SVEZIA	68	0,3
DANIMARCA	66	0,3
RUSSIA	44	0,2
SERBIA	33	0,2
REP. SAN MARINO	32	0,2
UCRAINA	30	0,1
ESTONIA	21	0,1
LUSSEMBURGO	19	0,1
BIELLORUSSIA	19	0,1
LETTONIA	15	0,1
BOSNIA	13	0,1
NORVEGIA	11	0,1
IRLANDA	4	0,0
TURCHIA	3	0,0
MACEDONIA	2	0,0
TOTALI	20.521	100%

Figure 4.30: Number of tour busses charged entrance fee to city[52]

[52] Il Gazzettino. Page 3. 17 July, 2002

5 Analysis

This chapter is completely dedicated to presenting and discussing our suggestions for the City of Venice and VESTA to improve the efficiency of the current waste collection process, to balance the known financial deficits and discrepancies, and ultimately, to recommend a detailed scheme for a practical and successful recycling system in the Historical Center.

5.1 Transfer Station Inefficiency

The team noted the inefficiency inherent in the transfer of the collected garbage from the collection boats to the barge used to transport the waste to the Fusina processing plant. The current method is time consuming in two distinct places in the operation: unloading of the boat inserts, and loading of garbage into the trailers for transport from the Fusina dock to the disposal plant.

The first operation takes upwards of 90 seconds to complete, and generates a backlog of collection boats waiting to be unloaded. The time spent waiting in line costs VESTA in the wages paid to boat and arm-lifter operators, and in fuel costs of boats idling. A second problem with the unloading process is the space lost to decompression of the garbage upon being dumped into the barge. While no quantitative data is available for the amount of decompression the trash undergoes (from its original 3:1 compression), it is not unreasonable to guess that the ratio drops by half upon being opened and dumped several meters from the boat insert into the barge. This inefficiency is not as costly as the time spent waiting, but could add to fuel costs if the barge must push two barges to Fusina when the waste could fit in one.

The second operation (unloading the barge into the trailers at Fusina) is where the largest inefficiency lies. The barge arrives at Fusina carrying the loose, less compacted, garbage from the transfer station, where a single crane and bucket scoop spends an entire morning emptying the contents into a tractor-trailer which must make 11 trips from the barge docking location to the entrance of the incinerator to dispose of the Historical Center's waste.

5.1.1 Fusina Conveyor Belt System

One suggestion for reducing the time spent unloading the barge at the Fusina dock is the installation of a conveyor system which would take the garbage from the barge directly into the waiting chamber for the incinerator. The conveyor would be loaded either automatically, or with a bucket scoop larger than the one currently used (since the scoop no longer needs to fit inside the trailer).

Pro:

- Fully automated transfer process, minimal personnel required.

Con:

- May not be feasible depending on system flow capabilities.
- Will require new equipment and equipment design.

"Handling efficiency for a MRF is greatly enhanced by using conveyor lines to move waste from the tipping area through processing. Conveyor lines can be used merely for transporting materials to mechanical equipment or can act as moving lines that allow workers to separate various commodities. Conveyor lines are an integral part of any well-designed MRF."[53]

5.1.2 Transport of Boat Inserts to Fusina

A second suggestion for improving the efficiency of the transfer process, which could be coupled with the first one, is to load the full garbage inserts into the barge, rather than dumping the contents. This method could save time on both ends of the transportation process; the time spent emptying the boats would be reduced (reducing waiting time as well), and the full inserts could be loaded directly onto trucks where the trash could be dumped directly from the insert to the incinerator waiting room.

Pro:

- No new equipment required – little modification needed.

Con:

- Garbage inserts may not get back to the Giudecca transfer station in time, which would require the purchase of more compactor inserts to keep the garbage collection rotation going as scheduled.

5.2 Tourist Littering

In a city with the tourist appeal of Venice, it comes as no surprise that food wrappers, drink bottles, and gelato cups can be seen strewn about in nearly every major walkway. Being tourists themselves to the city, the team members felt they could relate to the throngs of foreigners who purchase a soda as they walk, and too often find themselves with the empty can, bereft of an appropriate place to put it. The team did not notice any sort of carelessness or malice on the part of these visitors, in fact many seemed to keep the trash with them for a time while they looked for a trash can. However, too often there are stretches of walkways devoid of trash

cans for hundreds of meters, and even the most resolute friend of the environment cannot be expected to carry his waste all day.

As a method of reducing the amount of litter left by well-meaning visitors of the city, the team suggests the introduction of more trash cans, located not only *in* the tourist destinations (San Marco, Rialto, Ferrovia), but also along major thoroughfares (Strada Nuova) *connecting* tourist areas.

The team also recommends using trash cans with two compartments; one for regular trash, and another for plastic/glass/metal (PGM). The option for recycling would allow those tourists and residents already inclined to recycle to do so. While it would be overly optimistic to assume that a large majority of tourists would take time to differentiate their waste, much of the waste carried (and thereafter disposed of) by tourists is in the form of bottles and cans, which would not make any sorting necessary. Additional precautions include: the labeling of both sides of the receptacle with symbols (and perhaps select languages) indicating what is appropriate for each side; and making the opening for the PGM a rounded shape (as the top of current PGM dumpsters are), to prevent accidental disposal in the wrong side.

Pro:

- Gets tourists involved in recycling as well as some local residents as they walked casually through the streets.
- Pretty easy to implement – little modification needed.
- Simple user friendly bin design.

Con:

- May complicated collection/emptying process for the bins.
- Require more personnel and/or more collection time.

5.3 Future Obstacles

The future of any city depends on the values instilled in the next generations of residents, and Venice is no different. While the suggestions proposed in this document are not meant to be only short-term solutions, the team has no illusions as to the dynamic and evolving nature of the City of Venice. There can be little doubt that the city will encounter problems unforeseen by either the team or anyone else at this juncture in time, which could endanger the role of recycling in the city.

We realize that the only way to deal with the variations Venice is sure to see, is to have residents and policy-makers who have a good background in the benefits and methods of recycling. If future Venetians have had a desire to recycle instilled in them from an early age, they will find ways to surmount any obstacle they may encounter in their lifetimes. The best way to instill such an interest is through education from a young age, when recycling can be taught as a

desirable alternative to environmentally unfriendly actions like land filling, dumping, and incineration. Recycling should be taught truthfully, explaining the problems (limited market, complexity of garbage pickup, weakening of fibers in paper products, hazardous chemicals used in processing) as well as the overall benefits (lower consumption of precious resources, lower energy consumption, preservation of land) to ensure the complete education of future decision-makers.

The education of today's young Venetians is not without its short-term benefits, however. Educating the children is one way to educate the parents, if indirectly. If the importance of recycling is impressed upon the children, the children will discuss recycling with their parents, who may, in turn, become more environmentally aware. The team realizes that a new recycling program is as much a social change as it is a logistical change, and recognizes the value of long-term changes in the social acceptance of recycling within the community and household.

Pro:

- Educates and instills a recycling initiative in Venice's youth.
- Sets the foundation for the long-term success of a recycling system.

Con

- May be expensive to develop and implement a solid recycling education program.

5.4 Imballaggi Collection

In accordance with the EU mandate already in existence, the producers of packaging material (shipping boxes, packing crates, shrink wrap from bulk items) are legally and financially responsible for the collection and disposal/recycling of such material. As discussed in **Chapter 4,** 12% of all the Historical Center's waste is some form of packaging material. This material is currently being collected along with all other waste, but due to considerations already in place in the tax formula (TIA), such collection is not being paid for by anyone. This oversight adds a significant cost to the collection budget (the team observed one worker in the San Lio region dedicated to the pickup of imballaggi), and may be partially responsible for the deficit the city faces in terms of garbage collection.

The team suggests that the city take a more aggressive stance on regulating this mandate, and proposes the use of cargo boats to pick up the imballaggi from businesses at the same time that they make their regular deliveries. In this manner, the cargo boats do not make trips back to their loading docks without freight, and the cost to transport the material is lower than if a dedicated imballaggi pickup service were implemented.

Pro:

- No additional cost to implement.

- Very easy to implement.
- No inconvenience to anyone.
- Cargo boat drivers profit financially.
- Reduces the large volume of space that the current imballaggi takes in the garbage boats during collection.
- Reduces garbage collection time by reducing the volume of garbage that must be collected.

Con:

- May not be recycled in the end if the imballaggi collected by the cargo boats is just thrown away.

5.5 Resident Incentives for Bottles/Cans

The team recognized the importance of incentives in a successful recycling program from a very early point. The greatest pitfall with most methods of incentive is the likelihood of cheating or the cost associated with supervising the incentive system.

The team, therefore, recommends the institution of a deposit bottle program, which provides incentives to consumers, without the need for additional enforcement. A fixed deposit of 5 to 20 Euro cents (the team recommends 10) would provide consumers with a reason to return their empty containers to get their money back. There is no need to punish consumers who fail to return their bottles, as the deposit has already been paid, and the city can use the money from the deposits to fund a broader recycling program.

This recommendation is aimed primarily at permanent residents, who would be more likely to notice the accumulated effect of ten cents per bottle than tourists who may only buy one container during their visit. This fact does not diminish the value of this suggestion, however, since full time residents are also consumers of bottled and canned beverages.

Pro:

- Increases awareness and recycling by locals due to financial impact of deposit bottles on large scale.
- Decreases littering of bottles and cans by locals.
- Bottles and cans that are left on the streets may be picked up by mendicants and returned for their cash value.

Con:

- Has little, if any, effect on tourists who would not find the added cost a sufficient incentive to return the bottles, once empty.

- The deposit system could be difficult to implement, as it requires the cooperation and supervision of all vendors of beverage containers.
- The administration of the system could be difficult, since the stores would be asked to first collect the depo sit as part of the sale of the item, and then refund the customer when he returns the bottle.
- Additional problems lie in the storage of the collected bottles by the stores, many of which are pressed for space as it is.

5.6 Recycling Collection

Of vital conc ern to both the City of Venice and VESTA was the issue of cost and complication of collection that any new system might introduce. It was obvious to the team that any suggested system could not increase the number of workers needed, the number of hours worked, or increase the traffic in the already congested canals. At the same time, the needs of the residents of the city could not be overlooked, since they would be an integral part of any recycling system. This requirement called for as little drastic alte ration of the current collection system as possible, as this would be met with unwillingness on the part of many residents.

The team realized from the beginning of the project that a successful recycling system suggestion would also require the restructur ing of the current garbage system, as widespread recycling would change the volume and perhaps even collection method of undifferentiated waste disposed. Therefore, each suggestion for recycling includes a description of the changes required or suggested o f the garbage collection, to ensure an optimi zed system throughout the city.

5.6.1 Alternate Day

A system of recyclable collection devised by the team that would keep the number of boats and workers roughly steady is an alternating day collection schedule. Th e city would be split into two halves in such a way that the amount of waste generated by each half is roughly the same. Half of the boats in the current fleet would have their compactor insert replaced with an open insert as used now for recyclables. Ever y day, half the city would have its trash collected by boats with a standard trash insert (with compactor), while in the other half recyclables are collected. The volume of waste that could be collected by the recycling boat would be slightly lower than a standard insert (30 m^3 total capacity vs. 18 m^3), but a small addition to the fleet would suffice in bridging the difference.

Pro:

- Few, if any, additional boats are required, since the volume of trash remains unchanged, and is simply collected on a two -day cycle rather than collecting everything every day.
- The system does not dramatically alter the collection method to which people are accustomed.
- Home-sorted recyclables reduce downstream sorting costs.

Con:

- Alternating collection days result in resident s and businesses having to keep their garbage for more than one day.
- Both VESTA and the City of Venice have already expressed that moving away from daily collection is very inconvenient and totally unacceptable.
- It will be difficult to gain resident supp ort for such a collection schedule, as it increases space taken up by garbage within the house.

5.6.2 Spaced Collection

Spaced collection uses the same principle as alternating day collection, but takes into account the possibility for large differences in th e volume of recyclable material disposed of as compared to regular trash. In this system there could be one, two, three, or four days of recycling collection, with the remaining days (out of six, Sundays no collection occurs) used for trash pickup.

Pro:

- More flexible/adjustable pickup scheduling – can adapt to fluctuations of garbage vs. recyclables volume.

Con:

- This variation of the alternating day system requires a greater number of boats, since there is no longer an even division of recycling and ga rbage boats.
- Can become a very confusing collection schedule to residents since they must remember what is collected on which day.

5.6.3 Daily pickup of Recyclables and Trash

The daily pickup of recyclables and trash together would have less effect upon the residents than either of the two aforementioned suggestions, since there would not be a new collection schedule to deal with, and garbage would not accumulate uncollected (except on Sundays, as it already does). In such a system, garbage collection would occ ur as it does today, on

a door-to-door basis. Residents would be provided with marked containers or bags in which they would be instructed to put their recyclables. Both their regular trash (in any bag they wish to use, as it is today), and their differentiated recyclables (in the new bag or container) would be placed outside their home. While the garbage collector picked up the regular trash, a recycling collector would make door-to-door rounds collecting the specially marked recyclables in a cart like that used by garbage. When the recyclables cart became full, the collector would return to a boat stop where a non-compacting boat was waiting, into which the recyclables would be dumped, and the collector would resume his route.

Pro:

- Minimal adjustment required for residents and businesses.

Con:

- Costly to implement since it requires new equipment or substantial modifications.
- Complicates collection logistics.

5.6.4 Island Dumpsters

One method of recyclables collection which would reduce the amount of money spent on collection labor is the transition from door-to-door pickups to 'bring' collection at a few locations on each island (depending on size and population). Central dumpsters would reduce the number of collectors, and could reduce the frequency of garbage boat stops on the islands. The dumpsters could be linked to garbage collection in one of the following ways: the dumpsters could be the only form of waste disposal, in which case recyclables could be sorted out automatically at a sorting facility; there could be dumpsters for the four types of waste (organic, paper, PGM, trash), at which residents would be asked to sort their waste at the dumpster; or the dumpsters could be used to supplement a door-to-door garbage collection scheme, which would effectively be an extension of the method currently in use in parts of the Historical Center.

Pro:

- Simplifies collection by centralizing disposal points.
- Decreases the number of personnel required for collection, which leads to dramatic reduction in labor costs (see **Figure 4.1** for current density of workers per island).

Con:

- No space for dumpsters in the Historical Center.
- Dumpsters are ugly in appearance.

5.6.5 Parked Garbage Boats

The idea of parking garbage boats at a designated dock all day is similar to the dumpster idea, except that manpower requirements are even lower. One or more boats parked on each island would enable residents to dispose of their waste at any time they wish, without worrying about remembering to set it out, or dealing with confusing collection schedules. The boats would be equipped with non-compacting inserts onto which a top with two or more chutes is fixed. Residents could put anything that would fit down the chute into the boat, with no limit on quantity or composition. The boat would be emptied daily (possibly including Sunday) to prevent odor or overfill problems. Such a system reduces the cost of labor for collection to near-zero, leaving only boat operators (which could also be reduced, since the boats need not (and in fact should not) be emptied all at the same time) and street sweepers on the payroll. The garbage boats would be taken to a proposed sorting facility on the island where the old incinerator lies where mechanical and minimal manual sorting of PGM, paper, and organic would occur.

Pro:

- Greatly reduces collection costs by reducing most of the personnel and some of the equipment.
- Greatly simplifies collection.
- Greatly reduces collection time.

Con:

- Many of the dock locations are in areas which are used heavily throughout the day for cargo, construction, and gondolas. Some docks are in such narrow canals that a permanent boat in that location would effectively block the canal completely.
- The aesthetics of a parked garbage boat in a prime tourist and gondola location are not good.
- No compaction will cause the garbage boat to fill up faster.
- Residents will have to adjust to carrying their garbage to the boat dock.

5.7 Financing Methods

The team realized that one of the greatest obstacles of any garbage or recycling system is accounting for the amount of waste generated by each resident and business. Without this ability, any funding system is bound to be flawed, as assumptions will have to be made, or formulas designed, to approximate the waste generation (and therefore financial responsibility) of each citizen. Since the Historical Center already faces an annual deficit, and citizens already complain about the high cost of garbage collection, the problem of accurate appraisal of waste generation

is an acute one, both financially and politically. The following suggestions were developed by the team to maximize the ease of accountability for waste generation.

5.7.1 Marked Bags

One method of financial accountability for the Historical Center is th e introduction of specially marked or color -coded garbage bags, bought from the city. This front -end solution (the city receives the payment for the bags before they collect the bags, thus doing away with monthly or yearly billing schemes) combines fair pa yment for waste generation, with the easy option of adding recycling (a differently colored bag). Bags purchased from the city or a designated reseller would act as a Pay -As-You-Throw financing method, with easy enforcement (any unmarked or uncolored bags would not be collected). Areas of the city with high rates of illegal dumping (dumping of unmarked bags) would be easy to pinpoint for increased vigilance by the Vigile Urbani (urban police) or temporary security camera to catch the offender.

Pro:

- Easy to sort since bags are marked.
- Front-end revenue stream (VESTA is paid for services before providing said service).

Con:

- May increase illegal dumping rates.
- Purchase of designated bags is inconvenient.
- Distribution of designated bags requires more regulatio ns.

5.7.2 Adhesive Labels

Adhesive labels, similar to postage stamps which have seen widespread success around the world for mail handling, would work the same way marked bags would, with an additional level of accountability built in. Adhesive labels would be offered in a variety of sized (three or more), color-coded for easy identification, and could be affixed to any bag or container being disposed of. The labels could either be offered through retailers, as with the bag suggestion, or could be mailed to residents directly, along with their bill. The first option provides the front -end financial solution, while the mailing of the labels would allow the city to know exactly how much waste each household or business generates, making enforcement easier (if a bu siness disposes of more waste than it receives stickers per month, an audit and further inspection of th e business would be justified).

Pro:

- More convenient than color coded bags since any generic bag can be used.
- Easier to distribute than color coded or designated bags.

- Easy to enforce.
- Front-end revenue stream.

Con:

- Having to purchase labels can be inconvenient.
- Not as obviously identifiable as color coded or designated bags.

5.7.3 Barcodes

Bar-coded stickers would provide the highest level of financial security and accountability for the city. Bar-coded stickers would be purchased from designated retailers (with appropriate barcode printers) to be affixed on garbage containers, as in the adhesive label suggestion. In order to purchase the labels, residents would be required to present their ID cards (or a card issued to their business, if the labels are to be used there) to prove their identity. The address and type of establishment would be contained on the barcode, which would be scanned by handheld scanners carried by collection workers. The information acquired from the scanned barcodes could help VESTA make more efficient use of their boats (by re-assigning boats to maximize fill level), and to provide information that would prove useful in the event that VESTA decides to separate business and resident collection in the future.

Pro:

- Accounting method for tracking garbage generation by establishment.
- More difficult to find loopholes around the system.
- Very fair way to bill garbage generation.
- Front-end revenue stream.

Con:

- Adds more work for collection workers.
- Requires additional high-tech equipment.
- May encourage more illegal dumping.

5.7.4 TIA (Unmodified)

The TIA is becoming well established as the method of paying for garbage collection in the Historical Center, after replacing the previous tariff known as TARSU. The TIA is based upon the square meters of the building being charged, multiplied by pre-determined constants depending on the location of the building (higher costs were assessed to businesses closer to high tourist areas).

Pro:

- No more legislation needed.

Con:

- The TIA is still considered flawed, due to the reliance upon the area of the building, rather than any real accounting for waste generation.

5.7.5 TIA (Modified)

Using the foundation of the current TIA, which has the advantage of already being in place and becoming better established in the Historical Center, the team suggests making modifications to the existing TIA structure to fund the fixed costs of garbage collection (boat maintenance, property and equipment costs, sweeping, aqua alta, city beautification), but replacing the variable portion with a more accurate measurement system for garbage production (see suggestions above). Combining the TIA with a Pay-As-You-Throw system ensures that all citizens pay the same base amount for services used by all, while paying only for the collection costs they create.

Pro:

- Adjusts TIA to hold large garbage producers more accountable.
- Reduces the yearly 10 million Euro deficits.
- Balances the current unfair payment structure.

Con:

- Requires legislation

5.8 Complete Packages

The team analyzed the recommendations made above, and combined the ones with the most promise into a series of succinct and thorough packages that will address all the needs of the city. Each package contains a rudimentary overview of the suggested system, followed by in-depth analysis of each component (identified with **bold** font), and a final "pro and con" section stating the benefits or problems foreseen by the team.

5.8.1 First Package

The first package put together by the team is aimed at the highest recycling rate possible for the city, with cost as only a secondary concern. The **collection system** suggested for this package remains unchanged from the current garbage collection method, to reduce confusion and complexity for both residents and collectors. Garbage would be picked up on a daily (except Sunday) basis and transported by cart to a waiting garbage boat. The **boat** would house a non-compacted insert (like the ones used for recyclables now), into which all the garbage (unsorted) would be dumped. Boats, once full, would travel to the westernmost end of the Guidecca (where the transfer station now is), where the garbage would be unloaded into a newly built **sorting**

facility. The sorting facility would be as automated as possible, to reduce time and cost of sorting, and to limit the exposure of personnel to raw garbage. Sorting the garbage at a sorting facility would ensure that the highest rate of differentiation (and therefore recycling) is achieved, without reliance on residents. **Barges** at the transfer (now sorting) station would be on hand to pick up the remaining, unrecyclable garbage, as well as the sorted material for transport to Fusina and the recycling plants, respectively. Compostable waste, once differentiated, could still be sent to Fusina with the remaining garbage, since the composting facility there can handle an additional 16,000 tons of material per year (more than enough for the Historical Center).

The system would be paid for through the current **TIA**, as well as the implementation of an **imballaggi tariff** paid by packaging producers to the City of Venice upon import of any packaged good. This process of charging producers at ingress would be greatly facilitated by the construction of a **warehouse facility**, as proposed by a recent project completed by Worcester Polytechnic Institute students, since all goods could be identified and charged the tariff as they enter the warehouse.

5.8.1.1 Collection System

The collection system would remain unchanged in almost every aspect, including times (8 am to 12 pm), number of collectors (roughly 400), routes, garbage stops, and frequency of collection (daily except Sunday). Only the removal of recycling dumpsters, and the use of former recycling boats (7) as garbage boats would be changed from the current system. In the few sections of the city where autoconferimento is currently used, it would continue, but the recycling dumpsters in those sections would be removed and replaced with garbage dumpsters, thus eliminating any need for self-sorting of recyclables. The elimination of all recycling dumpster locations (40), with an estimated 1.5 recycling dumpsters per location would result in 3.6 m3 of waste per day (using a biweekly collection schedule) moved into the regular waste pickup stream.

5.8.1.2 Boats

All current garbage boats would be retrofitted with non-compacting inserts (like those used for recycling now), which would reduce the overall capacity of the fleet by 576 m^3, or 32 boat loads. The 3.6 m3 of recyclables per day would raise the number of boats needed daily to 33. The 5 boats currently used for 'ingombranti' or bulk item collection would remain unchanged (as would their role in collection), but the 7 boats used for recyclables could be applied towards the 33 necessary boats. The remaining 26 unaccounted-for boat loads could either be collected with 26 newly purchased boats, or by existing boats doing double rounds. The team recommends double rounds, as this does not increase initial costs, does not add to backlog problems at the transfer station, and does not add workers.

5.8.1.3 Sorting Facility

The construction of a new sorting facility would be a major financial and logistical commitment to recycling in the Historical Center. A small sorting facility (which would serve the Historical Center) costs close to $2 million (in the United States), and the cost of high-end automated sorting machinery can double that number. Complete cost analysis of the design, construction, and operation of such a facility is the subject of further research. The sorting facility could be built anywhere with easy access to an unloading location for the boats, a large space to minimize resident discomfort from noise and traffic, docking locations for multiple barges, and easy access to the Historical Center (to minimize fuel costs and transportation time). The island on which the old incinerator is built, and where transfer of garbage currently takes place is the team's preferred location, as it is already being used for garbage transfer purposes, and satisfies all the requirements just listed.

5.8.1.4 Barges

Barges would still be used to transfer waste from the transfer/sorting facility to Fusina. However, instead of all the waste generated by the Historical Center being sent to Fusina, only the non-recyclable and the compost portion would be shipped there. Even these would be separated in the barge by a dividing wall or a separate container, so the compost could be easily sent to the composting facility, and the remaining trash burned for energy or landfilled. A second barge, also with two or more compartments would also be needed at the sorting facility, where plastic, glass, metal, and paper would be put in their respective compartments (or commingled, depending on the desires and abilities of the final recycling plant). The garbage barge would be shipped to Fusina daily, as it is now, while the recycling barge could make trips to the recycling facility(ies) as often as necessary. No additional barges would be required, only small modifications to existing barges.

5.8.1.5 TIA

The TIA would remain in place as the primary source of funding for VESTA's collection and management costs. While improvements could be made to the TIA formula (greater consideration for restaurants with outdoor seating, lower cap on total discounts available), they are not critical to the implementation of this suggestion.

5.8.1.6 Imballaggi Tariff

The major change to the financing method used in the Historical Center is the creation of an 'imballaggi' tariff (tariff on packaging waste), requiring all producers of packaging waste to

pay for the appropriate disposal of said waste (as required by the European Parliament and Council Directive 94/62/EC on packaging and packaging waste). The cost of imballaggi disposal is already taken into consideration by the authors of the TIA, so no modification would be necessary to any existing law. The city would charge a certain amount (depending on the type of material, quantity, and ease of recyclability) to the producers of the goods, either directly (through accounting and billing) or via the distributor of the goods (who would in turn charge the producer). The exact scope of the packaging law (see Appendix O), and the legality of the proposed tariff are unknown, and require further study prior to implementation.

5.8.1.7 Warehouse Facility

The creation of a warehouse facility on Tronchetto, as suggested by a WPI project in 2001, would greatly ease the assessment of the imballaggi tariff, as all cargo deliveries would be required to go through the warehouse, instead of being unloaded on the docks, as they are now. The warehouse could also be useful for transporting the differentiated material from the lagoon to a mainland recycling plant (if no water access is available), since the material could be stored and put in appropriate containers (train or tractor trailer) for transport.

5.8.2 Package Two

The second package put together by the team is aimed at improving the recycling system at the lowest cost to the city. Such a proposal would not be expected to have the same high rate of recycling expected from the previous suggestion, but would provide a more widespread recycling program with a potential reduction in waste collection costs.

Garbage in this system would be collected exclusively in an **autoconferimento** (self-conferred) manner to dumpsters located on every island (in multiple locations for most islands, for increased convenience). Every dumpster location would have trash dumpsters, plastic/glass/metal, and paper dumpster. Residents would be asked to sort their waste into the appropriate dumpster before disposal. The dumpsters would be collected on alternate days by a reduced staff of collectors whose job would be to roll the dumpsters from their locations on the island to the boat pickup dock for emptying. In some areas a designated collector would be unnecessary, as the boat driver could easily push the dumpsters to the boat himself, saving collection cost. The city would be split into **two zones**, based on geographical proximity and volume of waste dumped, so that the fleet of boats could be split in such a way that no switching of inserts would be necessary. Full garbage boats would be taken to the current transfer facility, where the garbage would be transferred to the current barges for processing at Fusina. Full recycling boats would also return to the **transfer facility**, where they would be emptied into a second barge, divided into two sections for PGM and paper. Garbage processing would remain

unchanged, on a smaller scale (from the now-sorted garbage), and the recycling barge would transport the materials to the recycling facility for processing.

Financing for the system would be achieved through the **TIA**, with the introduction of the **imballaggi tariff**, as explained in Package One. However, rather than having imballaggi collection by VESTA it is suggested that **cargo boats** pick up the imballaggi from stores as they drop off new shipments. In this manner, the imballaggi is removed from the waste stream completely, and the city is no longer responsible for collection or transportation of the packaging. Cargo boats would be hired by businesses (at an expense passed on to the producers of the packaging) to collect the imballaggi, which would be taken back to the producers by truck or train, or dumped on a barge bound for the recycling centers (through contracts between the packaging producers and VESTA).

5.8.2.1 Autoconferimento

The self-conferred collection method downsizes the collection staff for the Historical Center by 70 and 90% of the collection staff needed for the Historical Center (70% if some collection workers remain to help boat drivers retrieve the dumpsters, near 90% if only the boat drivers are used to retrieve the dumpsters), which translates to a saving of over 6.5 million Euros in the first year alone. That figure does not include the cost of providing benefits for those workers, which would conceivably amount to over a million Euros as well.

5.8.2.2 Two Zones

Dividing the city into two zones with equal trash production in each would allow for a fixed ratio of trash boats to recycling boats, reducing labor time needed to replace the inserts in boats. A two zone system only works with alternating day pickup, since one set of boats would be servicing one zone while the other set services the other zone. Few, if any additional boats would be required in this system, despite the loss of 12 m^3 of garbage space per recycling boat (since recycling boats are uncompacted), since the imballaggi is picked up separately by the cargo boats. Therefore, using 12% as the percent of the Historical Center's volume of waste generated by packaging, the daily volume of garbage collected by VESTA each day drops from 1440 m^3, to 1152. Then, even if the differentiation rate is 50% (much higher than would be expected by such a system), only 52 total boats would be required to service the entire Historical Center (32 recycling boats, 20 garbage boats).

5.8.2.3 Transfer Facility

The transfer facility would continue to operate as it currently does, with the possible expansion of the recycling transfer side to accommodate a longer line of boats waiting to be emptied. The recycling inserts would be of the split-compartment design, to hold both the paper and PGM in the same boat without cross-contamination. Recycling barges would need to make more frequent trips to the recycling facility than they currently do to handle the additional volume of material from the Historical Center, while garbage barges could make less frequent trips, or use the small (500 m^3) barges rather than the larger (1200 m^3) ones.

5.8.2.4 TIA

As with the first package, the TIA would remain the sole source of funding for the entire garbage collection system. In order to reduce costs and ensure that all citizens of the city are paying an adequate amount for the disposal of waste and maintenance of the city, it may be wise to re-evaluate the TIA multipliers for businesses like bars, snack shops, and hotels. The data shown below indicates that the quotas attributed to these businesses in particular do not accurately account for the waste produced.

5.8.2.5 Imballaggi Tariff

Please see Section 5.8.1.6 for the imballaggi tariff suggestions.

5.8.2.6 Cargo Boats

A final money saving measure the city could encourage would be the use of cargo boats returning from making deliveries for imballaggi pickup. Cargo boats are already used to deliver goods to all the businesses throughout the city, however, upon completing their rounds in the morning they usually return to their docks without any cargo, resulting in a loss of productive time. If VESTA made businesses aware that they would be responsible for the disposal of their own imballaggi, the cargo companies could implement a service in which they collect residue packaging as they deliver the daily cargo. The cost of this service could be charged directly to the packaging producers (if legal, see Section 5.8.1.6 for ideas on how to charge producers), or could be charged to the businesses, who would make arrangements with the producers themselves.

5.8.3 Package Three

The following set of suggestions represents the package preferred by the members of the Recycling in Venice team. This package is expected to result in a higher recycling rate than the

second package, while avoiding the costs associated with the first package. The package contains some suggestions which have not been attempted in the Historical Center at any previous time, and may encounter resistance from residents and political groups. Howeve r, the team recognized these obstacles and is confidant that the advantages brought by the syste m will outweigh these problems.

This package restructures the entire garbage collection and financing system from the ground up. The most dramatic change is th e move from a back -end (tri-monthly billing), to a **unit-based pricing** scheme for the collection of garbage. The **TIA** would remain, in a limited form, to fund city projects not directly related to collection of waste (aqua alta, sweeping, park preservation). However, the brunt of the revenue used for garbage collection would come through the sale of specially **marked garbage bags**. Garbage collectors would be instructed to pick up only such bags (marked with text or color), which residents and businesses would be required to purchase from **designated retailers** (supermarkets, grocers, tobacconists). The revenue from the bags would go directly to VESTA to fund the variable portion of the garbage collection process (boat maintenance, fuel, salaries, operating costs) . There would be severe and escalating **fines** for disposing of waste in unmarked bags to discourage the evasion of such unit - based pricing. The collection schedule of **garbage pickups** would remain essentially unchanged, with collection workers making door -to-door rounds in the mornings and filling regular garbage boats. Full garbage boats would be driven to the transfer station on the Giudecca, where the arm - lifter would remove the trash insert and place the entire insert into the barge for transport to Fusina. Once all the **trash inserts** have been stacked in the barge, the full barge would be taken to Fusina, where an arm -lifter like the one used at the transfer station would remove the inserts and place them on **flatbed trucks** designed to hold the inserts. The flatbed trucks would drive the inserts to the incinerator entrance, and dump the contents using the compactor's own hydraulics. The inserts would then be returned to the barge for transport back to the Giudecca transfer station.

The second major change f or the Historical Center would be in introduction of a citywide recycling program. Residents (and businesses) would be issued (at no cost) two **bins** for the storage of recyclables, one for paper and cardboard, and the other for plastic/glass/metal. The coll ection of these bins would be free, and would occur on a daily basis. **Recycling collection** would occur in the late afternoons (4 -7 pm), after much of the cargo traffic in the canals has decreased, and before residents complain about the noise of the boats. The same boats used for garbage collection earlier in the day, would be retrofitted with **split-compartment inserts** without compactors (after their garbage inserts had been removed for transport), and would retrace their morning collection path. VESTA coll ectors would use the same routes as were used for garbage collection, collecting the contents of each bin in the two separate compartments of their **carts**. Full carts would be taken to the retrofitted boats, where the contents would be dumped into their app ropriate section of a split insert. Filled boats would

return to the transfer station, where the inserts would be emptied into a split barge (as is used now), and the inserts stacked in a holding area to make room for the now empty garbage inserts (back from Fusina).

As with the previous packages, the introduction of the imballaggi tariff would lower costs of garbage pickup, and the use of cargo boat contracts could reduce the volume of waste being collected and transported by VESTA (possibly reducing the number of workers and/or boats needed).

Finally, the use of **public awareness** campaigns (mailed flyers, brochures, print/radio/television advertisements) has been shown to increase public participation and acceptance of unit-based pricing and recycling systems. Such awareness campaigns should be linked to recycling **education programs** in schools, which serve to educate from the bottom up (children discuss recycling issues with parents), and will ensure that recycling obstacles in the future are handled by well-informed citizens.

5.8.3.1 Unit-Based Pricing

Unit based pricing is a concept designed to achieve three purposes: provide front-end revenue for the city or collection agency, encourage the use of recycling (as it is a free service), and reduce the total amount of waste generated in the long run. The purchasing of bags allows VESTA to have real-time control over the revenue stream used for the collection of trash, without the hassle of billing people. Customers will be given the incentive to recycle, since the 'price increase' (which may not be a price increase for some since they may be overcharged under the TIA) is coupled with a way to dispose of their waste for free, as long as it is sorted. Finally, unit-based pricing provides consumers with an incentive to reduce the total volume of waste they generate, and will put pressure on retailers and producers to reduce extraneous packaging. In the long run, a reduction in total waste generation may hurt the economies of scale of garbage and recycling collection, however such extreme reductions are unlikely in the near future. More than likely the waste generation will drop only marginally, perhaps enough to reduce the collection costs through the reduction of collection staff and boats needed to service the city.

5.8.3.2 TIA

The TIA would remain in place as the sole source of revenue for VESTA responsibilities like street sweeping, trash can emptying, laying down aqua alta planks, park preservation, equipment maintenance, and management costs. Since all these costs are fixed costs, the variable portion of the TIA formula could be removed, and the billing of the TIA could be included in residents' water bills (as VESTA controls the water to the city as well), or could remain as its own bill on a tri-monthly period. Since all the costs are fixed costs, and are not determined by the

amount of garbage produced by the building, the charges could be simplified to a fixed number for every customer.

5.8.3.3 Marked Garbage Bags

Either the city or VESTA would be responsible for purchasing bags in large quantities which would be either colored or printed with a distinct marking. Bags should be available in at least three sizes (10, 40 and 100 liters) for families and businesses of various sizes. These bags would be priced in such a way that they correspond to the cost associated with the collection and disposal of that volume of trash. However, the price should not be so high as to make illegal dumping of trash a desirable alternative to proper disposal. Collectors would be instructed to take note of any locations where unmarked bags were dumped, so that increased patrols by the Vigile Urbani or the installation of surveillance cameras could apprehend the offender.

5.8.3.4 Designated Retailers

The marked bags would be available through a variety of retailers, to ensure that everyone has convenient access to the bags, and to prevent price gauging by businesses. The bags should have fixed prices that could not be changed by the retailer.

5.8.3.5 Fines

Since unit-based payment schemes tend to increase the rates of illegal dumping, it is important to make people aware that abandoned or incorrectly packaged trash will not be tolerated. A public announcement of an escalating fine for illegal dumping would serve to deter most residents from risking such fines to avoid paying for trash bags. Three methods of enforcement are possible: increased patrolling of high illegal dumping areas by the Vigile Urbani, the temporary installation of surveillance cameras in such area, or, in the worst case, the special creation of a dumping task force to monitor and patrol the city.

5.8.3.6 Garbage Pickups

Garbage pickups would continue as they do now, with the possible reduction in the number of boats and collectors used. While the volume of trash would (at least initially) remain unchanged, the separation of garbage from recyclables could allow for a significant reduction in volume per collection shift. A 50/50 split of recyclables and garbage (while unlikely to be that high) would require only 24 garbage boats (with compactor inserts), and 40 recycling boats (without compactors). Such a scenario would allow for the possible reduction of 15 boats (the

five boats currently used for bulk items would remain as a separate system) out of the 60 currently used, or a 25% reduction. An ide al split would be around 63% garbage, where only 31 boats would be required to service the entire Historical Center (reducing the fleet by 19 boats, or 32%). The actual reductions possible would also depend on the time taken to collect the garbage, as it would still take time for collectors to walk through every street, even if the volume of trash were reduced. Therefore the total reduction is not directly quantifiable without knowing exactly how each collection route would be affected.

5.8.3.7 Trash Inserts

The transport of the entire garbage insert to Fusina rather than dumping the contents and replacing the insert in the collection boats (as is currently done) achieves two purposes: reduced waiting time at the transfer station, and the increased efficiency of emptying the barge at Fusina. By removing the insert and placing it in the barge at the transfers station, the time required to unload a collection boat could be reduced by well over a minute, or 66%. The only steps required for the boats would be pulling up to the dock, unhooking the hydraulic hoses from the compactor, and waiting for the arm-lifter to remove the insert. Once the insert has been lifted, the boat can leave the docking area, and the next boat can pull into its spot.

Once the barge arrives at Fusina the process is streamlined even more. While the trash is currently unloaded using a moderately sized bucket scoop to load a semi trailer, the inserts could be loaded directly onto the back of a customized truck which would hold the insert in plac e, and have connectors for the hydraulics of the compactor. The truck would drive to the bay of the holding chamber for the incinerator, and use the compactor's hydraulics to open the hatch and push the garbage into the holding chamber. Three of such truck s could maximize the efficiency of the system (one being loaded while one dumps the waste, and the third on its way back down to have its empty container removed and a full one replaced.

5.8.3.8 Flatbed Trucks

The trucks, mentioned in the section above, would b e trucks with a flat bed, hooks for holding the garbage insert in place, and hoses for connection to the hydraulic system. These trucks would park next to the arm-lifter on the Fusina dock and be loaded with an insert, drive the short distance to the loadi ng bay, deposit the waste in the holding chamber, and drive back down to the dock to be unloaded and reloaded. In this manner, it would take less than half an hour to unload and empty 30 inserts, which would allow the barge to return to the transfer station in time to replace the garbage inserts when the boats return from the evening recyclables collection.

5.8.3.9 Bins

Every customer would be provided with two durable plastic containers, including lids to prevent rain or animals from accessing the bins and scat tering or wetting the contents. These bins would be left outside the entryway to the building or inside the door, as the trash is now. People would be asked not to set their bins out until the afternoon (when they come home for lunch), although there should be no punishment for leaving them out all day, as they should not contain any organic material which would be a health or animal hazard. The contents of the bins would be dumped into the collection carts, and the bins left by the door, as they were.

5.8.3.10 Recycling Collection

In the afternoons, when recycling collection begins, VESTA workers would retrieve their carts from the storage area on their island, insert the divider into the cart (see the following section), and begin their rounds as they do with tr ash. Collectors would be instructed not to collect any bins which were contaminated with large quantities of organic or wet waste, or bins which had garbage mixed with the recyclables. Such bins, if found to be a reoccurring problem, would be reported to V ESTA, which would give out pamphlets reminding residents of the proper use of the bins. Persistent misuse would result in fines by the Vigile Urbani.

5.8.3.11 Split-Compartment Inserts

The inserts used on the boats for recycling pickups would be slightly modified versions of the current recycling inserts. They would be uncompacted, for downstream sorting reasons, and would be divided in some proportions for plastic/glass/metal and paper (presumably much smaller volume for paper, as it is denser, but takes much les s space than the large volume containers expected in the PGM pickup. The carts would be emptied over the dividing line of the two compartments, the paper section of the cart corresponding to the paper section of the insert. A framework raised above the sid es of the insert would serve to activate the false bottom of the cart, as is used on the garbage inserts.

5.8.3.12 Carts

The carts used for garbage collection would be the same ones used now for garbage, with a minor modification for the separation of the two typ es of materials. Slots, welded to the sides of the cart in some proportion (like those used in the split -compartment inserts) would allow a wooden or metal panel to be dropped into the cart. To prevent accidental mixing of the two types of materials during dumping, the dividing wall in the cart would be allowed to drop down with the bottom of the cart (the divider would be attached by a chain to the handle of the

cart which is pushed down to activate the false bottom, so as the handle moves down, the divide r drops with it) thereby blocking off the opening between the dividing wall of the insert and the bottom of the cart.

5.8.3.13 Public Awareness

Public awareness campaigns are designed to inform residents of changes in the waste disposal process ahead of time, and to encourage participation in voluntary programs offered by the city. While the impact of public awareness campaigns is difficult to quantify, as participation varies with a number of factors including population density, education level, and crime rates, most published manuals for the successful creation of a PAYT system include some mention of public awareness campaigns, if only for the first few months of the new program.

In the case of the Historical Center, the team found, through casual discussion with residents and officials, that most residents were uncomfortable with any sort of change in the methods or schedules of collection.

6 Conclusions

The primary goal of this project of this project was to devise a method of recycling for the Historical Ce nter while taking the city's unique nature into account. While logistical considerations arising from the city's configuration were vital, keeping the Venetian residents in mind was of equal importance. Through extensive collection of information and analy sis of the existing system, our project team devised a set of comprehensive recommendations for implementing the recycling system the city has been requesting and clearly needs.

Our recommendation to the C ity's Environmental Department consisted of an alte ration of the current accountability measures already in use. In order to best integrate the equipment already in use by the city into collecting recyclables, 2 sets of pickup schedules were created. While the generic garbage is to be picked up in the morn ing, the recyclable materials are to be picked up in the late afternoon to early evening, when it will inconvenience few people.

In adapting the new recycling system to the current garbage system, the daily pickup can be made entirely door -to-door, elimina ting all the conflicts that arise between VESTA and the Soprintendenza of the city in regards to the numerous dumpsters located throughout the city.

Additionally, business collection will be distinguished from residential collection, such that a business may opt out of using the city's collection program to gather their garbage. Rather, businesses will have the option of tapping the services of an independent contractor (such as WMI) to tailor their collection schedule to their own needs.

In accordance to the EU directive concerning packaging, the City of Venice, in following our recommendation, will cease to collect packaging goods from businesses. These goods will instead be shipped back to the packaging companies by the businesses themselves, whereupon they will be disposed in accordance to EU standards.

Given the inadequacy of the TIA to account for all garbage produced in the city, the garbage and recyclable collection will instead be funded by the purchase of specially marked garbage bags. As such, VEST A will easily be able to account for each unit of garbage produced without having to fore see all eventualities through tentative tax equations. The TIA will continue to exist to fund VESTA's cleaning and maintenance of the city which are typically fixed co sts.

The benefits provided by the proposed recycling programs include increased environmental awareness, a reduction or outright elimination of deficits resulting from garbage collection, and a decrease in the TIA for the residents of the city who will n ow only have to pay for their own garbage. In handing over the accountability of paying for garbage to each individual citizen and business, the incentive to reduce the city's overall waste management costs is in place .

Thus, in creating our final recommendation to the City of Venice, the goals we originally set out were accomplished. The logistical issues were overcome, the financial concerns were fully addressed, and full attention was paid to the locals and how the reengineering of the collection system would affect their livelihood.

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